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CONTENTS

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F. L. DULEY AND L. L. KELLY [2]

In connection with investigations of runoff and erosion in the Great Plains an attempt has been made by means of artificial applications of water to determine certain principles concerning the effect of different soils and soil conditions on runoff and soil erosion. Such information is needed in planning all field operations dealing with soil erosion and moisture control. It is also needed in connection with watershed studies that are being established in the Central Great Plains, dealing with runoff and flood flows from larger areas. The method employed makes it possible to obtain comparable data on a wide range of soil types, slopes, and surface conditions, and with different rates of water application. The purpose of this paper is to give a brief description of the methods used and a condensed report of the results obtained during the first season's operation.

EQUIPMENT AND METHODS

For conducting these tests, there was constructed a sprinkling apparatus similar to that developed by the Soil Conservation Service personnel for the Colorado Springs, Colorado, project. The essential parts of this equipment consisted of an overhead supply pipe about 6 feet above the ground provided with fan-shaped garden-sprinkler nozzles directed downward as shown in Figure 1. These gave a reasonably even distribution of water over the plot when the pipe carrying the nozzles was oscillated through an arc of about 60°. The streams of water were broken into droplets and seemed to give much the effect of natural rainfall. The falling drops of water were protected from the wind by canvas as shown in Figure 2. The water supply was provided by means of a 1,000-gallon pressure tank mounted on a trailer and by a 750-gallon supply tank mounted on a truck. Water was forced from these tanks to a small constant-level tank placed at the upper end of the test plot; this gave a water pressure head of about two feet.

The amount of water applied to the plot was measured through a special water meter which could be read to 0.1 cubic foot. Frequent readings of this meter made it possible to have a continual record of the rate of application. The water used was from the nearby city water supply.

The plots used in these tests were 6.6 x 33 ft. or 1/200 acre. The plot was surrounded by an iron or wood border set in the ground to a depth

[1] Contribution from the Soil Conservation Service, United States Department of Agriculture, and the Nebraska Agricultural Experiment Station cooperating. Published with the approval of the Chief of Research, Soil Conservation Service, and the Director of the Nebraska Agricultural Experiment Station, Lincoln, Nebraska.

[2] Senior Soil Conservationist and Assistant Agricultural Engineer, Soil Conservation Service, Division of Research. Acknowledgment is hereby made of contributions to this project by R. R. Drake, M. G. Santi, and G. C. Conners, Division of Research, Soil Conservation Service, and to J. C. Russel, cooperative agent, for suggestions on the project and assistance in preparing the manuscript.

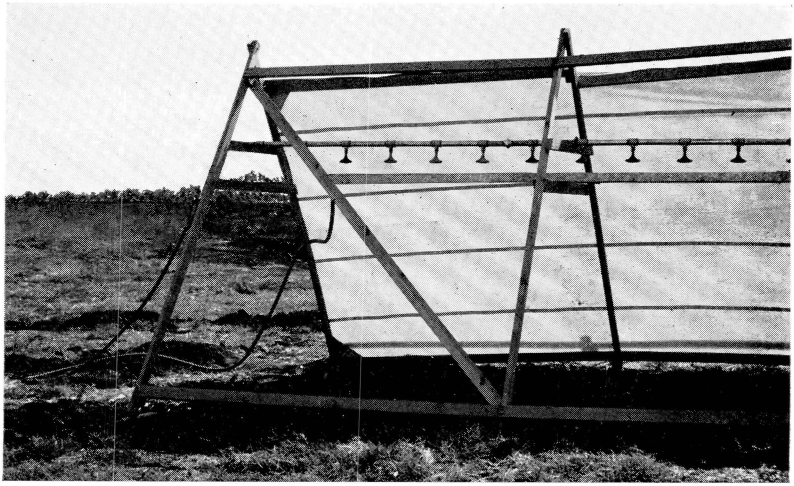

FIG. 1.—Pipe carrying sprinkler nozzles shown supported by wood frame work. This was later replaced by iron frames.

of 6 inches and extending 3 inches above the surface. Water falling outside the plot was collected by means of gutters and was measured so that the actual rate of application to the plot could be determined. The soil outside the plot boundaries was not wetted during the test. There was, of course, a certain amount of lateral movement of water in the subsoil beyond the plot boundaries.

