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Sheet Erosion Studies on Cecil Clay

By

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Sheet Erosion Studies on Cecil Clay

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Contents

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EROSION control has become a serious agricultural problem since the advent of intensive agriculture. Excessive soil erosion has resulted from certain activities of man which have disturbed the natural equilibrium between the processes of erosion and of soil formation. Since the soil is agriculture's greatest natural resource, its conservation is a fundamental problem. Experiments have shown that man-accelerated erosion may result in an annual loss of plant nutrients several times as great as that required to produce a normal crop of cotton or corn (1)[1]. The natural productive capacity of an enormous acreage of once fertile land has been depleted by sheet erosion which has washed away varying portions of the surface soil (2, 3). In addition, gullying, a more apparent type of erosion, has damaged extensive areas of once agricultural soil beyond the stage of immediate recovery (3).

The basic agriculture of the Cotton Belt is built around a system of open-cultivated crops. Even the average farmer is aware that erosion is a serious hazard under such conditions. Terracing has been practiced for more than two generations. This practice is almost universally accepted by Alabama farmers as a necessity. It is an accepted fact that the construction and maintenance of an adequate system of terraces is the first step in any sound program of erosion control under the above described system of agriculture. Likewise, contour planting and cultivation are widely accepted and practiced by nearly all progressive farmers. Further control measures by necessity must be modifications of or supplemental practices built into and around this basic system.

It is apparent that sheet erosion control must be considered as a "between-terrace" problem since the land between terraces constitutes the unit areas from which runoff occurs. Three groups of supplemental practices offer possibilities from which practical sheet erosion control measures may be developed. They are as follows: (a) increased and improved use of vegetation, (b) improved methods of tillage and mechanical manipulation of the soil, and (c) a wiser selection and use of land for the production of clean-cultivated crops. The last mentioned is beyond the scope of this publication but results of work of the type herein reported should be of value in serving as a guide to a sound land use program.

Much has been written concerning the erosion process. However, a large portion of these writings are opinions based on

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[1] Numbers in parentheses refer to literature cited.

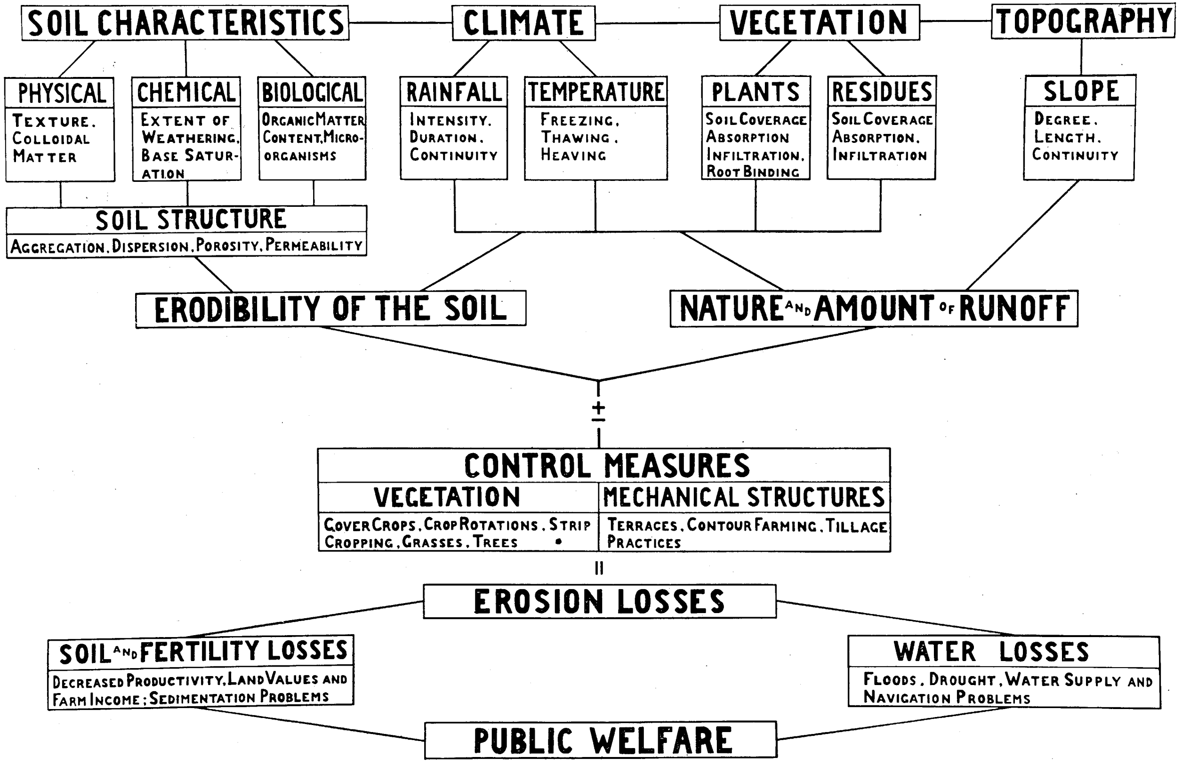

FIGURE 1.—Interrelationship of factors involved in the soil erosion problem.

empirical observation. Notable exceptions are the work of the Missouri Agricultural Experiment Station (6, 10) and that of the recently established Federal Erosion Experiment Stations (8, 9).

The extent of erosion losses is dependent on a large number of complexly related variables which in turn are dependent upon factors of climate, topography, vegetation and soil. An attempt has been made in Figure 1 to show diagramatically the interrelationship of these factors.

Topography influences vegetation, climate, and soil characteristics. Climate, vegetation, and soil conditions mutually exert pronounced influences on each other. As a result soils with different physical, chemical, and biological properties have been formed. Nature has integrated these environmental forces with the result that different soils possessing characteristic structure have developed. Structure, along with precipitation, temperature, plant growth, and organic residues, determines the tendency of a given soil to erode—the erodibility of the soil. The climatic and vegetative factors as well as the slope factors of topography are important in determining the nature and amount of runoff.

It is the purpose of this publication to (a) present methods and procedure by which some of the basic principles involved in sheet erosion control may be analyzed, and (b) to report the results of several years experimentation on the measurement and control of sheet erosion on Cecil clay.

EXPERIMENTAL METHODS AND PROCEDURE

Description of Plots.—The experimental area consisted of ten controlled plots, each enclosed by concrete walls. Each plot was 1/58 acre; the slope length was 50 feet and the width was 15 feet. The slope length was chosen to correspond approximately with the horizontal distances between terraces on critical slopes (4). The areas were sufficiently large to approximate field conditions and still permit the control of variable factors involved in the sheet erosion process. A concrete cistern 3 feet wide, 15 feet long and 5 feet deep, located at the lower end of each plot, was used to facilitate the measurement of both runoff and soil losses. These cisterns were constructed so that they might be drained by gravity. A general view of the plot layout is shown in Figure 2.

Soil Type and Uniformity.—The soil used in these experiments was a Cecil clay. Detailed data concerning the physical and chemical properties of the Cecil series as represented in Alabama have been reported by Davis (5). In order to insure uniformity of soil on the ten plots, the surface soil and six inches

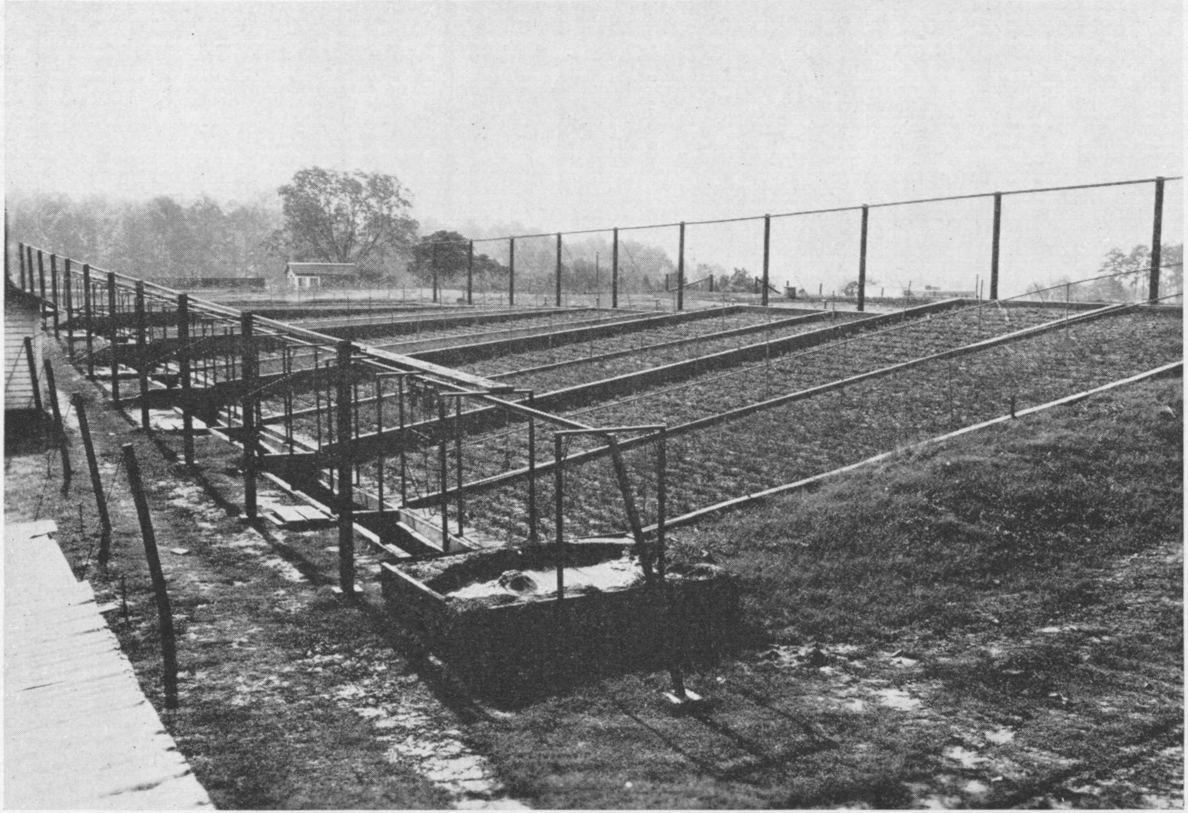

FIGURE 2.—General view of erosion plot layout.

of the subsoil were removed separately and each thoroughly mixed. Small quantities of the subsoil were added and tamped until the required six-inch layer was replaced. The same procedure was followed in replacing the surface soil. Mechanical analyses of the soil by the pipette method (12) showed that texture was uniform from plot to plot. A three-foot fill was required at the upper ends of three of the steeper plots in order to establish the required grades. Subsoil was used in making these small fills and an attempt was made to tamp it back to its normal volume weight before the surface soil was added.[1]

By 1933 the initial surface soil had become so severely eroded, especially on the steeper slopes, that it was removed and six inches of another typical Cecil clay added. Mechanical analyses showed that the texture of this soil was uniform from plot to plot. Thus, only the mean values and the standard deviation from the mean values of these analyses are given in Table 1.

TABLE 1.—Mechanical Analysis of the Surface Soil on the Erosion Plots.

Diameter in millimeters	Quantity in per cent of total
2.0 -1.0	0.9±0.4
1.0 -0.5	2.4±0.2
0.5 -0.25	5.4±0.4
0.25-0.10	13.4±0.5
0.10-0.05	9.2±0.5
0.05-0.005	16.3±0.5
< 0.005	52.4±1.2

Precipitation Measurements and the Control of Artificial Rainfall.—Two rain gauges were located at the plots. One was a standard rain gauge; the other was a standard recording gauge which recorded the amount, rate and duration of natural rainfall.

Control of quantity, intensity and duration of rainfall is an essential part of experimental technique required in certain types of sheet erosion studies. A portable irrigation system of the "Skinner" type was designed to meet this need. The apparatus used to distribute the artificial rainfall consisted of two 50-foot sections of ¾-inch galvanized steel pipe equipped with "catfish" nozzles which were attached at 1-foot intervals along each pipe. These distribution pipes were located three feet above the soil and 3½ feet from the side walls of the plots and were supported by means of open hangers inserted in the top of pipe posts which were driven vertically into the soil.

Water was supplied by a three-inch main which led to one corner of the plot area. From this main a two-inch pipe was run along the upper ends of the plots; this line was equipped with valves and hose connections located at appropriate points.

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[1] The fill was of appreciable area on the last plot of 20 per cent slope. Runoff from this plot has been low, indicating that it is undesirable to disturb the subsoil in the construction of plots for erosion studies.

