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 -10J/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).

Horton (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, Θ_0, 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.

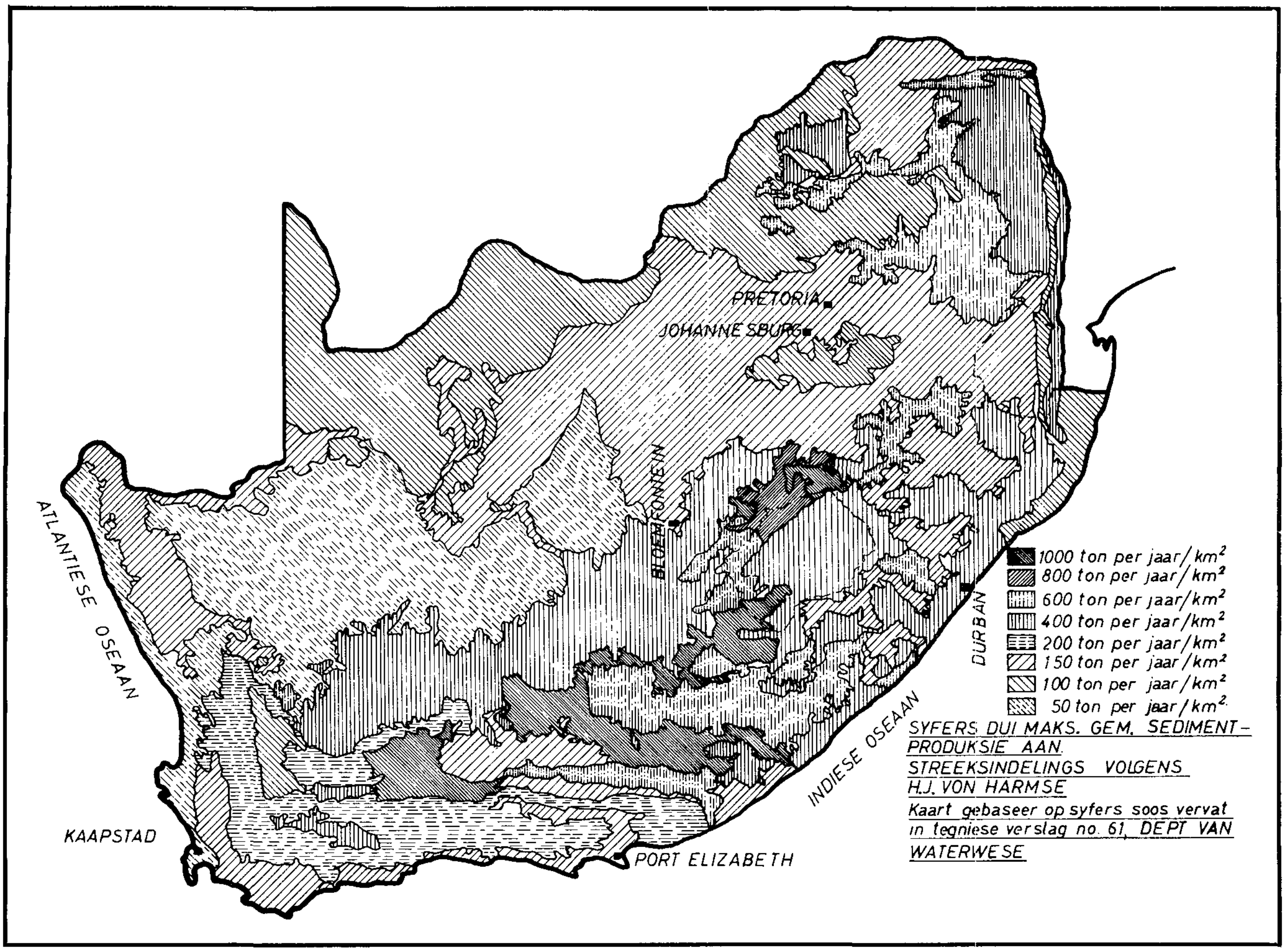

Figure 2
Veralgemeende sedimentproduksiekaart

Bespreking en Gevolgtrekkings

Soos uit die voorafgaande blyk kan sedimentlewering en sedimentafvoer geweldig wissel. Om 'n betroubare gemiddelde sedimentafvoersyfer te kan bepaal vanaf gemete sedimentkonsentrasies by 'n tipiese riviersnit is aaneenlopende bemonstering en vloeimeting oor 'n tydperk van minstens 5 jaar nodig. Wanneer volumes van sedimentafsettings in damkomme gebruik word om die gemiddelde sedimentlewering vanuit die opvanggebied te bepaal, is dit raadsaam om slegs met afsettings ouer as 8 jaar te werk. Hierby moet wel deeglik rekening gehou word met die konsolidasie van sodanige afsettings. (Rooseboom, 1976).