The amount of runoff was measured in a two-compartment metal tank calibrated in 0.001 inch of runoff from the plot area. It was possible by the use of this tank to secure a representative sample for determination

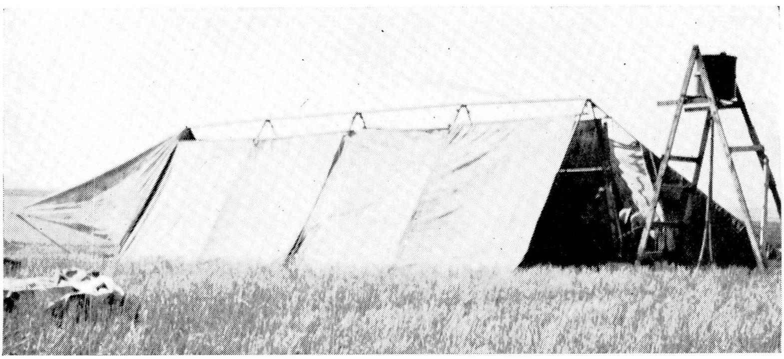

FIG. 2.—The application of water was protected from wind movements by a canvas cover.

of suspended material from one compartment, which held 0.05 inch of runoff, while the other similar compartment was filling. The time necessary for filling each compartment was determined by the use of a stop watch, thus making it possible to obtain practically a continuous record of the runoff and also to determine at very short intervals the rate of erosion.

FIG. 3.—View showing surface condition of cultivated plots.

Four different types of soil were included in the first group of tests made with this equipment. Later five additional types were studied. The first tests were designed to give information on at least three different degrees of slope with two rates of water application made on two successive days. All possible combinations of the two rates of application and three slopes were used. In a few cases additional slopes were included. The variation in slope was obtained by placing the plots at different angles on the hillside, similar to the plan used by Duley and Hays.[3] This group of tests was made on plots that were first cleared of excessive debris, leveled crosswise, spaded to a depth of six inches, and worked down by hoeing, raking, and leveling until they were in about the condition of a firm garden bed. Very few clods left on the surface were larger than one inch in diameter as shown in Figure 3. This condition was used primarily because it could be approximately duplicated on the different soil types. A few tests were made on land with different crops, but this phase of the

[3] F. L. Duley and O. E. Hays, The effect of the degree of slope on runoff and soil erosion, Jour. Agr. Research 45:349-60 (1932).

work was not carried out extensively since there is already a considerable amount of information on the effect of different crops on runoff and erosion.

As these investigations progressed, the emphasis was shifted somewhat; less time was given to the effect on intake of such factors as slope and rainfall intensity and more time was devoted to a study of surface condition as one of the chief factors governing the rate and amount of intake of water by soils. The intake of water when the surface soil was protected by straw, combine wheat stubble, or burlap was compared with the intake on bare cultivated soils. Special tests were made on certain plots to determine the effect on the infiltration rates of a number of repeated runs on the same plot.

These latter studies led into the question of a consideration of the effect of different horizons in the soil profiles on the rate and amount of water intake. Special attention was given to soils having heavy clay subsoils in comparison with other types having uniform, medium-textured subsoils, and with still others having uniform sandy subsoils.

RELATION OF SOIL TYPE TO TOTAL INTAKE AND INFILTRATION RATE

One of the first considerations in this investigation was to determine the effect of soil type on the amount of water the soil will absorb and the rate of intake throughout the period of application. It was desired to determine whether soils differ sufficiently in this respect so that the rate of intake might eventually be used as a more or less definite characteristic of a given soil. If this were true, it should then be possible to arrange a group of soils in a definite order with respect to their capacity

TABLE 1.—*Effect of soil type on total intake of water and infiltration rates on bare cultivated soil with a slope of 4 per cent.*