The distribution pipes were moved from plot to plot and were attached to the two-inch pipe line with a one-inch rubber hose. A gate valve and water meter were inserted in the three-inch main; these, together with a stop watch, were used to control the rate and quantity of artificial rainfall.

The "catfish" nozzles were selected after testing several different types. These tests were made by placing a large number of small pans at intervals over the plots and measuring the amount of water caught in each pan. It was found necessary to adjust the openings in the nozzles in order to obtain a uniform distribution of water.

During artificial rainfall applications, ten-foot portable canvas walls were used to surround the plots to prevent wind from blowing the water onto adjacent plots. These walls were supported from cables suspended between steel I-beam tracks located above and extending along the two sides of the plot area; the ends of the cables were attached to small cars mounted on the tracks. This equipment facilitated the movement of the canvas barriers from plot to plot during artificial rainfall experiments.

Measurement of Runoff and Eroded Materials.—A trough located at the lower edge of each plot was used to divert runoff and eroded material through 6-inch sheet-metal pipes and into 32-gallon galvanized cans. These pipes extended to within a few inches of the bottom of the cans. Utilizing the principle of Stoke's law of settling velocity (14), the coarse sediments which could not be measured accurately by suspension samples, were retained in the can. After the can overflowed, the smaller sediments which were measured by suspension samples passed into the pit with the water. The water was slowly decanted and the cans were then lifted from the cisterns by a differential hoist mounted on a continuous metal track extending over the entire length of the cisterns. The coarse, wet material was weighed when it was lifted from the pit. This material was thoroughly mixed and a 500- to 600-gram representative sample was taken and its oven-dry weight determined. The amount of coarse, dry sediment was then calculated in pounds lost per acre.

Runoff and the finer eroded materials in the cistern were thoroughly agitated by means of a perforated metal agitator. Three one-half gallon samples were quickly taken after each agitation from three uniformly spaced locations in the pit. These samples were thoroughly mixed and a one-half gallon composite sample taken. The suspension solids were flocculated with an aluminum sulfate solution, filtered, oven dried, and weighed. The pits were calibrated and the depth of the runoff water was measured to the nearest one-hundredth of a foot. Calculations of the pounds of suspended material lost per acre were then made and the amount added to the dry weight of coarse material lost per acre, thus giving the total quantity of soil losses.[1]

In event the galvanized can did not hold all the coarse eroded material and some of it passed into the cistern, which was frequently the case during extremely heavy rains, a sample of the suspension was taken without agitation. The water was then slowly drained off and the remaining coarse material was shoveled into a can and weighed as previously described.

A special gauge was designed to measure the rate of runoff produced by artificial rainfall of known intensity and duration. (See Figure 3.) By means of this gauge, the rise of water in the cistern was recorded on a calibrated chart at the desired time intervals. A permanent record was made by marking on the chart at the desired time as the pointer moved down the chart.

Runoff and soil losses depend upon a number of interrelated factors; these have already been listed. Under ordinary field conditions it is frequently impossible to evaluate the influence of a single variable because of its close association with or interdependence on one or more other factors. In order to isolate and study the influence of a single factor, it is essential to have an experimental set-up which permits the control or measurement of the maximum number of interrelated variables while the single factor is allowed to vary.

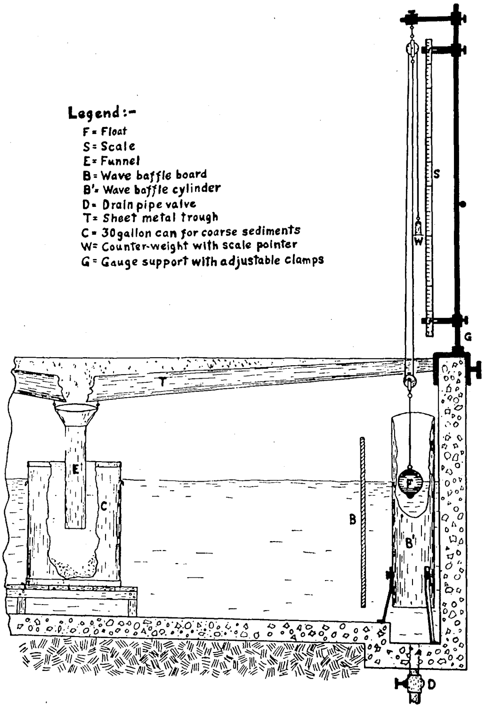

FIGURE 3.—Sketch of a cistern showing equipment for measuring soil losses and rate of runoff.

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[1] The term "soil losses" as used herein refers to the quantity of soil eroded from the plots into the cisterns. Under field conditions with an adequate system of terraces, undoubtedly an appreciable portion of the "so called" soil losses would be deposited in the terrace channels.

The plot layout and methods already described were developed in an attempt to obtain such a set-up. The factors which could be controlled or measured were as follows:

Soil conditions	Vegetation	Climate	Topography
Controllable variables			
Factors of soil type	Type of plants Planting methods	Rate, amount and duration of artificial rainfall	Length, degree and continuity of slope
Measurable variables			
Soil moisture Organic matter Pulverization (Dynamic conditions)	Ground coverage Amount of growth	Rate, amount and duration of natural rainfall Temperature	Microtopography (height of beds)
Resulting variables			
Erosion losses—rate, amount and nature of runoff, soil movement and soil losses			

Natural rainfall is so fortuitous with respect to distribution and intensity that interpretation of resulting data concerning erosion losses is exceedingly difficult. (See Table 2.) Thus, the artificial rainfall system was not only necessary to control intensity, quantity, and continuity of rainfall, but it also speeded up experimental work.

The high rates of rainfall application were chosen so that measurable erosion losses would be produced on all slopes under a wide range of conditions. The rates approach the maximum intensity of natural rainfall of the region as recently reported by Yarnell (15). The intensity and duration of a large number of natural rains, as recorded at the erosion plots during the course of these experiments, are given in Table 3.

EXPERIMENTAL RESULTS

The following discussions are based for the most part on experimental work conducted on Cecil clay. Many of the principles involved are believed to be of rather general application to the sheet erosion process. However, it is realized that the magnitude of erosion losses is quite different from that which would be obtained under similar conditions with other soil types of markedly different physical and chemical properties.

The Relation of Soil Moisture Content and Absorption to Erosion Losses.—It is obvious that the extent of saturation of a soil with respect to water determines the rate and extent of further absorption and hence influences the amount of runoff and soil losses. Both the immediate absorptive capacity and

TABLE 2.—Rainfall by Months at Auburn, Alabama (1929-1936) with the 55 year Average.

Month	Year								55 yr. average
	1929	1930	1931	1932	1933	1934	1935	1936	1881-1935
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
January	4.28	4.78	2.91	5.61	2.56	1.79	1.82	12.09	4.70
February	9.64	3.05	3.38	4.43	6.58	4.25	3.90	7.89	5.35
March	17.47	6.36	2.97	3.45	7.41	3.57	7.17	4.85	5.77
April	5.32	3.19	4.95	1.92	2.27	3.77	3.85	9.34	4.07
May	7.05	2.84	2.82	2.58	1.33	3.63	3.00	1.17	3.51
June	4.19	2.09	0.57	2.43	2.32	5.20	3.78	2.93	4.07
July	1.68	4.97	4.63	4.79	3.21	3.11	5.48	3.68	5.36
August	1.53	4.56	6.37	4.38	3.49	6.28	6.01	7.72	4.64
September	4.55	6.17	0.48	3.21	3.44	1.66	2.44		3.08
October	4.04	2.59	0.95	2.12	4.19	4.82	1.49		2.81
November	6.83	7.14	1.50	6.18	1.10	2.52	2.86		3.39
December	4.71	2.12	8.54	7.14	1.95	2.25	3.81		5.11
Totals	71.24	49.86	40.07	48.24	39.85	42.85	46.61		51.86

TABLE 3.—Duration and Amount of Continuous Portions of Intense Erosive Rains by Months at Auburn, Alabama.

Month	Year											
	1931		1932		1933		1934		1935		1936	
	Inches	Hours	Inches	Hours	Inches	Hours	Inches	Hours	Inches	Hours	Inches	Hours
January	0.50	1.0	1.70	7.3					0.35	1.5	1.00	1.0
February	0.40	0.8	1.15	4.7	0.75	4.2	0.70	2.8			0.85	0.1
March			0.95	1.7			1.70	9.0	3.00	18.0	0.90	0.1
April	1.60	6.0	0.45	0.5			1.05	4.0	0.95	3.0	0.50	0.2
May	0.40	1.3	0.55	0.8			1.45	1.8	0.50	0.7	0.60	0.1
June			0.40	0.5	0.50	0.2	0.60	1.0	1.10	2.3	0.65	0.3
July	2.00	1.5	1.35	1.3	0.55	0.2	0.60	0.2	1.35	5.3	2.15	11.0
August	1.35	0.7	0.55	0.7	0.80	0.5	1.50	2.0	0.65	4.3	0.50	0.3
September			0.50	0.2	1.20	1.0						
October					0.50	1.5			0.60	1.2		
November	1.65	8.5	0.60	1.5	0.40	0.2	0.95	5.0	1.15	3.1		
December	1.10	3.0	0.50	1.7	0.30	0.8			2.00	14.7		

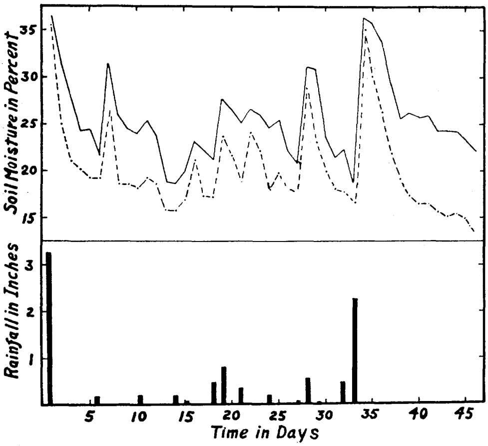

FIGURE 4.—Relationship between time and amount of rainfall and soil moisture content on different slopes; .————. 0% slope; ----------. 20% slope.

permeability are influenced by the moisture content of the soil profile (11, 13). Moisture content also affects the dispersion or slaking of the soil at the time rainfall occurs (16). In Figure 4 is given a comparison of the moisture content of the surface soil on a level plot with that of a 20-per-cent-slope plot over a period of 45 days. The time and amount of rainfall are also shown graphically on the same figure. The average moisture contents of the surface soil during the 45-day period were 24.6, 23.1, 22.0, 21.2, and 21.0 per cent on the 0, 5, 10, 15 and 20 per cent slopes, respectively. Moisture content was consistently lower as slope increased. This may be accounted for by the fact that the rate of runoff increases with increasing slope. Thus for any given rain the time interval during which the absorption and infiltration processes could function decreased with increased slope. Other data relevant to absorption are shown in Table 4.

The moisture content of the soil profile exerts a pronounced influence on the quantity of erosion losses from a given rain. The influence of soil moisture on erosion losses is revealed by the following example. A one and one-half-inch artificial rain was applied in 25 minutes to a 5-per-cent-slope plot when the surface soil contained 10.8 per cent moisture. The runoff from the plot was 26 per cent and the soil eroded was 72 pounds per acre. On the same plot, when the surface soil was saturated, the runoff from an artificial rain of the same amount and rate was 69 per cent and the material eroded per acre was 3,555 pounds.

Soil moisture content is sufficiently important to make it highly desirable to duplicate artificial rainfall experiments at low field moisture with runs immediately following when the surface horizon is still saturated with water.

During the growing season of clean-cultivated crops and of winter cover crops, there are invariably one or more rains which produce extreme erosion losses. A large percentage of the seasonal losses result from such rains. Three rains were responsible for 89 to 100 per cent of the soil losses (depending upon slope)

TABLE 4.—Percentage Runoff from Cecil Clay with Variations of Slope, Vegetative Cover and Rainfall (Natural rains - 1935).

Amount of rainfall	Duration of rainfall	Estimated coverage of vetch	Slope of land in per cent									
			0		5		10		15		20	
			F[1] [2]	V[1]	F	V	F	V	F	V	F	V
Inches	Hours	Per cent	Runoff in per cent of rainfall									
0.83	7	4	2	4	37	35	40	34	45	37	43	36
1.28	13	7	1	10	48	50	49	44	50	42	46	42
0.81	2	10	3	9	62	64	56	49	44	48	52	50
1.65	14	35	1	3	59	39	51	19	35	21	59	21
3.93	18	50	25	24	75	63	76	62	80	65	90	56
1.64	2	75	57	39	87	83	87	75	87	76	89	69
1.08	1.3	100	37	4	86	6	88	20	95	18	97	24

[1] F = smooth fallow; V = vetch planted in 18-inch, contour rows.

