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INFILTRATION CHARACTERISTICS IN RELATION TO TILLAGE PRACTICES AND INITIAL MOISTURE IN SANDY LOAM SOIL

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Effect of tillage practices and initial soil moisture contents on infiltration rate and cumulative infiltration in sandy loam soil were studied and cumulative infiltration was predicted by using Kostiakov equation. The decrease in density values from 1.42 to 1.37 and 1.30 g cm^{-3}, at air dry moisture content, resulted in increase in infiltration rate considerably from18.76 cm $hour^{-1}$, to 22.53 and 30 43 cm $hour^{-1}$, respectively. With increase in initial moisture content both infiltration rate and cumulative infiltration showed decreasing trend. The predicted cumulative infiltration values were in good agreement with the corresponding observed values with deviation of 1 02 2.23 and 1.61 per cent in zero tillage, normal tillage and light compaction, respectively. The constants in Kostiakov equation relating to cumulative influx and infiltration rate were found out in different surface conditions at air dry moisture content.

The entry of water into soil is a time function and by nature a transient flow system dependent on soil physical conditions and antecedent moisture content. Infiltration rate is influenced by bulk density which is altered by cultivation or artificial compaction (Joshi and Das, 1977). It is recognised that more the infiltration, less the water and soil loss and more the availability of moisture in the soil for plant growth. The rate of water entry into the soil fluctuates widely between soil types and significant variation may be observed within a single soil type depending upon the antecedent moisture content and soil management practices employed (Parr and Bertrand, 1960). The object of this project is to study the infiltration process in sandy loam soil in relation to tillage practices and antecedent moisture content.

MATERIAL AND METHODS

The experiment was conducted during 1978 at the Central Campus Farm, Mahatma Phule Agricultural University, Rahuri. Soil texture was categorised as sandy loam containing 16 08, 33.96 and 49.96 percent clay, silt and sand, respectively. Organic corbon and $CaCO_3$ content were 0.41 and 3.42 per cent respectively. The mositure contents were 30.77, 18.87, 15.97 and 7.0 percent at 1/3 bar, 5 par 15 bar and air dry condition, respectively.

The experiment was laid out in split plot design with three main plot treatments (tillage) and four sub plot treatments (initial moisture content) replicated four times giving 48 plots. Each main treatment was superimposed with the sub-plot treatment of 4 initial soil moisture contents in a rando-

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miscd manner. Details of treatments are given in Table 1. Bulk density variation due to different tillage treatments were determined by taking core samples at 0-20 and 20-30 cm depth layer with the help of standard core sampler (Blake, 1965).

Infiltration rates were measured with the help of double ring infiltrometer having 30 and 60 cm diameter of inner and outer cylinders, respectively, with a height of 25 cm. A common irrigation of 8 cm was applied initially to all plots except control for confirming the sub-plot treatments. Soil moisture were determined daily by gravimetric method to find out the time for application of substeatments.

Infiltration rates were measured at different initial moistute contents for 180 minutes elapsed time till approximate steady infiltration rates occurred. The cumulative infiltration was predicted by using Kostiakov equation.

$$I = at^{\infty} + b \quad t=/=0 \quad \ldots\ldots\ldots 1$$

Where, I indicates the cumulative infiltration. (cm) in time t, t is the elapsed time (min), and a, ∞ and b are characteristic constants. These constants were evaluated as described by Michael *et al* (1978). The observed and predicted values of cumulative infiltration were compared to find out the deviation.

RESULTS AND DISCUSSION

Infiltration rate :

The infiltration rates as influenced by tillage practices and initial moisture contents for a period of 180 minutes elapsed time are presentad in Table 2. Infiltration rate of 30.43 cm hour^{-1} a 5 minutes elapsed time was maximum when the initial moisture content was 0.091 cm^3/cm^3 in normal tillage plots. This value of infiltration rate was reduced to 22.50 and 18.7 cm hours^{-1} in light compacted and control plots, respectively. The infiltration rate of 6.12 cm hour^{-1} after 180 minutes of elapsed time at air dry moisture content, in the normal tillage treatment was about 1.39 and 1.85 times greater than in light compaction and untilled plots, respectively. The results showed the similar trends at 1/3 bar 5 bar and 15 bar moisture contents under different tillage practices. The rate of infiltration occuring on a particular soil type may be varied between wide limits simply by changing tillage practices or by repeating the water application (Duley and Kelly, 1939). Mistry and Chatterjee (1965) reported that the rate of water intake was forest soils (26 cm hr^{-1}), having maximum amount of organic matter and also due to the lighter texture of soils followed by other upland soils under grassy vegetation (9-12 cm hr^{-1}), containing fairly a good amount of organic matter. Approximate steady infiltration rate of 5 85 cm hour^{-1} at initial moisture content of 0.39cm^3/cm^3 after 180 minutes elapsed time in normal tillage plots showed a declined trend (3 08 cm hour^{-1}) in light compaction and untilled plots (1.69 cm hour^{-1}).