Suid-Afrika is in die gelukkige posisie dat die Departement van Waterwese en sy voorgangers so vroeg as in 1918 reeds met sedimentbemonstering begin het en daarmee volgehou het sodat ons vanaf 'n beter beeld van sedimentafvoer in riviere besit as meeste ander lande. Hoewel die aanvanklike oogmerke van die sedimentbemonsteringsprogramme om toeslikking van damkomme te kan voorspel grotendeels bereik is, is dit noodsaaklik dat daar voortgegaan word met sedimentbemonstering en navorsing.

Die kwaliteitsaspekte van water wat afgevoer word, word steeds belangriker en afgevoerde sediment bly een van die belangrikste komponente by die bepaling van kwaliteit.

Dankbetuiging

Die skrywer spreek graag sy dank en erkentlikheid teenoor die Departement van Waterwese uit vir die geleentheid om navorsing te kon doen wat onder andere tot hierdie publikasie gelei het asook vir toestemming om die gegewens soos vervat in hierdie artikel te kon publiseer.

Verwysings

HARMSE H.J. von M. (1975) Sedimentproduksiekaart van Suid-Afrika (ongepubliseer)

ROOSEBOOM A. MAAS N.F. (1974) Sedimentafvoergegewens vir die Oranje-, Tugela- en Pongolariviere *Tegniese Verslag* No 59, Departement van Waterwese, RSA.

ROOSEBOOM A. (1975) Sedimentproduksiekaart van Suid-Afrika *Tegniese Verslag* No 61, Department van Waterwese, RSA.

ROOSEBOOM A. (1976) Sedimentneerlating in damkomme *Tegniese Verslag* No 63, Departement van Waterwese, RSA.

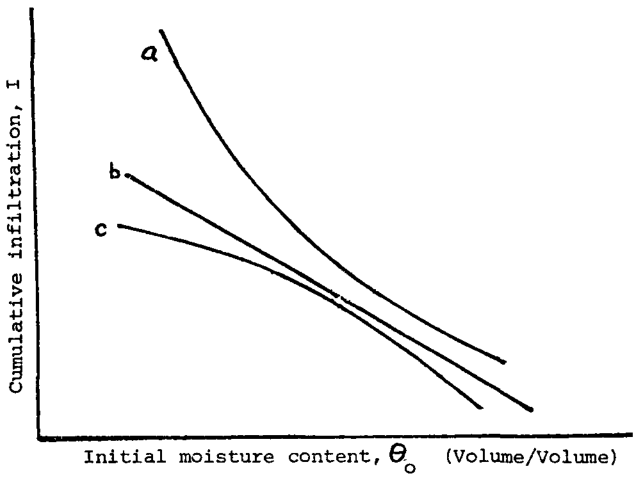

Figure 1
Schematic illustration of the influence of initial moisture content Θ_o, on cumulative depth of infiltration, I. Curves a and b are typical of the experimental data of Tisdale (1951), and those presented in this paper. Curve c schematically represents the data of Philip (1957c) for a Yolo light clay (adapted from his Fig. 4).

However, in spite of these limitations the fact that all curves exhibit similar trends after having been obtained independently is indeed highly significant and would indicate the overall importance of initial moisture content on infiltration.

It is a commonly held view that various other physical and chemical parameters (for example, clay percentage, aggregate stability, organic carbon) influence infiltration. It is the opinion of the authors that, for non-saline soils, their influence is of a secondary nature to that of initial moisture content and that comparisons only be made for soils of similar moisture contents or pressure potentials.

This paper strives to document the influence of initial soil moisture content on field measured infiltration rates. It also highlights the very large variability associated with the measurement of infiltration rates and in part explains this variability in terms of a simple capillary model.

Methods and Materials

Infiltration determinations were carried out using two sets of 12 double-ring infiltrometers placed at intervals of one metre from each other. Infiltrometer rings had the following dimensions:

inner ring 300 mm diameter × 5 mm × 300 mm long,

outer ring 500 mm diameter × 5 mm × 300 mm long.