[2] Plot out of level, hence runoff values are abnormally low.

during the growing season of a crop of cotton. The three rains accounted for about 30 per cent of the seasonal rainfall. This principle is in agreement with the findings of Bartel (1).

Erosive rains of this type are usually characterized by high percentages of runoff. Excessive runoff is caused by (a) the soil profile being highly saturated with water and hence possessing a low rate of infiltration or by, (b) hard rain falling at an intensity that greatly exceeds the rate of infiltration. Excessive soil losses sometimes occur when the amount of runoff is not extremely excessive. Such results have been found to occur from rains falling when the surface soil was extremely susceptible to erosion, i.e., a fine pulverized condition immediately following cultivation or plowing. (See Tables 5 and 6.)

Influence of Intensity of Rainfall on Erosion.—Studies have shown that the intensity of rainfall is more important than the amount of rainfall in determining the extent of erosion losses. This is shown by the following example. During February, when the plots were partially covered with a small growth of vetch, a 1.0-inch rain occurred over a period of 76 hours and the soil losses varied from zero on the level plots to 4 pounds per acre on

TABLE 5.—Runoff and Soil Losses from Different Amounts of Rainfall under Saturated and Non-saturated Conditions on Fallow, Plowed and Vetch Plots of Cecil Clay.

Rainfall Applied in inches	1st. increment	2nd. increment	1st. increment	2nd. increment	Continuous	Continuous
	1.25	1.25	1.25	1.25	2.50	2.50
Duration of rainfall in minutes	11	11	11	11	22	22
Soil moisture[1]	F.M.	Sat'd	F.M.	Sat'd	F.M.	Sat'd
Surface conditions	Freshly plowed	Freshly plowed	Smooth fallow	Smooth fallow	Smooth fallow	Mature vetch
Slope in per cent	Runoff in per cent of rainfall					
0	0	34	27	52	58	40
5	0	66	70	58	84	51
10	4	62	79	86	87	51
15	5	65	81	90	91	53
20	10	72	81	86	97	59
	Soil losses in pounds per acre					
0	0	147	20	53	227	8
5	0	1,277	5,027	4,541	11,188	6
10	127	3,743	11,238	6,356	30,150	26
15	217	19,402	18,778	9,287	34,384	48
20	1,794	39,981	25,152	12,377	42,519	521

[1] F. M. = soil at low field moisture; Sat'd = surface soil saturated from 1st. increment of rain or by rainfall immediately preceding the run. 2nd. increment applied immediately following the 1st. increment.

the 20 per cent slope. About five days later a 1.1-inch intermittent rain fell in 6 hours. The losses varied from 113 pounds per acre on the level plots to 3,122 pounds on the 20 per cent slope.

Excessive soil losses frequently occur before absorption is satisfied, provided the rate of rainfall exceeds the rate of infiltration. When the plots were planted to cotton, an 0.83-inch rain occurred in 20 minutes. The soil losses varied from zero on the level plot to 5,452 pounds on the 20 per cent slope. Later a 1.4-inch rain fell in 36 hours and the losses varied from zero on the level plot to 114 pounds per acre on the 20 per cent slope. These results are in accord with the findings at the Statesville Station (1). (See also Tables 7 and 8.)

A comparison was made of the erosion from two artificial rains of constant amounts applied at different rates when the soil was broken five inches deep. In one case a 1.0-inch rain was applied in 8 minutes and in the other case 1.0 inch of rain was applied in 16 minutes. The moisture content of the soil at the beginning of each test was the same. The erosion resulting from the first application of rain ranged from 636 pounds per acre on the level plot to 19,000 pounds on the 20 per cent slope. When one inch of rain was applied in 16 minutes, the soil losses

TABLE 6.—Soil and Water Losses from Cecil Clay with Different Surface Conditions of the Soil.

Slope of land	Soil condition	Soil moisture	Runoff	Soil losses[1]
Per cent		Per cent	Per cent	Pounds per acre
0	Freshly cultivated	10	13	117
	Compact and crusted	12	37	83
5	Freshly cultivated	9	52	662
	Compact and crusted	10	60	706
10	Freshly cultivated	8	62	21,377
	Compact and crusted	11	67	19,151
15	Freshly cultivated	9	64	36,486
	Compact and crusted	11	70	20,325
20	Freshly cultivated	10	72	50,358
	Compact and crusted	11	[2]	[2]

[1] Losses from 2 inches of artificial rain applied in 18 minutes; cotton planted in 3-foot, contour rows in all cases.

[2] Values not determined.

TABLE 7.—Erosion Losses Produced by Natural Rainfall on Cecil Clay during the Growing Season of Winter Cover Crops (Nov. 1933 - April 1934, inclusive).

Time of rainfall	Amount of rainfall	Duration of rainfall	Estimated ground coverage (Vetch)	Slope of land in per cent									
				0		5		10		15		20	
				Vetch[1]	Rye[1]	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch	Rye
Date	Inches	Hours	Per cent	Soil losses in pounds per acre									
11/22/33	0.40	1/3	Nil	136	352	923	1,002	1,000[2]	1,168	2,000[2]	2,115	2,084	2,152
12/6/33	0.72	2	Nil	Nil	43	78	55	146	74	100	160	253	205
12/19/33	0.65	1	Nil	Nil	55	100	84	181	117	308	291	499	405
12/24/33	0.30	1/3	5	3	65	145	103	194	114	282	256	350	318
1/22/34	0.43	1/3	7	34	153	189	241	295	283	321	339	413	478
2/1/34	0.59	10	10	Nil	5	45	45	53	35	59	49	56	48
2/10/34	1.00	76	10	Nil	Nil	Nil	Nil	Nil	Nil	5	2	4	2
2/18/34	0.62	7	20	Nil	Nil	57	28	46	53	73	36	45	29
2/22/34	0.83	5	20	Nil	46	79	97	176	163	160	210	136	197
2/25/34	1.11	13	25	113	174	1,674	1,355	1,811	1,183	2,020	2,797	3,122	3,103
3/3/34	2.83	30	30	412	950	2,101	3,296	3,326	3,292	5,000[2]	4,686	6,457	6,110
3/19/34	0.62	2	50	Nil	Nil	43	57	36	64	56	50	49	45
3/26/34	0.50	9	75	Nil	Nil	10	16	23	25	16	27	38	35
4/15/34	1.39	7	100	Nil	27	64	90	85	221	95	274	142	303
4/19/34	0.95	3	100	Nil	50	22	216	34	354	143	427	114	407
4/29/34	1.05	18	100	Nil	13	1	46	10	112	13	181	13	170
Totals	13.99	184		698	1,933	5,531	6,731	7,416	7,258	10,651	11,900	13,775	14,007

TABLE 7.—Erosion Losses Produced by Natural Rainfall on Cecil Clay during the Growing Season of Winter Cover Crops (Nov. 1933 - April 1934, inclusive). (Continued).

Date	Inches	Hours	Per cent	Runoff in cubic feet per acre									
11/22/33	0.40	1/3	Nil	427	780	1,287	1,287	1,340	1,152	1,482	1,293	1,398	1,320
12/6/33	0.72	2	Nil	5	272	331	378	531	335	395	341	475	358
12/19/33	0.65	1	Nil	40	357	440	610	664	638	994	802	1,168	881
12/24/33	0.30	1/3	5	38	496	721	644	730	682	875	779	892	735
1/22/34	0.43	1/3	7	212	502	748	819	742	633	889	683	925	712
2/1/34	0.59	10	10	69	89	400	378	430	466	523	390	616	384
2/10/34	1.00	76	10	102	113	102	112	126	109	165	119	149	131
2/18/34	0.62	7	20	293	292	568	500	610	470	731	392	673	392
2/22/34	0.83	5	20	85	234	1,495	1,861	1,650	1,575	1,622	1,334	1,448	1,130
2/25/34	1.11	13	25	1,210	1,992	3,445	3,785	2,800	2,860	2,776	2,794	2,805	2,795
3/3/34	2.83	30	30	3,598	5,330	7,120	7,760	6,120	6,170	6,230	5,780	5,725	5,435
3/19/34	0.62	2	50	26	38	325	440	209	449	382	325	318	276
3/26/34	0.50	9	75	39	49	50	92	154	181	148	229	299	283
4/15/34	1.39	7	100	156	215	673	920	720	1,850	856	2,023	1,472	2,280
4/19/34	0.95	3	100	54	1,048	635	1,786	684	1,575	1,052	1,732	1,512	1,717
4/29/34	1.05	18	100	70	255	69	839	182	1,055	174	1,023	341	596
Totals	13.99	184		6,424	12,062	18,509	18,211	20,872	20,200	19,394	20,139	20,216	19,425

[1] Vetch planted in 18-inch drill rows on contour; rye planted in 10-inch drill rows on contour; 20.0 inches total rainfall during the period.

[2] Data incomplete; values estimated to obtain seasonal totals.

TABLE 8.—Soil Losses and Runoff Resulting from Natural Rainfall on Cecil Clay during the Winter Season with and without Vetch as a Cover Crop (Nov. 1934-May 1935), Inclusive.

Time of rainfall	Amount of rainfall[1]	Duration of rainfall	Estimated ground coverage (Vetch)	Slope of land in per cent									
				0		5		10		15		20	
				Fallow	Vetch[2]	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch
Date	Inches	Hours	Per cent	Soil losses in pounds per acre									
11/21/34	0.95	5	2	13	81	242	357	327	465	355	884	946	1,844
11/29/34	0.63	5	3	11	58	207	197	445	522	509	448	694	868
12/19/34	0.83	7	4	Nil	Nil	92	129	192	180	280	242	295	322
12/28/34	1.28	13	6	12	37	237	280	413	529	922	728	1,320	641
1/7/35	0.81	2	10	48	87	373	509	436	934	863	676	1,158	1,116
2/14/35	2.85	72	30	106	247	4,782	1,321	21,534	2,529	35,007	7,156	56,160	7,306
2/26/35	1.65	14	37	14	20	1,533	96	4,185	54	5,184	992	6,682	1,046
3/6/35	3.93	18	50	167	139	8,247	620	26,354	843	42,915	2,574	54,233	4,527
3/12/35	1.64	2	65	369	84	6,529	237	17,598	265	25,261	986	31,090	1,772
3/28/35	1.25	3½	75	53	11	1,478	24	5,750	23	6,686	28	8,456	106
4/8/35	1.47	1½	90	Nil	Nil	Nil	Nil	1,314	Nil	2,411	Nil	3,487	Nil
4/11/35	1.08	7	100	117	1	981	2	4,294	33	6,732	33	8,475	107
5/7/35	1.63	14	100	17	8	2,863	12	7,376	15	8,054	20	9,666	20
Totals	20.00	164		927	773	27,564	3,784	90,218	6,392	135,179	14,767	182,662	19,675
Date	Inches	Hours	Per cent	Runoff in cubic feet per acre									
11/21/34	0.95	5	2	Nil	765	2,220	2,683	2,872	2,552	2,354	2,587	2,401	2,610
11/29/34	0.63	5	3	63	574	1,478	1,552	1,395	1,500	1,511	1,583	1,567	1,297
12/19/34	0.83	7	4	73	113	1,096	1,039	1,195	1,012	1,337	1,123	1,305	1,070
12/28/34	1.28	13	6	26	458	2,251	2,324	2,297	2,037	2,310	1,964	2,141	1,938
1/7/35	0.81	2	10	76	273	1,831	1,877	1,643	1,435	1,285	1,414	1,518	1,465
2/14/35	2.85	72	30	825	1,625	4,610	3,740	4,440	2,940	4,805	3,140	4,530	2,735
2/26/35	1.65	14	37	76	169	3,554	2,332	3,064	1,120	2,098	1,284	3,554	1,284
3/6/35	3.93	18	50	3,550	3,380	10,755	8,915	10,860	8,850	11,335	9,220	12,875	8,065
3/12/35	1.64	2	65	3,410	2,330	5,180	4,960	5,225	4,500	5,215	4,530	5,340	4,150
3/28/35	1.25	3½	75	95	58	2,363	95	2,253	425	2,318	352	2,022	718
4/8/35	0.47	1½	90	Nil	Nil	Nil	Nil	151	Nil	658	26	757	52
4/11/35	1.08	7	100	1,452	156	3,359	256	3,464	772	3,715	722	3,821	939
5/7/35	1.63	14	100	412	200	4,490	328	4,217	700	4,261	810	4,255	862
Totals	20.00	164		10,058	10,101	43,187	30,101	43,076	27,843	43,202	28,755	46,086	27,185

[1] Total rainfall for period = 24.5 inches; 20.0 inches as rainfall producing runoff.