Soil type	Total intake water in 90 minutes		Infiltration rate at end 90 minutes	
	First day	Second day	First test	Second test
	In.	*In.*	*In. per hr.*	*In. per hr.*
Pawnee clay loam	1.20	0.76	0.50	0.33
Lancaster sandy loam	1.71	0.61	0.68	0.32
Knox silt loam—Blair, Nebr.	1.05	0.58	0.38	0.21
Butler silt loam	1.32	0.57	0.38	0.25
Dickinson sandy loam	1.37	0.48	0.40	0.24
Marshall silt loam. Eroded phase—Ralston, Nebr.	1.08	0.43	0.42	0.21
Marshall silt loam—heavy subsoil (A-slope)	2.43	0.38	0.28	0.21
Butler silty clay loam	1.24	0.37	0.30	0.16
Marshall silt loam. Heavy subsoil (C-slope)	1.07	0.37	0.41	0.17
Mean	1.39	0.51	0.42	0.23

to absorb water from rainfall. During the season of 1938, tests were made on nine different soil types or subtypes which had a rather wide range in surface texture and profile characteristics. These tests so far have been confined to soils found in eastern or southeastern Nebraska where they have developed under conditions of 28 to 31 inches of mean annual rainfall. They have included loessial, glacial, and residual soils. The surface soils have included clay loams, silty clay loams, silt loams, and sandy loams. The subsoils vary from deep, uniform sandy materials and uniform silty subsoils to heavy clay and claypan subsoils.

The amounts of water absorbed by these different soils are given in Table 1. The results shown are for bare cultivated soils on a 4 per cent slope for a 1½-hour period of application. After this water had been applied the plots were allowed to stand until the following day when a second application of water was made.

It will be noted that during the test period on the first day the amount of intake of water by these different soils varied from 1.05 to 2.43 inches. The high reading of 2.43 inches for the heavy-subsoil Marshall silt loam (A slope) was due to the fact that it was extremely dry when the first test was made.

On the second day, as shown in Column 2, the amount of water absorbed was much less than on the first day and varied between 0.37 and 0.76 inch. Between these extremes are to be found the results from both silty-clay and sandy-loam surface soils and also uniform sandy subsoils as well as claypan subsoils.

The amount of water absorbed during the first application does not show sufficient variation between the different soils to make it possible to classify them on the basis of intake capacity. This is particularly true in view of the fact that the second day's run did not place them in the same order as during the first day. In spite of a wide range in soil characteristics there appeared to be relatively small differences in the amount of water intake. The most striking thing about these results, therefore, seems to be their similarity rather than their differences.

When water falls on bare cultivated soil it may enter the surface at a relatively rapid rate at first and then the rate of intake decreases and finally becomes fairly constant over a considerable time if the application of water is continued. It was found in these tests that in most cases infiltration rates became essentially constant on cultivated soils within the 1.5-hour period of application. These essentially constant rates of intake are shown in Columns 3 and 4 of Table 1, for the first and the second day's tests respectively. Column 3 shows that the infiltration rate tended to become constant during the first day's test at a somewhat higher level than during the second test. The striking thing to be noted here, however, is that the variation from the mean in the infiltration rate between the different soils was not greater than 0.26 inch per hour during the first test and not greater than 0.10 inch per hour during the second test. Even though the final infiltration rate of the Pawnee clay loam was double

TABLE 2.—*Effect of hourly rate of water application and degree of slope on the amount of intake and rate of infiltration on bare cultivated soils (length of application 90 minutes).*