In hammering infiltrometer rings into the ground a wooden platform was placed over each ring. Blows were directed to the centre of the platform such that the ring was knocked evenly into the ground with minimum soil disturbance. Hessian sacking was placed within the inner ring to minimize soil disturbance when water was applied.

The inner and outer rings were filled simultaneously to give a ponded water depth of approximately 100 mm. The initial depth of water was immediately noted. The depth of ponded water above the soil surface was noted at times of 1, 2, 5, 10 and thereafter 10-minute intervals to a time of 120 minutes. Steady state infiltration rate which is less then initial infiltration rate, was usually obtained within 30 minutes. Where infiltration rate was high it was usually necessary to refill the infiltrometers before the 120-minute period had expired. This was done by noting the time and depth of ponded water, immediately refilling the infiltrometer to some new ponded depth and noting this new depth. Owing to greater lateral flows from the outer infiltrometer ring, water was periodically added to the outer ring to maintain it at an approximately equivalent depth (head) as the inner ring.

Cumulative infiltration, I, was plotted as a function of time, t, and infiltration rate evaluated from the slope of the line by simple linear regression. Correlation coefficients for the linear portion of the I(t) function between the times of 30 and 120 minutes were better than 0,99. The arithmetic mean steady infiltration rate evaluated from a number of infiltrometers (usually 10 to 12) was used in all subsequent calculations. Each set of (10 to 12) determinations has been collectively termed an infiltration run and for reference purposes allocated a number (Table 2). Infiltration runs were usually performed at 2 day intervals.

Initial soil moisture content was evaluated gravimetrically by augering from the 0 to 300 mm depth zone. For the first 'dry' run at a particular site moisture samples were taken from beyond the outer infiltrometer ring. In subsequent 'wet' runs samples were collected from within one infiltrometer which was not subsequently used to evaluate infiltration rate. Tabulated moisture contents are the mean of 6 replications.

The soil moisture retention curves were obtained from duplicate samples of undisturbed clods and disturbed (<2 mm diameter) sieved soil by a method similar to that of Young (1962). The clods were carefully cut from larger diameter undisturbed cores of known bulk density. Saturated moisture content was calculated from this bulk density value using an assumed relative particle density of 2,65. The soil moisture retention curves were evaluated using porous ceramic plates of 100 and 1 500 J/kg bubbling pressures placed in pressure chambers maintained individually at constant air pressures of 3, 10 and 100 J/kg, and 500 and 1 500 J/kg. Constant air pressures of less than 10 J/kg were maintained by a modified bleeder system (Hutson, 1975).

Site localities and tillage condition at the time of infiltration are given in Table 1.

Lateral flows from double-ring infiltrometers have been shown to be acceptably low for at least certain apedal soils (Turner, 1976).

Results and Discussion

Flow variability associated with the determination of infiltration rate from individual infiltrometers

Infiltration of water into soils can, for simplicity, be considered analogous to flow through a collection of idealised capillaries. Intuitively one would expect the flow rate in large capillaries to

TABLE 1

SITE LOCALITIES

Site No.	Soil Series	Soil Form	Tillage Condition	Locality	Geographic Co-ordinates South	Geographic Co-ordinates East
1	Zwagershoek	Griffin	Veld pasture	Cedara	29° 33,1'	30° 15,8'
2	Balmoral	Hutton	Protected grassland vegetation	Cedara	29° 34,4'	30° 14,9'
3	Balmoral	Hutton	Grazed veld pasture	Cedara	29° 34,4'	30° 14,7'
4	Balmoral	Hutton	Grazed veld pasture	Cedara	29° 32,8'	30° 15,8'
5	Balmoral	Hutton	Cultivated, irrigated ryegrass	Cedara	29° 32,8'	30° 15,8'
6	Farningham	Hutton	Protected grassland vegetation	Cedara	29° 33,4'	30° 15,2'
7	Farningham	Hutton	Cultivated maize field	Cedara	29° 33,4'	30° 15,2'
8	Farningham	Hutton	Protected grassland vegetation	Tabamhlope	29° 02,4'	29° 32,9'
9	Griffin	Griffin	Deep lime trial	Tabamhlope	29° 02,7'	29° 39,0'
10	Griffin	Griffin	NCIT/10 maize fertility trial	Tabamhlope	29° 02,7'	29° 39,0'
11	Griffin	Griffin	NCIT/39 maize fertility trial	Tabamhlope	29° 02,7'	29° 39,0'
12	Clovelly	Clovelly	Grazed veld pasture	Tabamhlope	29° 02,3'	29° 39,5'
13	Clovelly	Clovelly	Cultivated maize field	Tabamhlope	29° 02,1'	29° 39,0'
14	Doveton	Hutton	Cultivated maize field	Cedara	29° 32,6'	30° 15,9'
15	Doveton	Hutton	Veld pasture	De Hoek	29° 00,8'	29° 38,7'
16	Vimy	Hutton	Disused ryegrass field	De Hoek	29° 01,3'	29° 38,8'
17	Argent	Shortlands	Veld pasture	De Hoek	29° 01,1'	29° 39,4'
18	Shortlands	Shortlands	Maize field	Bayne's Drift	29° 30,9'	30° 28,6'
19	Soetmelk	Avalon	Veld pasture	De Hoek	29° 00,3'	29° 40,0'
20	Avalon	Avalon	Veld pasture	De Hoek	29° 01,0'	29° 39,4'
21	Waldene	Longlands	Veld pasture	De Hoek	29° 00,6'	29° 38,8'
22	Estcourt	Estcourt	Veld pasture	De Hoek	29° 00,5'	29° 39,4'
23	Cranbrook	Cartref	Veld pasture	Bayne's Drift	29° 30,7'	30° 28,7'