[2] Vetch planted in 18-inch drill rows on contour.

varied from 336 pounds per acre on the level plot to 7,520 pounds per acre on the 20 per cent slope. In the above case it is evident that the rate of rainfall rather than the amount is the influencing factor which determines the quantity of losses.

Numerous other examples showing the effect of the rate of rainfall on erosion may be cited from the erosion experiments. For example, two similar natural rains occurred when the plots contained a small growth of vetch two inches in height in 18-inch contour rows. The first rain of 0.83 of an inch was distributed over a period of 7 hours; soil losses ranged from zero on the level plot to 322 pounds per acre on 20 per cent slope. Nineteen days later an 0.81-inch rain fell in 2 hours. Soil losses varied from 87 pounds per acre on the level plot to 1,116 pounds per acre on the 20 per cent slope. Similar results were obtained on compact fallow during natural rains. Detailed data may be found in Table 8.

When the quantity of rainfall is constant, the rate of rainfall is the factor which determines the extent of erosion losses provided other conditions are comparable.

Influence of Quantity of Rainfall on Erosion.—With a given intensity of rainfall, the quantity of rain has a marked influence on erosion. In Figure 5 is given a comparison of the losses from a 0.74-inch rain which fell in approximately four hours with those from a 1.60-inch rain which fell uniformly throughout a ten-hour period. The rates were approximately the same but the duration of the first was about one-half that of the second. In the case of the 0.74-inch rain, the amount of eroded material varied from 30 pounds per acre on the level plot to 765 pounds on the plot having a 20 per cent slope. With a rainfall of 1.60 inches, the eroded material increased from 706 pounds per acre on the level plot to 8,720 pounds on the 20 per cent slope. The greater part of the 0.74-inch rain was consumed in saturating the soil. This accounts for the small amount of runoff and eroded material. In the case of the 1.60-inch rain, approximate saturation was reached and consequently a greater quantity of runoff and erosion occurred during the latter part of the rain. This principle has been repeatedly verified under numerous natural and artificial rainfall conditions.

Continuity or duration without intermission of rain is of vital importance in erosion control and is so closely related to intensity and quantity of rainfall that it will be discussed in brief at this point. The greater the duration of a rain of a given intensity the greater the soil and water losses. During the fall of 1934 when alternate plots were in smooth fallow, an 0.83-inch rain occurred in 7 hours. Several days later a 1.65-inch rain occurred in 14 hours. The amount of the second rain was approximately twice that of the first but the intensity was the same. The losses from the latter were about 20 times as great as those from the former.

It was found that with the same amount of rainfall erosion losses were greater when there were no breaks in the rainfall than when there were breaks or short lapses during the period of rainfall. This is clearly shown in Figure 6. The same principle is likewise substantiated by data reported in Table 5. Two 1.25-inch increments of artificial rain were applied during a period of 11 minutes per increment, with a slight interval between the two applications. The soil losses from the last rain were greater than those from the first. Later, when the soil conditions were comparable, 2.50 inches of rain were applied in 22 minutes without interruption. This was twice the amount of rain applied at the same rate. The losses from the 2.50-inch rain were considerably greater than the combined losses from the two 1.25-inch increments.

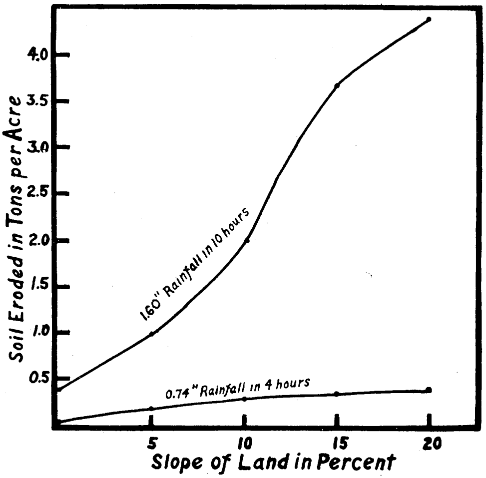

FIGURE 5.—Comparison of the amounts of soil eroded from various slopes by different quantities of rain falling at comparable intensities.

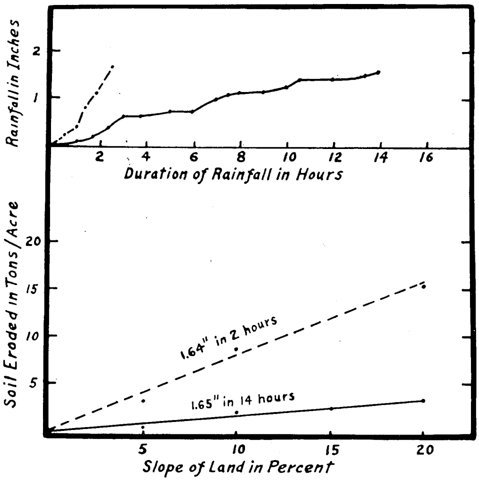

FIGURE 6.—Comparison of the amounts of soil eroded from different slopes by continuous and intermittent rains of comparable quantities.

Influence of Pulverization, Structure and Shape of Surface on Erosion.—Runoff and erosion are greatly affected by the shape of surface and state of pulverization of the soil. Soil and water losses from freshly plowed and from firm fallow[1] plots

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[1] The term "fallow" is used herein to describe a practice by which the soil was kept smooth, compact and free of weeds; weeds were removed by hoeing them off at the ground surface.

are shown in Table 5. In the case of the first 1.25-inch rain which was added when the surface soil moisture was low, the greatest losses in all instances occurred from the fallow plots. The rate of absorption was extremely high on the plowed soil as compared with that on fallow, hence runoff and soil losses from the plowed areas were extremely small.

A second 1.25-inch rain was applied within a few minutes after the completion of the first application. The surface horizon of the soil was still approximately saturated with water. Soil losses from the second increment of rainfall were appreciably less on fallow than those from the first increment even though runoff from the second rain was greater than that from the first rain. This may be attributed to the fact that the first rain slaked a thin layer of soil loose from the surface of the fallow plots; such material was quickly eroded from the steeper slopes and left the soil in a relatively non-erodible condition. The second 1.25-inch of rainfall on the plowed plots caused erosion losses many times greater than those produced by the first rain; runoff was likewise greatly increased.

A comparison of losses from fallow and plowed land during the second increment of rainfall shows that the soil losses from the plowed areas on steep slopes were markedly greater than those from fallow even though runoff was greater from the latter. This was not true on the more gentle slopes. The apparent inconsistency may have been due to the fact that the first rain did not nearly satisfy absorption on the plowed plots or to a failure of this first increment of rainfall to wash off all of the loose soil from the fallow plots.

To determine the effect of cultivation on erosion losses while all plots were in cotton, they were given a 2-inch artificial rain in 18 minutes when the soil was compact and crusted from previous rainfall. The plots were allowed to dry until the moisture was the same as in the first case after which a shallow cultivation followed. Two inches of rain were again applied in 18 minutes. With the exception of the 5-per-cent-slope plots, soil losses were greater when the plots were freshly cultivated than they were when compact and crusted; the differences were most pronounced on the steeper slopes. (See Table 6.) The increased losses on the freshly cultivated plots were caused by absorption being exceeded when the soil was in a very erodible condition.

The influence of cloddy structure and ridged effect is again brought out quite vividly in Table 9. These data are from interplanted corn and velvet beans and from firm fallow. Numerous clods were present in the cultivated area and the corn was planted flat, but as cultivation progressed ridges were gradually developed and were quite pronounced by the time of the last cultivation.

Increased obstruction due to clods and ridges increased the amount of absorption and decreased the runoff velocity. Pro-

TABLE 9.—Soil Losses and Runoff Resulting from Natural Rainfall during the Growing Season of an Interplanted Crop of Corn and Velvet Beans Compared to Smooth Fallow on Different Slopes.

Time of rainfall	Amount of rainfall[2]	Duration of rainfall	Estimated ground coverage on C. B. plots	Slope of land in per cent									
				0		5		10		15		20	
				F[1]	C. B.[1]	F	C. B.	F	C. B.	F	C. B.	F	C. B.
Date	Inches	Hours	Per cent	Soil losses in pounds per acre									
6/5/35	1.32	6	5	122	102	5,239	136	7,910	632	7,893	561	10,508	576
6/22/35	.95	4	8	79	0	1,760	12	5,169	57	5,047	143	6,793	380
6/29/35	.65	48	10	0	0	531	0	1,557	0	1,141	0	1,678	0
7/6/35	1.40	3½	15	45	23	4,318	350	7,705	684	12,945	2,914	14,512	3,997
7/11/35	1.15	¾	20	40	0	3,737	300	8,744	431	11,231	87	12,391	248
7/13/35	1.50	4½	25	198	110	7,075	930	11,555	4,510	16,868	13,720	21,450	16,350
7/16/35	1.45	3	40	0	0	2,378	254	6,449	2,981	7,344	7,190	10,714	7,174
8/6/35	1.01	½	75	121	0	350[3]	272	10,832	2,898	14,291	7,074	19,703	10,584
8/11/35	.75	½	85	0	0	150[3]	88	6,230	708	6,991	2,235	8,181	1,721
8/15/35	1.20	48	85	0	0	522	35	2,722	48	2,495	758	3,393	713
8/20/35	2.00	36	85	69	0	3,071	38	4,911	198	5,827	240	8,874	595
Totals	13.39	155		674	235	29,131	3,403	73,784	13,147	92,073	34,922	118,197	43,228
Date	Inches	Hours	Per cent	Runoff in cubic feet per acre									
6/5/35	1.32	6	5	1,688	162	4,620	148	4,431	1,030	3,814	598	4,516	441
6/22/35	.95	4	8	777	0	2,480	0	2,442	98	2,559	574	2,400	260
6/29/35	.65	48	10	0	0	1,005	0	1,130	0	1,090	0	1,267	0
7/6/35	1.40	3½	15	472	147	3,455	760	3,422	1,595	3,241	1,654	3,534	1,653
7/11/35	1.15	¾	20	1,020	0	3,325	0	3,162	185	3,174	321	3,375	348
7/13/35	1.50	4½	25	1,727	202	4,081	2,432	4,078	2,486	3,985	2,648	3,978	2,491
7/16/35	1.45	3	40	14	0	2,840	1,735	2,810	1,945	2,400	2,160	2,818	2,110
8/6/35	1.01	½	75	1,940	2,765	3,000[3]	2,225	3,500[3]	1,912	3,415	2,700	3,500[3]	2,520
8/11/35	.75	½	85	0	0	1,000[3]	507	1,786	612	1,380	905	1,662	774
8/15/35	1.20	48	85	0	0	2,347	670	1,975	43	1,386	937	2,033	963
8/20/35	2.00	36	85	789	317	5,162	841	4,756	1,653	4,297	2,070	4,862	1,839
Totals	13.39	155		8,427	3,593	33,315	9,318	33,492	11,559	30,741	14,567	33,945	13,399

[1] F = smooth, compact fallow; C. B. = corn and velvet beans interplanted at 18-inch intervals in 4-foot, contour rows which were converted through cultivation into rough or cloddy contour beds.

[2] 1.45-inch erosive rain falling in 25 hours not reported.

[3] Data incomplete; values estimated to obtain seasonal totals.

vided that the saturation capacity was not exceeded under such conditions, the erosion losses were decreased. When the soil was ridged and the intensity of the rain exceeded the rate of absorption to a point where the water "over-topped" the ridges, the soil losses were much greater than those on non-ridged soil. These extreme losses were probably due to a hydraulic head being released when the holding capacity of the ridges was exceeded. Under such conditions runoff started quicker on the non-ridged soil but was gradual throughout the duration of the rain. This resulted in less erosion on the smooth soil. The reverse was true when the capacity of the ridges was not exceeded.

From the above experiments and others, it was concluded that tillage practices are effective in controlling erosion until the rate and amount of absorption is exceeded. After these have been exceeded, greater losses will occur on freshly plowed soil than on firm soil.

The Physical Nature of Erosion Losses and Certain Factors Affecting the Nature of Erosion Losses.—Several basic facts concerning the sheet erosion process have been revealed by a detailed study of the physical nature of the soil material eroded from the controlled plots of Cecil clay located on the several slopes. The size distribution of water stable aggregates was determined on representative samples of the soil material eroded from plots under a wide range of soil conditions and vegetative coverage. The wet screening or sieve method of aggregate analysis developed by Yoder (16) was employed.