Infiltration rate of 10.07 cm hour^{-1} in normal tillage plots at moisture content of 0.39 cm^3/cm^3, increased to 1.79, 2.24, 3.02 times, as the initial moisture decreased to 0.24 cm^3/

cm^3, 21 cm^3/cm^3 and 0.09 cm^3/cm^3 moisture contents, respectively. Infiltration rate at 0.42 cm^3/cm^3 moisture content in zero tillage plots at 5 minutes elapsed time was lowest to the extent of 6.06 cm $hour^{-1}$ and it was 3.10 times more at air dry moisture content of 0.09 cm^3/cm^3. Philip (1957) showed that at small time intervals after infiltration begins, increasing the initial moisture content reduces the infiltration rate but increases the velocity of the advance of the wetting front. Approximate steady infiltration rate of 6.12 cm $hour^{-1}$ after 180 minutes of elapsed time in normal tillage plots at air dry moisture content (M_0) was greatest with the values of infiltration rate of 5.85, 5.84 and 5.57 cm $hour^{-1}$ at M_1, M_2 and M_3 treatments, respectively. Similar trends were observed in light compaction and untilled plots at different initial moisture contents. Joshi and Das (1977) evaluated the effect of initial soil water content ranged from 0.02 to 0.08 cm^3/cm^3 and bulk density ranged from 1.5 to 1.6 g cm^{-3} on infiltration in an alluvial sandy loam soil and predicted on the basis of unsaturated flow theory of Philip. At any particular time with the increase in bulk density or initial moisture, the sorptivity decreased with a concomittant decrease in infiltration rate. Tisdale (1951) observed that lower the initial soil moisture content higher the infiltration rate. In the first few hours of an infiltration run, antecedent soil mosture was the major factor in determining the initial infiltration rate of the soil. The longer the time of water of application, the less effect antecedent soil moisture would have on infiltration rate.

Cumulative infiltration :

Influence of tillage treatments and initial moisture contents on cumulative infiltration as a function of time for a period of 180 minutes elapsed time are presented in Table 3. The cumulative infiltrations were greatly influenced due to manifestation of soil physical conditions on untilled plots by ploughing or light compaction. The cumulative infiltration of 6.41 cm after 25 minutes of elapsed time, at air dry moisture content (M_0) under ploughed plots was 1.41 and 1.70 times greater than light compacted plots and untilled plots, respectively. Cumulative infiltration 13.43 cm in zero tillage plots increased to 16.95 and 23.65 cm in light compaction and ploughed plots, respectively at air dry moisture content (M_0) after 180 minutes of elapsed time.

The cumulative infiltration values of 6.41, 4.55 and 3.76 cm after 25 minutes of elapsed time for normal tillage, light compaction and zero tillage plots at air dry initial moisture content (M_0) decreased to 3.11, 2.10 and 1.36 cm, respectively as initial moisture content increased to M_1. Similar trends were also observed in respect of cumulative infiltration in relation to initial moisture contents after 180 minutes of elapsed time.

Predicted cumulative infiltration :

Cumulative infiltration was predicted at air dry moisture content (M_0) and under different tillage con-

ditions and compared with observed values. The values of a, ∞ and b in Kostiakov equation under different tillage treatments were worked out using equation 1 and are given as below:

$$I_{T_0} = 0.3162\ t^{0.71} + 0.61 \quad \ldots\ldots 2$$
$$I_{T_1} = 0.5888\ t^{0.70} + 0.83 \quad \ldots\ldots 3$$
$$I_{T_2} = 0.3802\ t^{0.73} + 0.68 \quad \ldots\ldots 4$$

The parametter 'a' represents the amount of infiltration during the initial time of interval and showed decreasing trend with the increasing bulk density. Normal tillage practices having bulk density 1.30 g cm^{-3} exhibited 0 5888 constant value of 'a' and subsequently decreased to 0 3162 as the bulk density in zero tillage changed to 0.42g cm^{-3}. A constant ∞ indicates infiltration rate decrease with time which depends upon changes in soil moisture conditions. Average deviation of 2.23 per cent from observed values in normal tillage plots was higher than light compaction (1 61%) and zero tillage plots (1.02%). The constants evaluated after exhaustive sampling and observations can be utilized for estimating or predicting cumulative infiltrations as a function of time in a sandy loam soil.

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Table 1 Description of tillage (main plots) and initial moisture content (sub-plots) treatments of the field experiment.