be greater than that of smaller capillaries. This expectation can be expressed mathematically as Poiseuille's law where flow rate in a capillary is proportional to the fourth power of the radius of that capillary (Hillel, 1971). In essence Poiseuille's law implies that a small increase in the radius of the capillary results in a considerably larger increase in flow rate. The soil matrix is infinitely more complex than envisaged in a simple capillary model. However, bearing in mind the variation in sizes of soil pores, root channels and cracks (all analogous to ideal capillaries) in the soil matrix, it does provide an explanation for the very large variability in flow rates that can be encountered in soils. It also accounts for flow variability over short distances and within soils of apparently uniform morphology.

Water flow in soils is in response to a potential energy gradient which has as most important components pressure, gravitational and osmotic potential gradients. As the soil fills with water from some arbitrary initial moisture content, the pressure potential gradient in the upper horizon decreases ideally to a negligible value in saturated flow. Flow is then largely in response to a gravitational potential gradient through the horizon in question. The ultimate moisture profile has been described by Philip (1957b) and by Childs (1964). In practice during the initial stages of infiltration, rate decreases with time until a steady state infiltration rate is attained. In most cases the steady infiltration rate (linear portion of curve, Figure 2) has been attained within 30 minutes. This trend is clearly evident in the four selected examples (Fig. 2) which illustrate the variable time before commencement of steady infiltration,

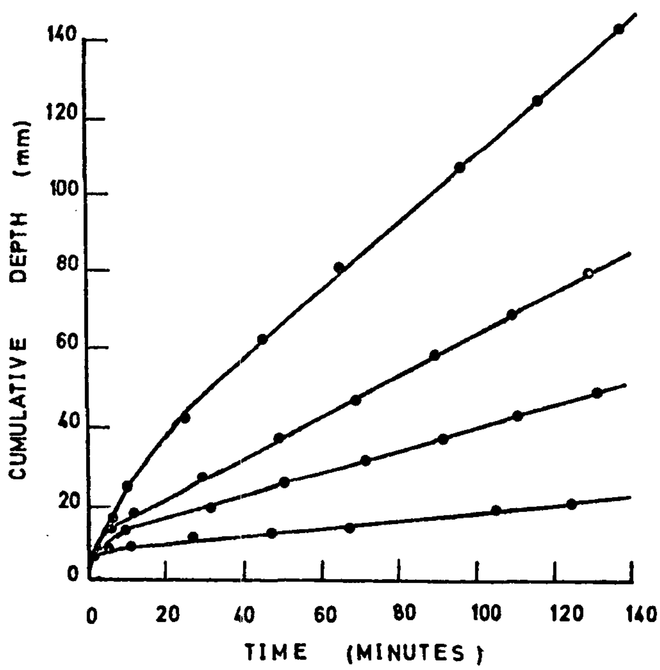

Figure 2
Plots of cumulative depth versus time for four infiltrometers on a Zwagershoek series, Cedara (Site No. 1) showing the excellent linearity of the curve (r<0,99) between 30 and 120 minutes. Infiltration rate is the slope of the plot.

and the excellent linearity of the infiltration rate over the illustrated time period (30 – 120 minutes). Infiltration rates have been evaluated from the slope of the cumulative depth-time plots. Subsequent reference to infiltration rate will imply this steady infiltration rate.