Typical results of this phase of the work are summarized in Tables 10 to 13 inclusive. In all cases, the mechanical analysis of the soil is given along with the aggregate analyses of the eroded materials. The latter determinations were made on the wet samples immediately following the completion of the rain in question. The aggregate losses are expressed in percentage of total soil losses and also in pounds per acre in order to facilitate study of these data. Runoff data are likewise included.

A comparison of the mechanical analysis of the soil and the aggregate analyses of eroded materials shows that the unit particles primarily involved in the erosion process, in the case of structural soils, are aggregates (compound particles) rather than textural separates (sands, silt and clay). Undue emphasis has been given the frequently encountered statement that sheet erosion losses are particularly detrimental because excessive amounts of the most valuable part of the soil—the colloidal fraction—are lost during the process. As a general statement, the above is not true.

From the results reported in Tables 10, 11, and 12, it may be seen that hundreds of pounds of aggregates or compound particles having diameters greater than those of coarse sands are frequently eroded from all unprotected (fallow) slopes during natural rains. This fact alone is sufficient reason for

TABLE 10.—Physical Nature of Erosion Losses from Cecil Clay when Fallow and when Protected by Vetch at 30 per cent Ground Coverage.

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope of land in per cent									
			0		5		10		15		20	
			Fallow	Vetch[1]	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses[2]									
		>2.0	0.4	0.2	12.9	2.5	9.7	3.6	12.2	5.9	12.5	6.3
2.0 -1.0	0.9	2.0 -1.0	0.8	0.9	16.5	3.9	11.7	3.7	13.3	8.6	15.9	9.3
1.0 -0.5	2.4	1.0 -0.5	3.7	2.1	13.9	6.9	18.4	8.6	13.0	10.1	14.8	12.9
0.5 -0.25	5.4	0.5 -0.25	4.8	2.2	9.4	5.7	15.4	8.0	13.8	8.2	12.7	12.9
0.25-0.10	13.4	0.25-0.10	8.1	5.2	8.7	6.9	14.4	9.6	15.0	8.8	13.8	15.1
0.10-0.05	9.2	0.10-0.05	12.8	6.2	7.9	5.9	14.4	7.8	14.2	9.8	13.9	15.9
<0.05	68.7	<0.05	69.4	83.2	30.7	68.2	16.0	58.7	18.5	48.6	16.4	27.6
0.05-0.005	16.3											
<0.005	52.4	Total	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre[2]									
		>2.0	0.4	0.5	617	33	2,088	91	4,270	422	7,020	460
		2.0 -1.0	0.8	2.2	779	52	2,520	94	4,655	615	8,930	678
		1.0 -0.5	3.9	5.2	665	91	3,964	217	4,550	723	8,315	942
		0.5 -0.25	5.1	5.4	449	75	3,316	202	4,830	587	7,135	942
		0.25-0.10	8.6	12.7	416	91	3,100	243	5,250	630	7,750	1,104
		0.10-0.05	13.6	15.3	378	78	3,100	197	4,970	701	7,810	1.162
		< 0.05	73.5	205.4	1,468	901	3,446	1,485	6,482	3,478	9.210	2,018
Total soil losses in lbs./acre			106	247	4,782	1,321	21,534	2,529	35,007	7,156	56,160	7,306
Runoff in cu. ft./acre			825	1,625	4,610	3,740	4,440	2,940	4,805	3,140	4,530	2,735

[1] Vetch planted in 18-inch drill rows on the contour.

[2] Losses from a 2.85-inch natural rain; 1.5 inches of rain falling in 2 hours producing most of the erosion losses.

TABLE 11.—Physical Nature of Erosion Losses from Cecil Clay when Fallow and when Protected by Vetch at 75 per cent Ground Coverage.

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope of land in per cent									
			0		5		10		15		20	
			Fallow	Vetch[1]	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses[2]									
		>2.0	2.2	0.7	4.2	1.3	6.6	2.2	7.7	2.6	10.5	3.8
2.0 -1.0	0.9	2.0 -1.0	2.3	1.3	8.3	1.2	9.5	2.2	11.9	4.9	12.9	5.7
1.0 -0.5	2.4	1.0 -0.5	3.0	1.9	11.2	2.2	13.3	4.2	16.0	5.3	13.4	7.3
0.5 -0.25	5.4	0.5 -0.25	3.3	3.5	14.5	3.2	14.9	3.5	15.6	5.3	13.7	8.5
0.25-0.10	13.4	0.25-0.10	8.2	4.3	16.4	5.9	23.6	6.0	16.0	12.4	14.2	12.8
0.10-0.05	9.2	0.10-0.05	5.1	7.5	8.5	3.2	13.3	5.7	14.7	10.4	16.6	11.6
<0.05	68.7	<0.05	75.9	80.8	36.9	83.0	18.8	76.3	18.1	59.1	18.8	50.3
0.05-0.005	16.3											
<0.005	52.4	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre[2]									
		>2.0	8.2	0.6	274	3.2	1,172	5.9	1,942	26	3,252	67
		2.0 -1.0	8.6	1.1	542	2.8	1,672	5.8	3,017	48	4,014	101
		1.0 -0.5	11.1	1.6	732	5.3	2,334	11.2	4,039	52	4,172	130
		0.5 -0.25	12.1	2.9	947	7.5	2,627	9.2	3,943	52	4,244	150
		0.25-0.10	30.1	3.6	1,071	14.0	4,152	15.8	4,036	123	4,421	226
		0.10-0.05	18.8	6.4	554	7.5	2,340	15.1	3,714	103	5,147	206
		<0.05	279.9	67.9	2,409	196.8	3,301	202.4	4,570	582	5,840	892
Total soil losses in lbs./acre			369	84	6,529	237	17,598	265	25,261	986	31,090	1,772
Runoff in cu. ft./acre			3,410	2,330	5,180	4,960	5,225	4,500	5,215	4,530	5,340	4,150

[1] Vetch planted in 18-inch drill rows on the contour.

[2] Losses from 1.64-inch natural rain falling in less than 2 hours.

TABLE 12.—Physical Nature of Erosion Losses from Cecil Clay when Fallow and when Protected by Vetch at Complete Ground Coverage.

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope of land in per cent									
			0		5		10		15		20	
			Fallow	Vetch[1]	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch	Fallow	Vetch
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses[2]									
		>2.0	3.1	Nil	3.0	Nil	10.4	1.1	6.7	1.5	4.5	1.6
2.0 -1.0	0.9	2.0 -1.0	4.0	Nil	4.3	Nil	11.1	2.7	9.3	3.9	8.4	3.5
1.0 -0.5	2.4	1.0 -0.5	7.5	Nil	18.0	Nil	16.3	5.0	15.8	6.0	14.0	8.5
0.5 -0.25	5.4	0.5 -0.25	6.6	Nil	19.1	Nil	14.3	4.2	16.4	5.6	14.2	12.7
0.25-0.10	13.4	0.25-0.10	19.8	Nil	16.3	Nil	18.0	10.3	19.4	9.7	24.1	11.4
0.10-0.05	9.2	0.10-0.05	14.1	Nil	13.0	Nil	11.2	6.9	10.4	7.7	12.7	8.8
<0.05	68.7	<0.05	44.9	100.0	26.3	100.0	18.7	69.8	22.0	65.6	22.1	53.5
0.05-0.005	16.3											
<0.005	52.4	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre[2]									
		>2.0	7	Nil	331	Nil	3,134	0.3	2,336	0.7	1,925	8.1
		2.0 -1.0	9	Nil	485	Nil	3,350	0.7	3,181	1.9	3,586	18.3
		1.0 -0.5	17	Nil	2,009	Nil	4,915	1.3	5,421	2.9	5,933	44.4
		0.5 -0.25	15	Nil	2,139	Nil	4,303	1.1	5,652	2,7	6,009	66.4
		0.25-0.10	45	Nil	1,828	Nil	5,431	2.7	6,677	4.7	10,248	59.6
		0.10-0.05	32	Nil	1,455	Nil	3,372	1.8	3,576	3.7	5,419	45.6
		<0.05	102	8.1	2,941	6.4	5,645	18.2	7,641	31.6	9,399	279.0
Total soil losses in lbs./acre			227	8	11,181	6	30,150	26	34,384	48	42,519	521
Runoff in cu. ft./acre			5,260	3,610	7,600	4,660	7,870	4,610	8,260	4,830	8,770	5,320

[1] Vetch planted in 18-inch drill rows on the contour.

[2] Losses from 2.50 inches of artificial rainfall applied in 22 minutes when surface soil was at low field moisture.

concluding that the sheet erosion process, when uncontrolled, bodily removes the top-most part of the soil profile layer by layer. In addition, field observations also indicate that if the process is not controlled, the surface horizon of the soil is finally washed away. If any part of the surface material is left behind, it is only a gravel or rock blanket.

However, there are certain conditions under which the relative loss of colloidal material may be excessive. The relative loss of colloidal material may be excessive during (a) erosion from soil protected by considerable vegetation (land planted in soil conserving crops), (b) erosion produced by soil conditions resulting in small amounts of runoff, (c) erosion from flat land and possibly from extremely gentle slopes, and (d) erosion produced by intermittent small showers of rain falling at slow rates.

The above conditions are all characterized by small quantities of runoff or by runoff of low forward moving velocity or by both. Ample supporting data for the first three conditions may be found in Tables 12, 13, and 14. The resulting effects of the last mentioned condition have been repeatedly measured on the controlled plots. In brief, the relative amount of colloidal material lost is excessive only when the sheet erosion process is controlled, in a practical sense, or when the total quantity of soil lost is almost negligible.

The above conclusions have the additional support of field observations. In the Southeast, the only conditions under which sandy surface horizons have developed on soil profiles having large clay contents are where topography is flat or where a thick, permanent, vegetative coverage has been allowed to persist on gentle slopes.

During the course of the experiments, considerable information has been obtained concerning the basic principles involved in the use of vegetation to control sheet erosion. Aggregate analyses of eroded materials served as a basis for the analysis of the problem. It has been found that cover crops function in reducing sheet erosion losses by (a) filtering out the larger water stable aggregates, (b) decreasing the quantity of runoff, (c) decreasing the velocity of runoff, (d) minimizing the turbulence of runoff and hence lessening the abrasive or dispersive action of sediment loaded water, and (e) minimizing the mechanical dispersive action of beating rainfall.

From a study of the data presented in Tables 10, 11, and 12, which permits a comparison of the nature of the materials eroded from fallow plots and from plots protected by vetch at different stages of growth, it may be seen that in every case the plants functioned by filtering out large quantities of the coarser aggregates. As the growth of the plants and hence the extent of ground coverage increased, the efficiency of the process increased. It was not uncommon to find two to three inches of soil piled above the upper side of contour rows of vetch which

TABLE 13.—Physical Nature of Erosion Losses from Cecil Clay under Different Strip Cropping Practices[1].