Soil type	Light rate of application (approx. 1.5″ per hr.)								Heavy rate of application (approx. 3″ per hr.)									
	First test—slope				Second day—slope				First test—slope					Second day—slope				
	2%	4%	6%	10%	2%	4%	6%	10%	0.6%	2%	4%	6%	10%	0.6%	2%	4%	6%	10%
TOTAL INTAKE—SURFACE INCHES																		
Marshall silt loam, heavy-subsoil phase (C slope)	0.84	0.81	1.69	...	0.34	0.52	0.39	...	...	1.23	0.99	0.87	...	...	0.32	0.45	0.20	...
Butler silt loam	1.65	1.26	1.46	...	0.64	0.62	0.61		...	0.94		1.27		...	0.41	...	0.59	...
Marshall silt loam—eroded phase	1.15	0.99	0.94	0.91	0.48	0.47	0.38	0.35	...	1.57	0.91	0.92	0.68	...	0.70	0.15	0.41	0.13
Knox silt loam	1.18	0.98	0.79	0.98	0.63	0.51	0.48	0.42	1.80	1.41	0.95	1.01	1.03	0.85	0.85	0.54	0.47	0.47
RELATIVE TOTAL INTAKE																		
Marshall silt loam, heavy-subsoil phase (C slope)	100	96	201	...	100	153	115	...	...	100	81	71	...	...	100	141	63	...
Butler silt loam	100	76	88	...	100	97	95		...	100		135	...	...	100	...	144	...
Marshall silt loam—eroded phase	100	86	82	79	100	98	79	73	...	100	58	59	43	...	100	21	59	19
Knox silt loam	100	83	67	83	100	81	76	67	128	100	67	72	73	...	100	64	55	55
INFILTRATION RATES—INCHES PER HOUR																		
Marshall silt loam, heavy-subsoil phase (C slope)	0.39	0.24	0.72	...	0.18	0.22	0.14	...	...	0.37	0.37	0.35	...	...	0.14	0.23	0.11	...
Butler silt loam	0.69	0.50	0.42	...	0.31	0.19	0.23		...	0.25		0.38		...		...	0.26	...
Marshall silt loam—eroded phase	0.77	0.33	0.32	0.30	0.14	0.19	0.10	0.15	...	0.55	0.15	0.39	0.28		0.35		0.22	0.05
Knox silt loam	0.45	0.38	0.25	0.42	0.23	0.20	0.10	0.17	0.52	0.55	0.40	0.21	0.46	0.31	0.36	0.20	0.19	0.17
RELATIVE INFILTRATION RATES																		
Marshall silt loam, heavy-subsoil phase (C slope)	100	62	185	...	100	122	78	...	...	100	100	95	...	...	100	164	79	...
Butler silt loam	100	72	61	...	100	61	74	...	...	100	...	152	...	...	100	...	...	...
Marshall silt loam—eroded phase	100	43	42	39	100	136	71	107	...	100	27	71	51	...	100	...	63	14
Knox silt loam	100	84	56	93	100	87	43	74	95	100	77	38	84		100	55	53	47

that of the Butler silty clay loam, the actual difference was only 0.17 inch per hour, which would probably have little significance under ordinary rainfall conditions.

The infiltration rate on all soils on the second day was found to be decidedly less than on the first day. The infiltration rate determined for a given soil was approximately constant only so long as water was applied continuously and was definitely altered in magnitude where a soil had stood in a wet condition.

As in the case of the total intake, it seems that the rather wide differences in soil characteristics have not resulted in any very great differences in the rate of infiltration of water into the soil.

EFFECT OF SLOPE

On four of the soils tested, different slopes and different rates of application were used. The results for total intake and the final or nearly constant rates of infiltration are shown in Table 2.

It will be noted that there is a tendency for the amount of intake to decrease slightly with increase of slope. The greatest intake was found on the more gentle slopes, particularly the 2 per cent slope or less. That the degree of slope has only a slight effect on infiltration is in line with earlier investigations.[4]

RATE OF APPLICATION

The data in Table 2 afford a number of comparisons between rates of approximately 1.5 and 3 inches per hour, as affecting total intake and infiltration rates on four different cultivated bare soils and with three or more slopes on each of these soils. No significant differences due to rate of application were found in either the total intake or in the final rate of infiltration. When the rate of application was sufficient to give runoff, a fairly definite amount of water entered the soil and any amount of application in excess of this appeared in the runoff.

CONTINUOUS AND INTERMITTENT APPLICATIONS

Where water was applied continuously to a soil, the rate of infiltration decreased rapidly at first and then very slowly, and gradually approached a constant for a given condition. In one test carried on almost continuously for 23 hours, the rate of intake dropped from more than 5 inches per hour at the beginning of the test to approximately 0.5 inch per hour after 15 hours and remained at almost exactly this point for a period of 8 hours before the application was stopped.