Infiltration rates quoted are those for the surface horizon only. These rates are, however, to some extent dependent on those of the subsoil horizons and the presence or absence of slowly permeable subsoil horizons.

A major source of flow variability is that arising from structural imperfections in the soil profile. However, a further probable source of variability in flow data is that arising from incomplete saturation of the soil matrix. In field situations even after the steady infiltration rate has been attained and a sufficient depth of profile been wetted, it is unlikely that a completely saturated flow regime in the upper horizon prevails. Air entrapment during infiltration can amount to a significant percentage of the total porosity. Reduction in flow rate inevitably results. This reduced value for hydraulic conductivity has been called the "resaturated hydraulic conductivity" by Whisler and Bouwer (1970).

In view of the often large reductions in conductivity at moisture contents slightly less than saturation this source of variability could be significantly large in field observations. It is, however, one that must be accepted as such, since air entrapment would in any event occur during natural rainstorms or irrigation.

To illustrate the variability between infiltrometers, infiltration rates of individual infiltrometers from six runs have been presented in Table 2. The values are those for a Balmoral and Shortlands series (representing high and intermediate infiltration rates) and a Zwagershoek series (Griffin form) (representing lower infiltration rates). These individual rates and the associated variability are typical of most infiltration runs conducted to date. Values for the coefficient of variation for single determinations (CV) of 30 to 100 per cent and greater have frequently been measured (Table 2). The CV value of 22 per cent for the Shortlands series (Table 2) represents one of the smallest measured. The generally large standard error (SE) and CV values illustrate the small measure of confidence that can be attached to individual infiltrometer measurements. To improve the estimate of infiltration rates, it is essential that a mean be evaluated from a number of replications. However,

TABLE 2
STEADY STATE INFILTRATION RATES FROM INDIVIDUAL INFILTROMETERS DETERMINED ON A BALMORAL, SHORTLANDS AND ZWAGERSHOEK SOIL SERIES. THE MEAN AND STANDARD ERROR, AND GRAVIMETRIC MOISTURE CONTENT AND BULK DENSITY ARE GIVEN AT THE FOOT OF THE TABLE. COLUMNS INDICATE INFILTRATION RUNS CONDUCTED AT TWO DAY INTERVALS.

Infiltrometer Number	Balmoral series *mm hr^{-1}*		Shortlands series *mm hr^{-1}*		Zwagershoek series *mm hr^{-1}*	
	RUN NUMBER					
	R11	R12	R31	R32	R1	R2
1	180	162	124	44	15	8
2	120	102	119	38	2	–
3	180	84	121	55	6	1
4	156	90	101	41	24	16
5	90	36	121	61	53	41
6	80	90	110	52	8	2
7	84	156	152	54	17	12
8	114	42	121	49	37	20
9	120	82	88	30	32	18
10	216	102	187	74	27	15
11	75	30	150	60	11	6
12	77	126	–	–	36	14
Mean	124	92	127	51	22	14
SE (Mean)	13,5	12,3	8,2	3,7	4,4	3,3
CV (Mean)	11	13	6	7	20	23
SE (single value)	46,8	42,6	27,2	12,2	15,2	10,9
CV (single value)	38	46	22	24	69	78
Moisture (%)	54,1	56,7	26,7	40,4	36,9	49,1
Bulk density) (kg m^{-3} × 10^3))	0,854	–	1,240	–	0,992	–

TABLE 3

STEADY STATE INFILTRATION RATES (mm hr^{-1}) STANDARDIZED TO FIVE INITIAL PRESSURE POTENTIAL VALUES. INFILTRATION RATES OBTAINED BY INTERPOLATION FROM PLOTS OF INITIAL MOISTURE CONTENT AGAINST INFILTRATION RATE. GRAVIMETRIC MOISTURE CONTENTS ARE ALSO QUOTED.