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope width of Strip[2]									
			12.5 ft. plowed 37.5 ft. vetch		25 ft. plowed 25 ft. vetch		37.5 ft. plowed 12.5 ft. vetch		50 ft. plowed No vetch		50 ft. fallow No Vetch	
			F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses on 5 percent slope									
		>2.0	Nil	Nil	Nil	0.2	Nil	0.1	Nil	0.4	2.1	2.6
2.0 -1.0	1.2	2.0 -1.0	Nil	Nil	Nil	0.2	Nil	0.1	Nil	0.8	2.4	5.9
1.0 -0.5	2.9	1.0 -0.5	Nil	Nil	Nil	0.4	Nil	0.1	Nil	1.7	9.2	15.3
0.5 -0.25	6.4	0.5 -0.25	Nil	Nil	Nil	0.3	Nil	0.1	Nil	2.1	12.5	11.1
0.25-0.10	13.0	0.25-0.10	Nil	Nil	Nil	0.8	Nil	0.2	Nil	3.3	23.9	19.1
0.10-0.05	8.5	0.10-0.05	Nil	Nil	Nil	0.4	Nil	0.3	Nil	3.3	16.1	13.8
<0.05	68.0	<0.05	100.0	100.0	100.0	97.7	100.0	99.3	Nil	88.4	34.0	32.2
0.05-0.005	15.9											
<0.005	52.1	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre on 5 per cent slope									
		>2.0	Nil	Nil	Nil	0.3	Nil	0.1	Nil	5	105	118
		2.0 -1.0	Nil	Nil	Nil	0.4	Nil	0.1	Nil	10	121	268
		1.0 -0.5	Nil	Nil	Nil	0.7	Nil	0.2	Nil	22	463	696
		0.5 -0.25	Nil	Nil	Nil	0.6	Nil	0.2	Nil	27	617	504
		0.25-0.10	Nil	Nil	Nil	1.6	Nil	0.6	Nil	43	1,202	869
		0.10-0.05	Nil	Nil	Nil	0.6	Nil	0.8	Nil	42	810	626
		<0.05	12.4	63.8	37.8	172.7	31.3	291.1	Nil	1,128	1,709	1,460
Total soil losses in lbs./acre			12	64	38	177	31	293	Nil	1,277	5,027	4,541
Runoff in cu. ft./acre			960	2,870	1,071	2,839	419	3,358	Nil	3,002	3,195	3,875

TABLE 13.—Physical Nature of Erosion Losses from Cecil Clay under Different Strip Cropping Practices[1]. (Continued)

m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses on 10 per cent slope									
		>2.0	Nil	0.3	Nil	0.1	0.1	0.1	1.3	4.4	2.8	4.0
2.0 -1.0	0.8	2.0 -1.0	Nil	0.7	Nil	0.1	0.2	0.1	1.3	8.1	6.4	7.0
1.0 -0.5	2.4	1.0 -0.5	Nil	1.2	Nil	0.3	0.7	0.2	3.9	10.2	17.2	18.4
0.5 -0.25	5.3	0.5 -0.25	Nil	1.1	Nil	0.6	0.9	0.2	3.2	7.3	12.6	13.7
0.25-0.10	13.5	0.25-0.10	Nil	2.2	Nil	0.6	1.4	0.4	11.5	7.3	23.7	18.4
0.10-0.05	9.7	0.10-0.05	Nil	1.4	Nil	0.5	2.0	1.7	13.5	8.0	9.5	10.2
<0.05	68.3	<0.05	100.0	93.1	100.0	97.8	94.7	97.3	65.3	54.7	27.8	28.3
0.05-0.005	16.9											
<0.005	51.4	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre on 10 per cent slope									
		>2.0	Nil	0.2	Nil	0.4	0.1	0.3	1.6	164	313	252
		2.0 -1.0	Nil	0.5	Nil	0.4	0.2	0.5	1.7	302	724	444
		1.0 -0.5	Nil	0.8	Nil	0.9	0.8	0.7	4.9	381	1,930	1,173
		0.5 -0.25	Nil	0.7	Nil	1.5	1.1	0.9	4.1	277	1,411	873
		0.25-0.10	Nil	1.5	Nil	1.6	1.6	1.5	14.6	272	2,662	1,167
		0.10-0.05	Nil	0.9	Nil	1.2	2.3	6.4	17.2	298	1,071	646
		<0.05	14.2	61.9	27.8	249.4	111.1	366.8	83.1	2,050	3,127	1,801
Total soil losses in lbs./acre			14	67	28	255	117	377	127	3,743	11,238	6,356
Runoff in cu. ft./acre			1,535	3,190	664	3,110	854	3,410	180	2,811	3,572	3,899

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[1] Losses from 1.25 inches artificial rainfall in 11 minutes with vetch at full ground coverage in all cases.

[2] Slope width of all plots = 50 feet; strip crop below plowed area; plowing done day previous to test in all cases; F. M. = soil at low field moisture; Sat'd. = surface soil saturated from first 1.25-inch rain as second 1.25-inch was applied immediately after the first run in each case.

TABLE 13.—Physical Nature of Erosion Losses from Cecil Clay under Different Strip Cropping Practices[1]. (Continued)

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope width of strip[2]									
			12.5 ft. plowed 37.5 ft. vetch		25 ft. plowed 25 ft. vetch		37.5 ft. plowed 12.5 ft. vetch		50 ft. plowed No vetch		50 ft. fallow No vetch	
			F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M	Sat'd
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses on 15 per cent slope									
		>2.0	1.5	0.5	Nil	0.1	0.4	0.1	3.8	8.7	3.8	4.8
2.0 -1.0	0.9	2.0 -1.0	2.0	0.7	Nil	0.2	0.3	0.1	4.8	11.6	3.4	7.0
1.0 -0.5	2.4	1.0 -0.5	3.5	2.1	Nil	0.3	0.7	0.1	5.8	14.3	11.7	15.5
0.5 -0.25	5.0	0.5 -0.25	7.9	2.2	Nil	0.2	0.7	0.4	7.0	13.0	13.1	13.4
0.25-0.10	13.8	0.25-0.10	9.9	3.3	Nil	0.6	1.9	0.6	10.1	8.7	20.1	14.1
0.10-0.05	9.4	0.10-0.05	5.4	2.8	Nil	0.5	2.4	2.5	18.6	12.9	15.0	11.1
<0.05	68.5	<0.05	69.8	88.4	100	98.1	93.6	96.3	49.9	30.8	32.9	34.1
0.05-0.005	16.2											
<0.005	52.3	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre on 15 per cent slope									
		>2.0	0.3	0.6	Nil	0.3	0.5	0.6	8.3	1,694	710	442
		2.0 -1.0	0.4	0.9	Nil	0.7	0.4	0.7	10.3	2,253	640	652
		1.0 -0.5	0.7	2.7	Nil	1.1	1.0	0.9	12.6	2,783	2,190	1,438
		0.5 -0.25	1.6	2.8	Nil	0.9	1.0	2.7	15.1	2,520	2,465	1,242
		0.25-0.10	2.0	4.2	Nil	2.4	2.7	3.7	21.9	1,678	3,770	1,310
		0.10-0.05	1.1	3.6	Nil	1.9	3.4	15.6	40.3	2,502	2,827	1,032
		<0.05	14.1	113.1	29.0	411.6	133.3	608.2	108.2	5,972	6,176	3,171
Total soil losses in lbs./acre			20	128	29	419	142	632	217	19,402	18,778	9,287
Runoff in cu. ft./acre			1,540	3,500	857	3,359	967	3,468	240	2,951	3,691	4,097

TABLE 13.—Physical Nature of Erosion Losses from Cecil Clay under Different Strip Cropping Practices[1]. (Continued)

m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses on 20 per cent slope									
		>2.0	1.1	1.8	0.3	0.2	0.2	0.1	1.9	7.7	8.6	6.8
2.0 -1.0	0.8	2.0 -1.0	1.6	2.4	0.4	0.4	0.2	0.2	2.0	10.6	13.4	7.8
1.0 -0.5	2.4	1.0 -0.5	4.9	5.3	1.2	1.2	0.6	0.4	5.9	14.2	15.9	12.0
0.5 -0.25	5.5	0.5 -0.25	3.5	5.7	1.4	0.8	1.2	0.8	4.8	12.1	11.7	13.3
0.25-0.10	13.7	0.25-0.10	15.2	9.2	1.8	2.7	2.2	1.9	17.2	17.7	13.0	11.8
0.10-0.05	9.1	0.10-0.05	11.4	6.4	2.9	2.3	3.6	4.9	20.2	13.8	11.1	10.1
<0.05	68.5	<0.05	62.3	69.2	92.0	92.4	90.0	91.7	48.0	23.9	26.3	38.2
0.05-0.005	16.1											
<0.005	52.4	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre on 20 per cent slope									
		>2.0	0.4	3.2	0.5	1.5	0.4	1.9	34	3,080	2,154	841
		2.0 -1.0	0.6	4.4	0.7	2.5	0.4	2.9	36	4,245	3,372	959
		1.0 -0.5	1.8	9.6	1.9	7.3	1.4	5.4	105	5,680	3,990	1,488
		0.5 -0.25	1.3	10.4	2.2	5.0	2.8	11.3	87	4,825	2,933	1,648
		0.25-0.10	5.6	16.6	2.8	17.1	5.2	25.8	308	7,080	3,271	1,455
		0.10-0.05	4.2	11.5	4.6	14.2	8.4	66.6	362	5,510	2,794	1,253
		<0.05	22.9	125.4	143.7	577.4	212.1	1,249.2	862	9,560	6,638	4,733
Total soil losses in lbs./acre			37	181	156	625	231	1,363	1,794	39,980	25,152	12,377
Runoff in cu. ft./acre			1,295	3,360	1,129	2,924	885	3,115	450	3,495	3,684	3,902

[1] Losses from 1.25 inches artificial rainfall in 11 minutes with vetch at full ground coverage in all cases.

[2] Slope width of all plots = 50 feet; strip crop below plowed area; plowing done day previous to test in all cases; F. M. = soil at low field moisture; Sat'd. = surface soil saturated from first 1.25-inch rain as second 1.25-inch was applied immediately after the first run in each case.

TABLE 14.—Percentage Runoff from Cecil Clay with Various Strip Cropping Practices (Artificial Rainfall—1935)[1].

Slope of land	Slope width of strips[2]									
	12.5 ft. plowed 37.5 ft. vetch		25 ft. plowed 25 ft. vetch		37.5 ft. plowed 12.5 ft. vetch		50 ft. plowed No vetch		50 ft. fallow No vetch	
	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd
Per cent	Runoff in per cent of rainfall									
0	0	54	0	54	0	68	0	34	27	52
5	22	63	24	63	9	74	0	66	70	85
10	34	70	15	69	19	75	4	62	79	86
15	34	77	19	74	21	76	5	65	81	90
20	28	74	25	64	20	69	10	77	81	86

[1] Runoff from 1.25-inches of artificial rainfall in 11 minutes in all cases.

[2] Slope width of all plots = 50 feet; strip crop was vetch at maturity or maximum ground coverage; strip crop below plowed area; plowing done immediately before tests in all cases; F. M. = soil at low field moisture; Sat'd = surface soil saturated from first 1.25-inch rain.

had been planted on smooth steep slopes. The stair-step effect produced by the filtering process may be seen in Figure 7.

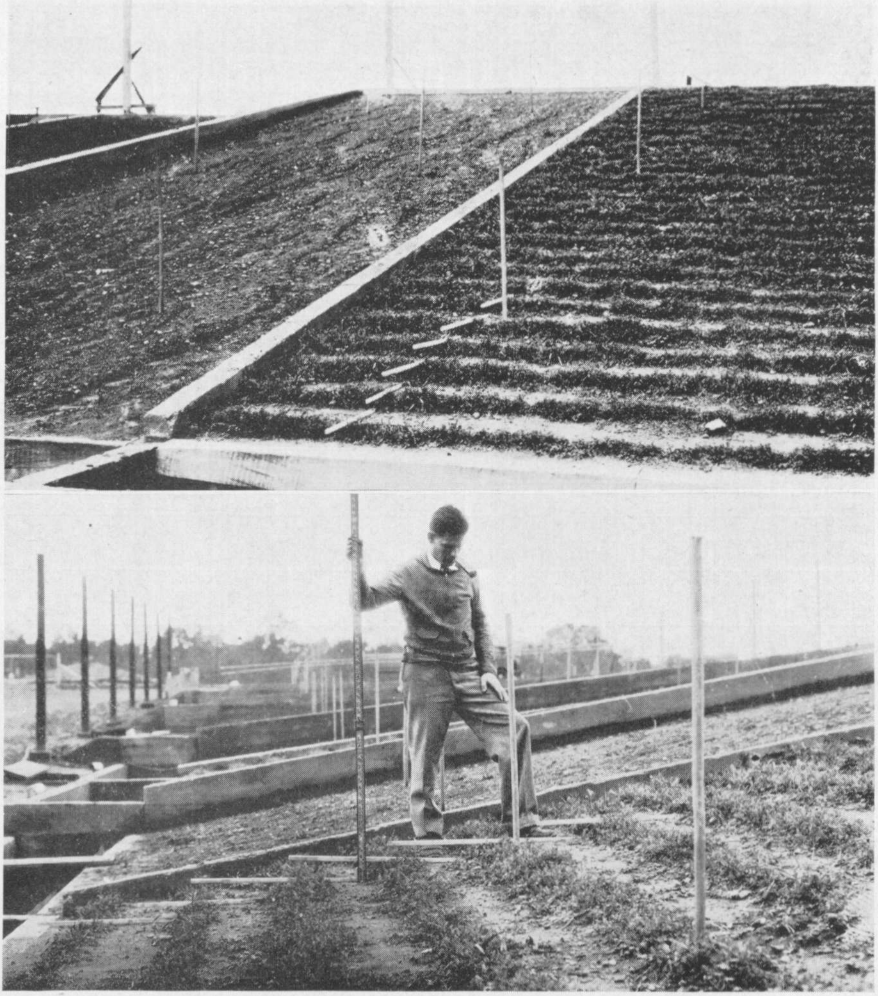

FIGURE 7.—Relative erosion on fallow and vetch plots on 20 per cent slope; both plots were brought to a uniformly smooth slope at planting time.