In practically all cases, however, if the application of water was stopped for a period of a few minutes, a few hours, or a day, there was still further reduction in the infiltration rate. Where plots were allowed to stand for

[4] F. L. Duley and O. E. Hays (see footnote 3). Jesse H. Neal, The effect of the degree of slope and rainfall characteristics on runoff and soil erosion, Missouri Agr. Exp. Sta. Res. Bul. 280 (1938). R. E. Horton, Surface runoff control, Upstream Engineering Conference, pp. 16-49, Washington, D. C. (1936).

several days or a week and then another application of water given, the infiltration rate usually approached a constant higher than the infiltration rate at the end of the previous application. A typical graph in one test, A, Figure 4, illustrates such variation in the infiltration rates for a plot covered with combined wheat stubble when tested on different dates. It will be noted in this figure that on certain days several different declining rates were obtained by stopping the application and then starting again

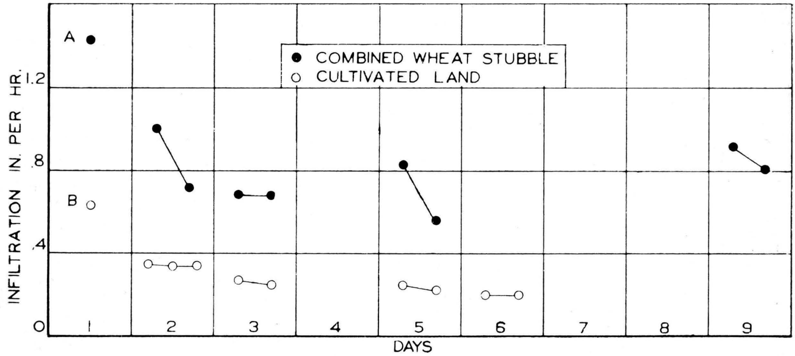

FIG. 4.—Infiltration rates determined at successive applications over a period of several days. Intervals between determinations on same day were about 30 minutes. A= Marshall silt loam—heavy subsoil (A-slope). B=Knox silt loam.

shortly after runoff ceased. It will also be noted that when the plot stood two or four days the constant infiltration rate was at first higher than at the end of the previous application, but dropped sharply when the application was stopped for a short time and then resumed.

A second graph, B, Figure 4, shows that if the application of water was repeated on a cultivated plot at short intervals the infiltration rate dropped materially below the approximately constant rate at the first test. This curve shows the change in infiltration rate during 10 successive runs on a cultivated Knox silt loam. In this case the infiltration rate dropped from 0.63 inch per hour at the end of the first test to 0.20 inch per hour at the tenth test.

EFFECT OF CROP RESIDUES ON INTAKE OF WATER

During the progress of tests on cultivated plots of four soil types, with different slopes and different rates of application, it became increasingly clear that these factors were exerting only a minor influence on the intake of water. The need for measuring other factors became very apparent. Another project was in progress at this station to determine the effect of crop residues in the conservation of water by reducing runoff and evaporation. This involved the need for more information on the specific effect of such residues on runoff. Accordingly, a test was made with a plot of Knox silt loam covered with wheat straw at the rate of 2.5 tons per acre, which is just enough to hide most of the ground. The effect of this straw cover on the total intake of water and on the infiltration rate was so great that this feature of the investigation came to dominate later tests.

Table 3 shows the effects of straw mulch compared with bare surface on the total amount of water absorbed and the final infiltration rates for six soil types. It will be noted that when the surface of the soil was thus protected, the total intake of water by each soil was much higher than on the bare plot. The infiltration rates were high also and remained at relatively

TABLE 3.—*Comparison of straw mulch and cultivated bare surface on the intake on different soil types.*[1]

Soil type	Character of subsoil	Treatment	Duration of application [2]	Total water applied	Total intake	Infiltration rate at end of application
			Hrs.	*In.*	*In.*	*In. per hr.*
Lancaster sandy loam	Sandy, uniform	Straw	12.8	45.83	28.89	0.92
		Cultivated	4.7	8.09	3.48	0.32
Knox silt loam	Silty, uniform	Straw	15.9	28.52	24.58	0.98
		Cultivated [3]	9.3	13.85	5.90	0.25
Marshall silt loam —heavy subsoil phase (A-slope)	Silty clay	Straw	14.0	28.39	24.46	1.20
		Cultivated	9.6	15.33	6.27	0.21
Butler silty clay loam	Claypan	Straw	13.5	41.14	21.89	0.50
		Cultivated	7.0	12.47	2.74	0.15
Pawnee clay loam	Claypan	Straw	10.6	34.31	20.17	0.38
		Cultivated	7.0	10.93	4.85	0.29
Dickinson sandy loam	Silty clay	Straw	6.5	20.29	11.12	0.48
		Cultivated	4.0	7.01	2.23	0.24
Average straw			12.21	33.08	21.85	0.74
Average cultivated			6.92	11.28	4.25	0.24

[1] These plots of mulched and cultivated land are not directly comparable so far as time of application is concerned, but water was applied on each plot until the rate of infiltration became essentially constant.