Series	Site No.	INITIAL SOIL PRESSURE POTENTIAL (J/KG)									
		−3		−10		−100		−500		−1500	
		Rate	Θg	Rate	Θg	Rate	Θg	Rate	Θg	Rate	Θg
Zwagershoek	1	18	42,0	24	37,2	36	31,8	43	29,4	56	26,3
Balmoral	2	51	58,0	58	53,5	68	47,2	73	44,3	79	40,8
Balmoral	3	79	61,0	82	54,6	93	43,3	96	41,3	97	40,7
Balmoral	4	45	42,3	50	38,2	–	30,3	–	29,8	–	28,8
Balmoral	5	15	41,3	30	35,5	–	31,6	–	28,0	–	26,5
Farningham	6	–	39,3	50	36,7	123	32,5	–	27,7	–	27,7
Farningham	7	16	39,7	34	36,5	70	30,7	82	28,4	89	27,7
Farningham	8	11	46,2	13	38,3	16	29,0	–	25,0	–	23,5
Griffin	9	40	58,7	64	40,0	–	21,8	–	17,0	–	13,0
Griffin	10	–	57,6	98	38,4	–	19,5	–	15,5	–	14,0
Griffin	11	–	57,8	65	42,5	–	24,0	–	16,8	–	13,9
Clovelly	12	56	33,0	104	27,5	–	19,5	–	17,8	–	17,2
Clovelly	13	3	39,8	6	35,7	16	21,4	–	17,2	–	12,3
Doveton	14	32	45,4	38	39,3	47	29,5	49	27,3	51	25,9
Doveton	15	196	32,4	260	26,8	316	22,7	320	20,5	358	18,2
Vimy	16	110	35,0	110	29,0	135	25,0	145	22,0	145	21,7
Argent	17	–	27,5	80	23,8	125	20,6	–	17,5	–	13,0
Shortlands	18	73	36,1	103	30,8	143	24,0	149	23,0	155	22,0
Soetmelk	19	–	22,3	12	19,4	14	13,5	15	11,2	–	9,6
Avalon	20	5	23,4	5	20,3	13	14,7	30	11,3	–	10,6
Waldene	21	–	26,2	40	23,3	55	18,2	70	14,0	–	8,5
Estcourt	22	1	23,6	3	19,0	6	11,5	7	8,7	8	8,3
Cranbrook	23	19	28,3	20	26,5	22	24,6	25	18,8	30	13,7

Θg – Moisture content in g water/100 g soil.

the work effort in increasing the number of replications beyond 10 or 12 becomes prohibitive. In general histograms plotted (data not presented here) from a set of infiltration rates (e.g. those of Table 2), usually have positive skewness with a greater chance occurrence of relatively high values (e.g. infiltrometer No. 10, Balmoral series, or No. 5, Zwagershoek series, Table 2). Various estimates of the mean have been advocated to account for this skewness (Slater, 1957; Bouwer, 1969). However, the supporting evidence is inconclusive and the commonly adopted arithmetic mean has been used in this study.

The influence of initial soil moisture content on field measured infiltration rates

Field infiltration determinations were conducted at 23 sites representing 14 soil series. Mean steady infiltration rates for each site were plotted against concurrently measured initial soil moisture content. The functional dependence of infiltration rate on initial moisture content was evaluated by a computer routine (Erasmus, 1975) producing a best fitting linear or quadratic curve by the least squares method. Alternatively, where data points were limiting, simple graphical interpolation was employed. Since field infiltration determinations preceded that of their soil moisture retention curves, it was not possible to accurately forecast the range of moisture contents that could reasonably be encountered in the field. However, for five sites comprising the following soil series; Zwagershoek (Site 1), Balmoral (Sites 2 and 3), Griffin (Sites 9, 10 and 11 in combination) and Shortlands (Site 18) it has been possible to evaluate the functional dependence of initial moisture content spanning the greater part of the moisture range important in agriculture and hydrology. These functions for the Zwagershoek and Shortlands series are presented as Figures 3 and 4. Figures for the other three sites are given by Turner (1976). The shape of these curves is in general agreement with those of Tisdale (1951) and Philip (1957c, 1969). The function of infiltration rate versus initial moisture content spanning a part of the range of plant available water has been evaluated for the remaining 18 sites representing 14 soil series (Turner, 1976). This data is summarized in Table 3 and discussed below.