(Top) End view of plots when vetch had attained about one-third ground coverage. Note the soil deposited above the vetch rows; this vetch plot lost 10 tons of soil per acre during the growing season. Also note the "rill" erosion on the fallow plot; 91 tons of soil per acre was eroded from this fallow plot during the same period.

(Bottom) Side view of vetch plot showing the pronounced stair-step effect produced by the filtering out of coarse soil particles and aggregates by the vetch plants.

It is common knowledge that the quantity of runoff is markedly decreased by vegetation. This fact is repeatedly verified by runoff data presented at various places in this publication. The reduction in quantity of runoff is caused primarily by (a) permitting increased absorption and infiltration of water through old root channels, and (b) by holding the water on the slope for a longer period of time during which these processes may continue to function. (See Table 12.) In addition, plant residues and resulting organic matter exert a pronounced effect on the aggregation characteristics of soils. The effects of these characteristics on erosion have been observed in the field but have not been quantitatively measured. The data in Table 15 may serve to illustrate the influence of organic matter on aggregation.

TABLE 15.—Aggregate Analysis of Hartsells Fine Sandy Loam and of Porters Sandy Loam.

Soil type	Aggregate size classes in millimeters						
	>2.0	2.0-1.0	1.0-0.5	0.5-0.25	0.25-0.10	0.10-0.05	<0.05
	Aggregate separates in per cent of total						
Hartsells fine sandy loam	5.9	5.9	8.1	8.7	13.1	35.7	22.6
Porters sandy loam	50.1	10.4	13.1	9.7	11.8	4.0	0.9

The above two soils were found to be very similar in mechanical analysis but the Porters soil contained 5.6 per cent organic matter while the Hartsells contained only 1.5 per cent organic matter. The Porters soil is strongly aggregated; field observations indicated that this soil possessed extreme resistance to erosion. The Hartsells soil is structureless (single grained) and is known to be very susceptible to erosion.

The velocity of the film or layer of water during runoff is the factor which primarily determines the tendency of runoff to produce soil movement. The size of soil particle which water can transport is a function of its velocity. This velocity is difficult to measure directly. However, rate of runoff curves may be used to approximate slope velocity. Data from which such curves may be constructed have been obtained from a large number of artificial rainfall trials during which water was added at constant and known rates. A portion of a typical set of such curves is shown in Figure 8.

From this figure it may be seen that between two and three minutes were required, after the addition of water had ceased, for runoff to stop on a 20 per cent fallow slope. With a plot slope-length of 50 feet, this indicates a slope velocity of about 20 feet per minute. In a like manner, it may be seen that for-

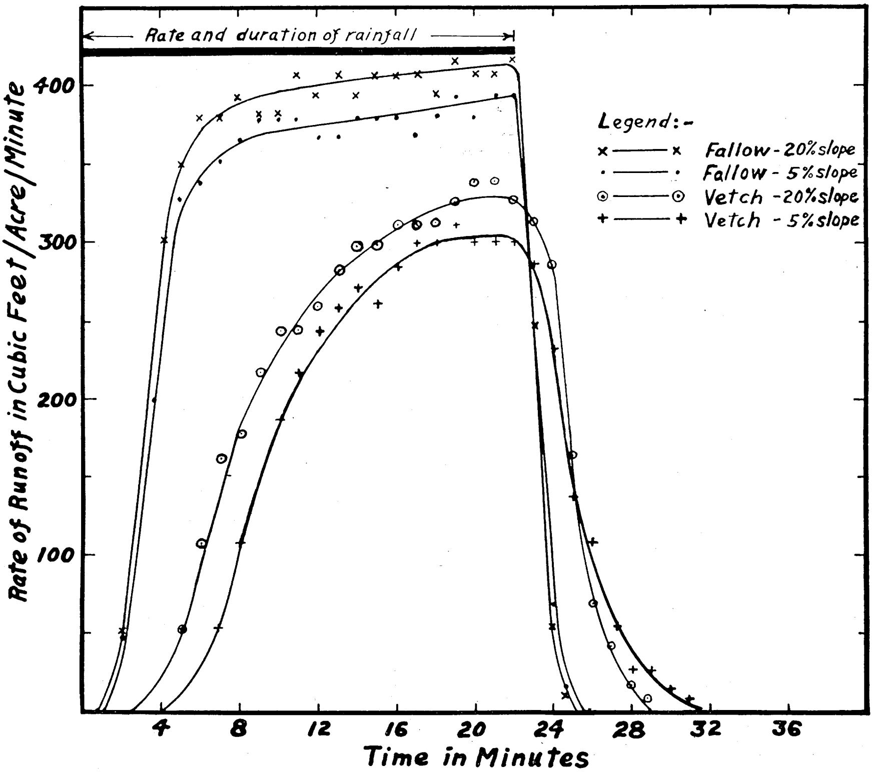

FIGURE 8.—Part of a set of typical runoff curves used to approximate slope velocities of runoff. (Rate of rainfall = 412.5 cubic feet per acre per minute.)

ward moving velocities of runoff were reduced to about 5 feet per minute and 7 feet per minute on 5 and 20 per cent slopes respectively, by a complete ground coverage of vetch. The approximate velocities of the runoff from flat plots during this trial were 2½ and 5 feet per minute, respectively, for vetch and fallow. These curves may be taken to indicate that on the slopes studied vegetative coverage had more influence than slope on the velocity of runoff.

The importance of vegetation in reducing the slope velocity of runoff can hardly be over emphasized. It is believed that this variable will have to be accurately measured before a quantitative relationship between runoff and soil losses can be established[1]. Nevertheless, it may interest the reader to compare the above approximated velocities with the magnitude of soil losses occurring during the same trial as reported in Table 5.

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[1] Concurrent measurement of slope velocity of runoff and rate of soil losses are being made under vegetative, tilled and fallow conditions on the different slopes. These findings wlll be reported at a later date.

It was observed that the flow of runoff frequently became turbulent on steeper slopes denuded of vegetation. The presence of thick vegetative coverage tended to promote a non-turbulent type of flow thus holding the abrasive action of sediment-loaded water to a minimum. At the same time ample soil coverage by vegetation caused a water blanket to be formed which protected the soil from further mechanical dispersion by beating rainfall. The relative importance of these dispersive processes has not been evaluated.

Influence of Vegetative Protection on Erosion.—Where nature has sufficiently covered the soil with vegetation, the runoff and soil losses due to erosion are not serious. Vegetation and vegetation residues contribute to retaining the soil in place in the following ways: (a) The vegetative cover breaks the falling velocity of rain which results in less soil being brought into suspension, (b) vegetative growth retards the forward moving velocity of runoff and allows coarse materials to be filtered out, (c) plant roots, organic matter, fungi and molds either increase absorption or bind the soil in place, and (d) vegetation intercepts a portion of the rainfall.

The value of vegetation in controlling erosion is determined by the growth habits of the plant (7) and methods of planting rather than the number of pounds of green material per unit area. Prostrate plants with a wide lateral spread are most effective in controlling erosion. Contour row plantings are much more effective than slope plantings.

A number of different crops have been tested to determine their value as soil saving crops. The winter cover crops grouped in order of their effectiveness in preventing soil losses from Cecil clay are: (a) vetch planted in 18-inch, contour rows, (b) rye planted in 10-inch, contour rows, and (c) oats planted in 10-inch, contour rows. The summer crops tested may be listed in order of their effectiveness in reducing soil losses as follows: (a) Alternate 12-foot, contour strips of soybeans planted in 18-inch rows and of cotton planted in 3-foot rows, (b) corn and velvet beans interplanted at 18-inch intervals in 4-foot, contour rows, (c) unchopped cotton planted in 3-foot, contour rows, and (d) chopped cotton planted in 3-foot contour rows.

During the fall and winter months rye was slightly superior to vetch in reducing erosion losses. Beyond this period the vetch rapidly outgrew the rye to an extent that it finally covered the entire surface of the plots. A maximum coverage of approximately two-thirds of the area between the 10-inch rows was attained by the rye. Thus, the vetch was much more effective than the rye during the latter stages of growth. From a study of the total seasonal losses in Table 7 it was concluded that rye was practically as effective as vetch for decreasing erosion.

However, vetch is a superior crop due to its nitrogenous value and is the most practical from a soil fertility viewpoint. In this experiment both rye and vetch were planted at normal seeding rates.

When the vetch and rye plants were at about one-half maturity a 1.25-inch artificial rain was added to each plot in 11 minutes. The soil was fairly well saturated from rainfall immediately preceding the trials. Under these conditions both runoff and soil losses were greater from the rye plots than from the vetch plots in all instances. The nature of the eroded material was rather similar when the plants were at half maturity. (See Table 16.) After the plants were mature, erosion was practically controlled on the vetch plots; the very small quantities of soil lost consisted for the most part of material in suspension. However, in the case of rye, appreciable quantities of both coarse material and suspension solids were eroded.

During the growing season of a crop of cotton, in which time the erosion producing rainfall was 12.50 inches, normal-spaced cotton plots lost appreciably more soil than plots of unthinned cotton. (See Table 17.) However, the low yields from unthinned cotton make it impractical to leave cotton unthinned.

During a period from November to May, vetch was found to be about ten times more effective for controlling erosion than was fallow; the erosion producing rainfall for the season was 20 inches. Detailed data for the experiment may be found in Table 8. Summary Table 18 reveals that the combined seasonal erosion losses from vetch and cotton are about one-half as much as those from cotton and fallow over the same period; the fallow condition differed from farm practice in that weeds and stalks were removed.

Influence of Strip Cropping on Erosion.—The practice of planting land to soil conserving crops in the form of contour strips of various widths between similar strips of clean-cultivated land is being recommended and used to some extent as an erosion control measure in some sections of the United States. A review of the literature fails to reveal experiments sufficiently comprehensive to serve as a basis for recommendation of such practices.

During the summer of 1932 cotton was grown on low contour beds on one of two plots on each slope; the companion plots were planted in alternate 12.5-foot, contour strips of cotton and of soybeans. Rainfall during the growing season totaled 22.5 inches. Soil losses from the plots in cotton alone ranged from 9,455 pounds per acre on 5 per cent slope to 62,121 pounds per acre on 20 per cent slope. Corresponding seasonal soil losses from the strip cropped plots varied from 7,614 pounds per acre on 5 per cent slope to 18,412 pounds per acre on the 20 per cent slope. The results of this experiment are summarized in detail

TABLE 16.—Physical Nature of Erosion Losses from Cecil Clay Protected by Vetch and Rye as Winter Cover Crops.

Mechanical analysis of soil (Textural separates)		Aggregate size class of eroded sediments	Slope of land in per cent									
			0		5		10		15		20	
			Vetch[1]	Rye[1]	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch	Rye
m. m.	Per cent	m. m.	Aggregate losses in per cent of total soil losses[2]									
		>2.0	Nil	Nil	1.7	0.7	1.0	2.8	2.4	3.1	2.7	5.3
2.0 -1.0	0.9	2.0 -1.0	7.5	3.6	2.6	1.7	2.6	8.0	4.7	8.3	3.5	7.9
1.0 -0.5	2.4	1.0 -0.5	6.6	4.1	5.3	4.0	7.3	15.5	10.9	20.6	8.4	12.6
0.5 -0.25	5.4	0.5 -0.25	5.8	3.4	4.4	2.7	5.9	9.4	9.6	9.6	6.7	8.3
0.25-0.10	13.4	0.25-0.10	22.6	15.6	20.6	14.5	18.7	15.0	21.4	17.6	22.3	17.4
0.10-0.05	9.2	0.10-0.05	17.0	15.5	42.4	40.5	37.6	15.9	27.3	17.2	25.9	14.0
<0.05	68.7	<0.05	40.5	57.8	23.0	35.9	26.9	33.4	23.7	23.6	30.5	34.5
0.05-0.005	16.3											
<0.005	52.4	Totals	100	100	100	100	100	100	100	100	100	100
			Aggregate losses in pounds per acre[2]									
		>2.0	Nil	Nil	2.3	3.0	4.2	70	20.6	125	46.0	271
		2.0 -1.0	2.2	4.0	3.6	7.2	11.0	203	40.6	332	60.5	404
		1.0 -0.5	1.9	5.0	7.3	16.8	30.7	394	94.1	826	144.8	644
		0.5 -0.25	1.7	4.0	6.0	11.4	24.8	238	83.5	385	114.8	427
		0.25-0.10	6.6	19.0	28.3	60.9	78.8	378	185.5	704	383.8	891
		0.10-0.05	4.9	18.8	58.3	170.5	158.3	401	236.5	692	446.7	717
		<0.05	11.8	70.0	31.8	151.1	113.3	843	205.0	947	525.1	1,763
Total soil losses in lbs./acre			29	121	138	421	421	2,527	866	4,011	1,722	5,117
Runoff in cu. ft./acre			1,772	3,305	2,730	2,988	3,046	3,127	2,844	3,037	3,311	3,908

[1] Vetch planted in 18-inch drill rows on contour at about 50 per cent ground coverage; rye planted in 10-inch drill row on contour at about 35 per cent ground coverage.