[2] Water applied during several hours on two or three successive days.

[3] These results from a plot with only an 0.85 per cent slope. All other plots reported in this table were on 4 per cent slopes.

high levels throughout long periods of application. On the other hand, on all bare cultivated soils the total intake of water by the soil was relatively low and the infiltration rates dropped rapidly and to much lower points. It was also noted where straw was applied that practically no soil was lost in the runoff.

As Table 3 indicates, there was a wide range in the texture of surface soils and the character of the subsoils among the different soils tested. The general effect of straw was to raise the level of total absorption and rate of infiltration on all soil types. While it is true that the infiltration rates of the soils having extremely heavy clay subsoils were finally reduced to lower levels than in the case of soils with more open subsoils, the total amount of water absorbed by any one of these soils was far in excess of any ordinary rainfall. This would indicate that the subsoil has not been an important factor in the reduction of intake, at least until an amount of water has been absorbed which is greater than is likely to fall under the climatic conditions of Nebraska.

EFFECT OF CROP COVER

Owing to the fact that many earlier experiments have shown the effect of crop cover in reducing runoff, and therefore increasing intake of water on land, only a limited amount of work was done on this point

TABLE 4.—*Effect of different crops in comparison with cultivated soils on rate of water intake—90 minutes after beginning application.*

Crop cover	Rate of intake at end 90 min.
	In. per hour
MARSHALL SILT LOAM, ERODED	
Alfalfa	1.34
Oats	0.82
None, cultivated	0.30
MARSHALL SILT LOAM, HEAVY SUBSOIL, A-SLOPE	
Native sod	3.30
Straw cover, 2.5 T.	3.50
Sod, clipped	0.65
None, cultivated	0.49

in these studies. A few tests were made on an eroded Marshall silt loam in eastern Nebraska and on a heavy-subsoil Marshall near Lincoln. Table 4 gives the rate of infiltration of water at the end of a 90-minute period of application. It will be seen that the alfalfa gave a higher infiltration rate than the oats, probably somewhat in proportion to the density of ground cover. The native sod took in water at about the same rate as the land covered with straw. Where the grass was clipped close to the ground and the surface litter removed, the infiltration rate dropped almost as low as on cultivated land. The fact that the soil still contained the grass roots did not cause it to absorb water rapidly.

EFFECT OF COMPACT SURFACE LAYER

The extremely low and relatively uniform amounts of water absorbed on the bare culivated land by the different soils would indicate that in these cases the reduction in the infiltration rate must have been due to surface phenomena.

Studies now in progress have led to the conclusion that the principal factor affecting the intake of water is the condition of the immediate soil surface. The thing which reduces the infiltration rate on cultivated land appears to be the development of a compact layer often only a few millimeters thick on the surface of the soil which does not permit rapid penetration of water. An idea of the compact structure of this layer may be obtained from Figure 5. The general effect of this phenomenon has been observed by many investigators and was especially pointed out by Lowdermilk.[5] However, the practical importance of this layer in relation to runoff control has not had sufficient consideration.