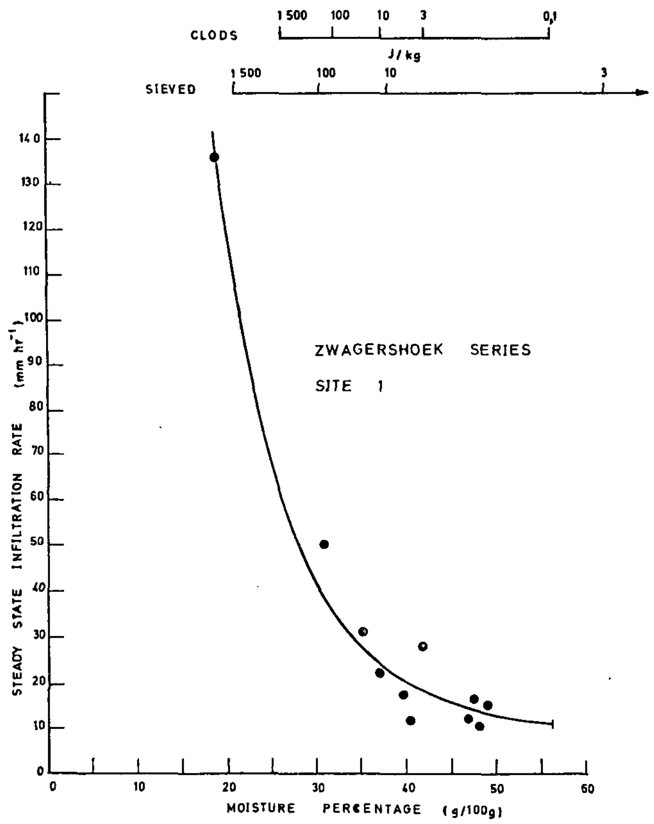

Figure 3
Steady state infiltration rate versus initial soil moisture content for a Zwagershoek series, Cedara. Site No. 1. Soil pressure potentials for clod and sieved soils are inset. Coefficients of variation of infiltration rate for individual points vary between 10 and 58 per cent.

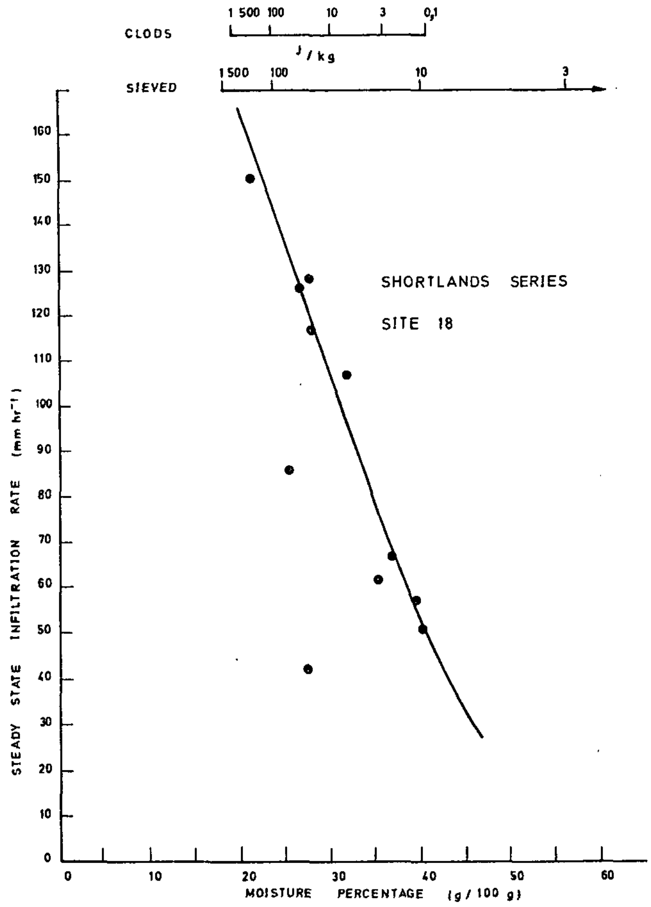

Figure 4
Steady state infiltration rate versus initial soil moisture content for a Shortlands series, Bayne's Drift, Site No. 1. Soil pressure potentials for clod and sieved soils are inset. Coefficients of variation of infiltration rate for individual points vary between 6 and 23 per cent.

Soil moisture retention curves determined from (i) undisturbed clods, (ii) < 2 mm sieved soil are inset (Figs. 3 & 4) to convey greater meaning in terms of the more fundamental water potential unit. The disparity between moisture retention curves determined for clods, and for sieved soils, in comparison to field measured moisture contents is obvious. It points to the unquestionable need to evaluate moisture retention curves from samples suitably reflecting field soil structural conditions. This need has apparently been fulfilled in the Zwagershoek series (Fig. 3) by the retention curve from undisturbed clods. However, the retention curve from sieved soils probably better reflects moisture retention in cultivated fields. This is demonstrated by the Shortlands series (Fig. 4) which had been cultivated to maize.