Treatment symbol	Treatment abbreviation	Treatments details
	Main plot treatments (tillage)	
T_0	Zero tillage	Weeds were removed and beds were prepared. The bulk density was 1.42 g cm^{-3}.
T_1	Normal tillage	Ploughing with tractor drawn mould board plough up to a depth of 20 cm followed by 2 harrowings by animal drawn wooden harrow. The bulk density was 1.30 g cm^{-3}.
T_2	Light compaction	After the application of T_1, the soil was compacted uniformly by wooden harrow beam twice. The bulk density was 1 37 g cm^{-3}.
	Sub plot treatments (initial moisture content)	
M_0	7 0%	Soil moisture was determined gravimetrically every day and soil water pressure was calibrated from moisture retention characteristic.
M_1	30.77%	
M_2	18.87%	
M_3	15.97%	

Table 2. Infiltration rate as influenced by tillage practices at different initial moisture contents in sandy loam soil.

Time elapsed (Minutes)	Infiltration rate, cm hour^{-1}											
	Zero tillage (T_0)				Normal tillage (T_1)				Light compaction (T_2)			
	M_0	M_1	M_2	M_3	M_0	M_1	M_2	M_3	M_0	M_1	M_2	M_3
5	18.76	6.06	10.83	12.78	30.43	10.07	18 08	22.55	22.53	8 57	13.24	17.15
10	8.41	2.96	4.70	5.84	15.34	7.37	8.97	10.53	10.47	4.63	7.02	8.41
15	6.73	2.61	3.95	5.02	11.62	6.77	7.57	8.71	8 75	4.08	5.88	7.05
25	5.61	2.31	3.64	4.39	9.77	6.55	7.31	7.93	6.43	3.97	5.28	5.84
35	4.91	2.19	3.28	4.08	8.39	6.44	7.12	7.55	5.98	3.82	4.62	5.08
45	4.53	2.11	3.02	3.88	7.47	6.30	6.82	7·27	5.61	3.54	4.26	4.79
60	4.22	2.13	2.90	3.53	7.17	6.25	6.73	6.91	5.19	3.34	4.14	4.71
75	3.95	2.02	2.78	3.32	6.89	6.12	6.60	6 57	5.06	3 26	3.96	4.54
90	3.73	1.97	2.68	3.21	6.68	5.99	6.40	6.27	4.84	3.20	3.8	4.43
110	3.56	1.93	2.61	3.09	6.50	6.00	6.19	6 00	4 62	3.17	3.65	4.38
130	3 47	1.83	2.54	2 98	6.37	5.91	6 05	5.80	4.50	3.09	3.58	4.28
150	3.37	1.73	2.45	2.90	6.22	5.90	5.98	5.65	4.44	3.06	3 51	4.19
180	3.31	1 69	2.40	2.82	6 12	5.85	5.84	5.57	4.38	3 08	3.47	4 12

Table 3. Cumulative infiltration as influenced by tillage practices at different initial moisture contents in sandy loam soil.

Time elapsed (Minutes)	Cumulative infiltration, cm											
	Zero tillage (T_0)				Normal tillage (T_1)				Light compaction (T_2)			
	M_0	M_1	M_2	M_3	M_0	M_1	M_2	M_3	M_0	M_1	M_2	M_3
5	1.57	0.51	0.91	1.07	2.54	0.84	1.51	1.88	1.88	0.72	1.11	1.43
10	2.27	0.76	1.30	1.56	3.82	1.46	2.26	2.76	2.75	1.10	1.69	2.13
15	2.83	0.97	1.63	1.97	4.79	2.32	2.88	3.48	3.48	1.44	2.18	2.72
25	3.76	1.36	2.23	2.70	6.41	3.11	4.10	4.80	4.55	2.10	3.06	3.69
35	4.58	1.72	2.78	3.38	7.81	4.18	5.27	6.06	5.55	2.74	3.83	4.54
45	5.33	2.07	3.28	4.03	9.06	5.23	6.41	7.27	6.48	3.33	4.54	5.34
60	6.39	2.60	4.00	4.91	10.84	6.80	8.09	9.00	7.78	4.16	5.57	6.51
75	7.38	3.11	4.70	5.74	12.56	8.33	9.74	10.64	9.04	4.78	6.56	7.65
90	8.31	3.60	5.37	6.54	14.23	9.82	11.34	12.20	10.25	5.78	7.51	8.75
110	9.50	4.24	6.24	7.57	16.15	11.82	13.40	14.20	11.79	6.83	8.75	10.21
130	10.65	4.85	7.08	8.56	18.52	13.80	15.42	16.14	13.29	7.87	9.92	11.63
150	11.77	5.43	7.90	9.53	20.59	15.77	17.41	18.02	14.77	8.89	11.09	13.02
180	13.43	6.27	9.10	10.94	23.65	18.69	20.33	20.80	16.95	10.42	12.83	15.08