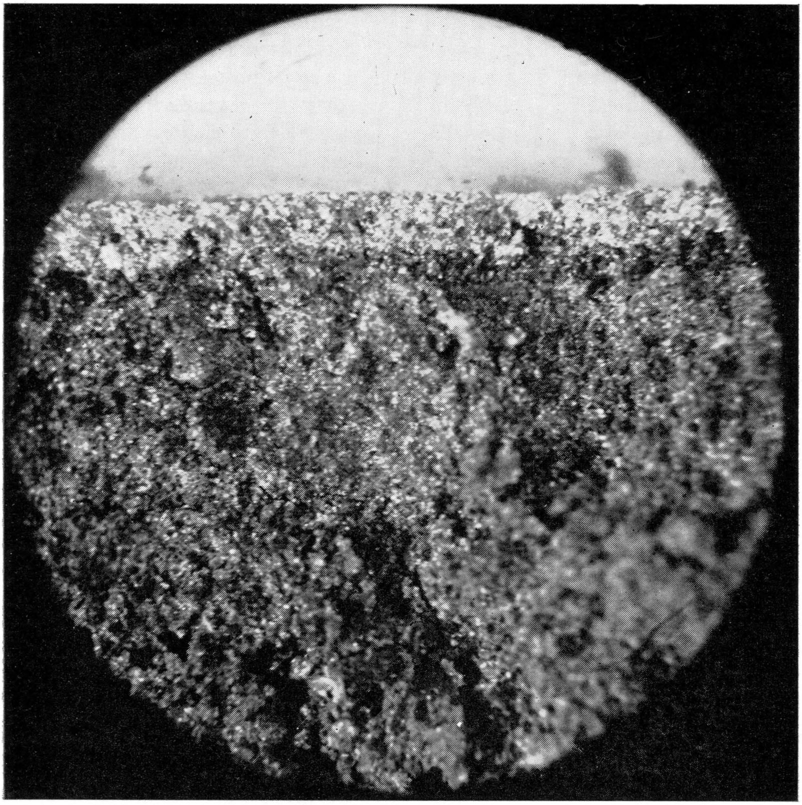

FIG. 5.—Photomicrograph showing condensed layer approximately 3 mm. thick formed on the surface of cultivated soil due to sprinkling and to flow of runoff water. Note that the large, open spaces present in lower part of picture are absent in surface crust. Water penetration is necessarily slow through this surface layer. Therefore, the infiltration capacity of the entire soil profile may be limited by the rate at which water can pass through this thin semi-pervious surface layer. Magnified about 4 diameters.

This compact layer appears to be formed through an alteration of the structure at the surface by the impact of rain and by further assortment of particles and the wedging and fitting of these into close formation by

[5] W. C. Lowdermilk, Influence of forest litter on runoff, percolation and erosion, Jour. Forestry 28:474-91 (1930).

running water, all of which slows down the entrance of water through the immediate surface. During this process some very fine material and organic matter may be carried away in the runoff water. Consequently, infiltration was slow and runoff high whenever this condensed layer developed on the surface. This compacted layer has developed on cultivated land of all soil types tested and has brought their infiltration rates almost to a common level. On the other hand, it did not develop to the same degree nor as quickly on any of the soils where the surface was protected with a dense growing crop or by crop residue. All soils so protected permitted a high intake of water over an extended period, even though they finally showed a greatly reduced infiltration rate. Some of this reduction may have been due to other physical changes in the lower part of the soil, as the result of protracted wetting.

These results indicate strongly, however, that the development of a condensed layer on the surface of cultivated bare soil has far greater effect on the intake of water than differences in soil type, degree of slope, previous moisture content of the soil, or the rate of the rainfall. In fact, in these tests it seemed to have a greater effect than all these other factors combined.

GENERAL APPLICATIONS

The results of this study sugggest the practicability of leaving organic materials or crop residues on top of the ground whenever possible to reduce runoff and erosion, and to retain more water in the soil for the use of the next crop. This method should be particularly applicable in regions of limited precipitation as a means of utilizing a higher percentage of the rainfall. In regions of higher rainfall this covering of debris should also be of great value in the control of erosion, but care will need to be taken under such conditions in order that the mulch may not prevent drying of the soil at a time when this would be necessary for optimum crop conditions.

It appears from these results obtained in eastern Nebraska that in the planning of soil and crop management programs in this territory special attention should be given to methods of protecting the soil surface whenever possible with densely growing crops or crop residues in order to obtain the maximum intake of water and reduce runoff. It seems practical to recognize that a cover of vegetation or plant debris not only has a mechanical effect in reducing erosion by either wind or water, but also maintains the perviousness of the soil at the immediate surface, which is highly essential for effective intake. Land thus protected should be given careful consideration in comparison with cultivated land when one is estimating the amount of flood water that is likely to come from any given watershed.

The tendency of cultivated bare soils to develop a more or less impervious surficial layer when exposed to the action of beating rain and runoff water can probably be counteracted to a degree by tillage methods that leave the surface rough, or ridged on the contour. However, any protracted wet spell or rain that produces runoff will definitely lower the rate of infiltration on exposed soils. Avoiding the ill effects of this thin dense layer at the surface on cultivated land appears, from these results, to be one of the most important practical considerations in the whole problem of runoff control.