Very high infiltration rates were measured on a Zwagershoek series (Site 1) (Fig. 3) following a dry winter. Moisture content of the surface horizon was well below the – 1 500 J/kg potential value. This is especially significant in that high infiltration rates could be expected on this series (and those of similar morphology) following dry periods. It also points to the extent that desiccation may occur even though the topsoil contained 19 per cent moisture when the infiltration run was conducted.

Philip (1957c) demonstrated the importance of the initial boundary condition, namely initial moisture content in infiltration theory. However, numerical evaluation of parameters to this theory have not kept pace with the theoretical development itself. These theoretical findings of Philip (1957a, c, 1969) have been substantiated by the field observations of, amongst others, Tisdale (1951) and Gerard (1974). To bring clarity to the presentation of data it would seem appropriate to express field determined infiltration rates at selected values of initial soil moisture potential. This would be the only reasonable method of summarizing infiltration data and would also provide a very sound basis upon which a comparison of infiltration rates between soil series or sites subjected to various types of agricultural management could be made. Table 3 presents infiltration rates interpolated at five pressure potential values from plots of measured steady state infiltration rate against concurrently measured initial soil moisture content (Turner, 1976). For reference purposes gravimetric moisture contents are also quoted.

Table 3 is a comprehensive summary of infiltration data evaluated in this study. It is both simple in presentation to the agriculturist requiring infiltration data while being technically accurate in presenting the important influence of initial moisture content on infiltration.

Table 3 demonstrates the variability in infiltration data, even within soil series. In general, the soil series provides a very suitable key to assimilate soil information. However, in the case of highly variable infiltration data it must be concluded that a generalized steady state infiltration rate cannot, at this stage, be assigned to a soil series. It remains necessary to overcome the vexing problem of flow variability in soil water flow phenomena. Valuable research in this direction has been conducted by Nielsen, Biggar and Erh (1973) and by Dirksen (1975). However, infiltration data contained in Table 3 does give an indication of probable steady state infiltration rates. Used in conjunction with known soil physical and pedological properties it could certainly form the basis for first estimates of infiltration properties.

Physical and chemical parameters affecting measured infiltration rate

The question of predicting infiltration rates for various soil series, and particularly those standardized to a common soil moisture potential, now arises. The answer to this problem is by no means a simple one. Consider the steady infiltration of water into soil and the deep percolation of water from the lower soil horizons. The magnitude of the hydraulic conductivity (for simplicity assume saturated flow) is dependent in part on the pore geometry (their size and arrangement) and the stability of the soil matrix during flow. Intuitively physical, chemical and pedological factors can influence pore geometry, its stability and ultimately water movement. Various physical and chemical parameters were measured to establish a relation, if any, to infiltration. A multiple regression computer program (Rayner, 1976) was used to evaluate correlation coefficients between infiltration rate at – 10 J/kg initial soil moisture potential and the sand, silt and clay percentages, aggregate stability, bulk density, exchangeable cations including Na, K, Ca and Mg and organic carbon percentage for the surface and subsoil horizon for 23 sites. The resultant correlation coefficient (r) were all very poor indeed ($-0{,}15 < r < 0{,}15$). Scatter diagrams (data not presented here) plotted between infiltration rate and each of the above parameters confirmed these results. The scatter diagrams show no trends whatsoever. The poor correlation stems from the very large variability in infiltration rates arising from unmeasured or undefined limiting factors. Furthermore, soils are non-ideal, but rather dynamic bodies and are probably not suited to this type of analysis without an initial selection procedure.

Finally, it should be noted that infiltration rates quoted in Table 3 are those determined experimentally from a ponded water supply. It is the contention of the authors that these values are thus realistic for furrow and flood irrigation. Furthermore, the trend of decreasing infiltration rate with increasing initial moisture content can certainly be extended to infiltration via rainstorms or sprinkler irrigation. However, since these processes are controlled by surface supply rate, infiltration may be less than for a ponded surface. This arises, since during rainstorms or sprinkler irrigation altered theoretical boundary conditions apply (Rubin, 1966). In addition raindrop impact may alter surface structural conditions to initiate surface ponding and subsequent runoff at an earlier stage than would be expected if infiltration data were derived from ponded conditions. However, for sprinkler irrigation these lower rates could be taken into account during the design stage.

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