From the limited amount of information available on this subject at the present time, protecting the surface either by crops or crop residues would seem to be a more effective method of insuring a high intake of water than any system of cultivation which leaves the bare soil surface exposed a large part of the time.

SUMMARY

Applications of water were made to soils by sprinkling 1/200 acre plots. Determinations of infiltration and runoff rates were made on different soil types found in eastern Nebraska. The effects of different degrees of slope and rates of application of water, as well as the initial soil moisture content, were also determined.

The water was applied with an overhead oscillating sprinkling device equipped with fan-shaped nozzles. A constant water head was maintained by pumping from a large supply tank into a smaller, elevated, constant-level tank.

The rate of application was determined by the use of a special water meter and the amount of runoff was measured in a two-compartment tank calibrated to 0.001 inch of runoff from the plot area. The time required for a given amount of runoff to take place was read on a stop watch. It was possible from these data to establish rate curves for both runoff and infiltration.

The rate of intake of water at the beginning of application was often very high. This resulted in a large total intake during the first part of each period of application. This rate decreased rapidly at first, finally reaching an approximately constant infiltration rate.

The total intake of water and also the final infiltration rates on cultivated bare land showed much less variation among the different soil types than was anticipated. In spite of the fact that the soils tested varied greatly in the texture of the surface soil and in profile characteristics, the amount of water taken in during a given time was strikingly similar for all soils and the infiltration rates were finally reduced almost to a common level. Even sandy soils closed up until infiltration was very slow.

The amount of total intake and the infiltration rate decreased slightly with increase in slope. However, this change in infiltration rate is very small and very gradual with changes in slope above about two per cent.

There seemed to be no consistent or significant difference in the rate of infiltration due to difference in the rate of application of water when the rate of application materially exceeded the rate of intake.

With continuous application of water the rate of infiltration gradually decreased to a point where it became essentially, but not absolutely, constant.

A plot which received water and was then allowed to stand for even a few minutes, a few hours, or a day's time showed a sharp decrease in the infiltration rate. However, upon standing for several days or a week and then having another application of water made, the infiltration rate approached a constant which usually was higher than the infiltration rate at the end of the previous application period. This rate was again reduced after the plot had again stood in a wet condition.

Soils covered with a crop gave a much higher rate of intake of water than bare soils and they maintained this higher infiltration rate throughout the most extended tests. The more dense crops like native sod and alfalfa gave the highest infiltration rates and these high rates were maintained throughout the longest period. Sod land with grass clipped close and surface debris removed gave a rate only a little above bare cultivated soil.

Soil covered with crop residue such as straw or other organic material gave an infiltration rate similar to or possibly higher than that obtained when the soil was protected by a dense growing crop. The total intake of water when the soil was thus protected was very great on all the soil types tested and the high rate of intake was maintained over an extended period. In fact it was sufficient to take care of an amount of water greater than that likely to be received during any rainfall period in Nebraska.

These results indicate that the rate of infiltration taking place on any soil type may be varied between wide limits simply by changing the surface tillage, crop, or crop residue, or by repeating the application of water. This makes it difficult to arrive at any figure that might be used as an infiltration rate characteristic of any given soil. There may be far greater variation between the rates obtained under different surface conditions on a single soil than would be shown by different soils having the same surface conditions. This may make it necessary to think of infiltration rates characteristic of surface conditions rather than of different soils.

Claypan soils like the Pawnee clay loam and Butler silty clay loam absorbed large quantities of water within a short period of time whenever the surface was protected by means of a straw mulch. This would indicate that the heavy layers in these subsoils probably did not retard infiltration to such an extent that they would likely have any appreciable effect on runoff under climatic conditions prevailing in Nebraska.

The breaking down of soil structure, by the compacting effect of the rain and the assorting and rearranging of the soil particles by running water forming a compacted layer at the immediate surface, appears to be the principal reason for the low infiltration rates on cultivated land. The formation of this semi-pervious layer, often only a few millimeters thick, was largely prevented by a covering of straw or by a growing crop.

The rate of infiltration remained at a relatively high level for a considerable period on the various soils when the surface was kept open by means of dense crop or crop residue. On bare soils the infiltration rate was reduced to a very low point and tended to approach approximately a common level on all the soils tested.

[3½M]