[2] Soil losses from 1.25 inches artificial rainfall applied in 11 minutes; surface soil partially saturated from previous rainfall.

TABLE 17.—Erosion Losses from Chopped Cotton and from Unchopped Cotton—1934.

Time of rainfall	Amount of rainfall[1]	Duration of rainfall	Slope of land in per cent									
			0		5		10		15		20	
			Chopped[1]	Unchopped[1]	Chopped	Unchopped	Chopped	Unchopped	Chopped	Unchopped	Chopped	Unchopped
Date	Inches	Hours	Soil losses in pounds per acre									
6/12/34	1.40	4½	150	440	3,900	3,700	11,700	11,000	26,400	23,400	31,800	27,300
6/18/34	1.94	[2]	827	1,551	9,959	7,620	19,285	19,970	40,013	39,301	49,106	47,634
7/13/34	0.83	⅓	Nil	Nil	1,934	1,292	3,794	2,625	4,658	4,151	5,452	4,100
8/12/34	2.93	13	199	191	2,118	732	21,145	5,344	29,621	14,308	28,068	15,174
10/6/34	4.00	38	Nil	Nil	17	20	206	49	238	135	170	112
10/13/34	1.40	36	Nil	Nil	26	15	84	35	115	85	114	42
Totals	12.50		1,176	2,182	17,954	13,379	56,214	39,023	103,045	81,380	114,710	94,362
			Runoff in cubic feet per acre									
6/12/34	1.40	4½	825	1,600	3,888	3,045	3,773	3,298	3,847	3,549	3,941	3,190
6/18/34	1.94	[2]	4,518	5,620	6,518	6,260	6,220	5,972	5,834	5,972	6,084	5,564
7/13/34	0.83	⅓	Nil	Nil	52	724	1,325	1,273	1,363	1,200	1,252	887
8/12/34	2.93	13	4,600	4,640	8,990	7,890	8,780	8,020	9,080	8,285	9,550	7,320
10/6/34	4.00	38	502	232	850	270	2,800	1,053	3,025	1,685	1,868	903
10/13/34	1.40	36	72	93	371	183	1,018	496	1,056	789	946	371
Totals	12.50		10,517	12,185	20,669	18,372	23,916	20,112	24.205	21,480	23,641	18,235

[1] Cotton planted in 3-foot, contour rows; total rainfall for the season = 21.1 inches; 12.5 inches falling as rains which produced erosion losses; cotton chopped on "chopped" plots between rains of June 18th and July 13th.

[2] Not determined.

TABLE 18.—Yearly Erosion Losses from Continuous Cotton and from Cotton and Vetch Rotation on Cecil Clay[1].

Period of Year	Slope of land in per cent									
	0		5		10		15		20	
	Cotton[2]	Cotton and Vetch	Cotton	Cotton and Vetch	Cotton	Cotton and Vetch	Cotton	Cotton and Vetch	Cotton	Cotton and Vetch
	Soil losses in pounds per acre									
Cotton Season June-October inclusive	1,237	2,251	18,883	16,344	62,434	62,419	113,800	110,088	138,465	132,493
Vetch Season November-May inclusive	927	773	27,564	3,784	90,218	6,392	135,179	14,767	182,662	19,675
June, 1934 to June, 1935	2,164	3,024	46,447	20,128	152,652	68,813	248,979	124,855	321,127	152,168
	Runoff in acre inches									
Cotton Season June-October, inclusive	3.53	4.05	6.85	6.55	7.73	7.53	7.75	7.71	7.83	7.48
Vetch Season November-May, inclusive	2.77	2.78	11.89	8.29	11.86	7.67	11.90	7.92	12.69	7.48
June, 1934 to June, 1935	6.30	6.83	18.74	14.84	19.59	15.20	19.65	15.63	20.52	14.96

[1] Total rainfall for the year was 45.4 inches; cotton season, 21.1 inches; vetch season, 24.3 inches; vetch used as a winter legume planted in 18-inch drill rows on contour.

[2] Plot out of level making losses abnormally low.

in Table 19. This strip cropping practice was particularly effective in reducing soil movements on the steeper slopes.

TABLE 19.—Seasonal Soil Losses from Cecil Clay Planted to Cotton and to Cotton-Soybean Strip Crops[1].

Period	Rainfall in inches	Cropping system	Slope of land in per cent			
			5	10	15	20
			Soil losses in pounds per acre			
Early summer (growing period of soybeans)	13.95	Cotton only	6,975	14,139	51,193	47,348
		Cotton-soybean strips	5,517	7,528	11,354	14,473
Late summer and fall	8.52	Cotton only	2,480	2,824	12,105	14,773
		Cotton-soybean stubble strips	2,097	2,205	3,665	3,939
Entire growing season	22.47	Cotton only	9,455	16,963	63,298	62,121
		Cotton-soybean strips	7,614	9,733	15,019	18,412

[1] 50-foot slope width of cotton alone; alternate 12.5-foot strips of soybeans and cotton; soybeans in 18-inch, contour rows planted flat; cotton in 3-foot rows on low contour beds.

Results of other experiments designed to determine the relative effectiveness of different widths of strip crops in controlling sheet erosion are summarized in Tables 20 and 21. Artificial rainfall of constant intensity and duration was applied in all instances while the ratio of strip crop to cultivated area was varied. The quantity of soil losses was greatly reduced by all widths of strip crops tested. Likewise, runoff as compared to that from fallow land was consistently reduced. These trials were made when the cover crops had reached maximum growth. At this stage the vetch in 18-inch rows completely covered the soil and the rye in 10-inch rows covered about two-thirds of the soil. A 12.5-foot strip of vetch or rye at maximum ground coverage on the lower end of a 50-foot plot practically controlled the movement of soil from all slopes studied when the upper 37.5 feet of each plot was freshly plowed and the soil was at low field moisture. One and one-fourth inches of water was applied to the plots in 11 minutes. When the soil was saturated and the above conditions held constant, a 12.5-foot strip of vetch or rye controlled erosion on a 5 per cent slope and reasonably controlled erosion on a 10 per cent slope. A 6.5-foot strip of vetch or rye controlled erosion on level plots when the rear part of the plot was freshly plowed. (Erosion was considered controlled when not more than 500 or 600 pounds of soil per acre was moved through the strips under the above conditions.)

The way in which strip cropping functions in reducing sheet erosion losses is plainly revealed by a study of the nature of

TABLE 20.—Soil and Water Losses from Cecil Clay under Different Strip Cropping Practices—1934[1].

Slope of land	Slope width of strips[2]													
	50 ft. Cover crop (at ½ coverage)		50 ft. Cover crop (at full coverage)		37.5 ft. Cover crop 12.5 ft. Plowed		25 ft. Cover crop 25 ft. Plowed		12.5 ft. Cover crop 37.5 ft. Plowed		12.5 ft. Cover crop 37.5 ft. Plowed		No Cover crop 50 ft. plowed	
	Sat'd		F. M.		F. M.		F. M.		F. M.		Sat'd		Sat'd	
	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch	Rye	Vetch Plot	Rye Plot
Per cent	Soil losses in pounds per acre													
0	29	121	6	35	0	29	0	26	0	4	160	420	1,592	1,518
5	137	421	17	169	23	128	45	54	58	35	582	524	2,787	2,183
10	421	2,527	103	1,199	47	832	40	504	71	292	1,243	1,071	20,537	8,038
15	866	4,011	223	1,870	88	972	100	643	204	257	1,663	1,507	28,035	18,729
20	1,722	5,117	170	1,927	120	585	183	519	201	278	2,261	2,714	37,745	35,150
	Runoff in cubic feet per acre													
0	1,772	3,305	82	2,632	319	1,461	Nil	818	Nil	163	2,595	3,202	3,952	4,508
5	2,730	2,988	1,157	2,759	1,592	2,268	1,022	1,078	667	501	3,387	2,949	4,023	3,709
10	3,046	3,127	1,534	2,702	2,377	2,811	872	1,617	446	637	3,710	3,247	3,912	3,082
15	2,844	3,037	2,058	2,680	2,520	2,899	1,433	1,620	1,079	777	3,881	2,598	4,057	3,129
20	3,311	3,908	1,646	2,625	2,491	2,191	1,538	1,430	1,103	831	3,767	3,468	3,401	3,754

[1] Losses from 1.25 inches of artificial rainfall in all cases.

[2] Cover crop at maturity or stage of maximum ground coverage in all cases except as noted; plowing was done a day previous to trial; plowed area above cover crop strip in all cases; vetch planted in 18-inch drill row on contour; rye planted in 9-inch drill rows on contour; F. M. = soil at low field moisture. Sat'd = surface soil partially saturated with water from rainfall immediately before trial.

TABLE 21.—Soil and Water Losses from Cecil Clay under Different Strip Cropping Practices—1935[1].

Slope of land	Slope width of Strip[2]											
	50 Ft. Fallow None Plowed	50 Ft. Vetch None Plowed	37.5 Ft. Vetch 12.5 Ft. Plowed		25 Ft. Vetch 25 Ft. Plowed		12.5 Ft. Vetch 37.5 Ft. Plowed		No Vetch 50 Ft. Plowed		No Vetch 50 Ft. Fallow	
	F. M.	F. M.	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd	F. M.	Sat'd
Per cent	Soil losses in pounds per acre											
0	227	8	Nil	Nil	Nil	26	Nil	101	Nil	147	20	53
5	11,188	6	12	64	38	177	31	293	Nil	1,277	5,027	4,541
10	30,150	26	14	67	28	255	117	377	127	3,743	11,238	6,356
15	34,384	48	20	128	29	419	142	632	217	19,402	18,778	9,287
20	42,519	521	37	181	156	625	231	1,363	1,794	39,981	25,152	12,377
	Runoff in cubic feet per acre											
0	5,260	3,610	Nil	2,470	Nil	2,440	Nil	3,067	Nil	1,542	1,207	2,376
5	7,600	4,660	960	2,870	1,071	2,839	419	3,358	Nil	3,002	3,195	3,875
10	7,870	4,610	1,535	3,190	664	3,110	854	3,410	180	2,811	3,572	3,899
15	8,260	4,830	1,540	3,500	857	3,359	967	3,468	240	2,951	3,691	4,097
20	8,770	5,320	1,295	3,360	1,129	2,924	885	3,115	450	3,495	3,684	3,902

[1] 1.25 inches artificial rainfall in 11 minutes in all cases except columns 1 and 2 in which 2.50 inches were added in 22 minutes. (The first 1.25 inches failed to produce erosion on the vetch plots.)

[2] Strip crop of vetch at full coverage below plowed areas in all cases; plowing was done a day previous to each test; F. M. = soil at low field moisture; Sat'd = surface soil saturated from first 1.25-inch rain; second 1.25-inch rain applied immediately.

sediments eroded from firm fallow and freshly plowed slopes. Aggregate analyses of sediments eroded under the above conditions are presented in Table 13; runoff data are included. Runoff expressed in percentage of rainfall applied is given for this set of experiments in Table 14.

A study of the data presented in Table 13 shows that, with the possible exception of the 12.5-foot strips on the steeper slopes, all widths of strip crop used almost completely filtered out the soil particles greater than 0.05 millimeters in diameter. A tremendous decrease of soil movement from the plots has resulted from the use of this control practice even in the case of relatively narrow filter strips.

However large quantities of soil were sheet-eroded from the cultivated portions of the plots and deposited in the strip crop areas. The strip crop functioned similarly to a broad-based terrace in that the velocity of runoff decreased and the coarser sediments were deposited. It was assumed in these studies that strip cropping is not a substitute for but rather a supplement to terracing.

A limited amount of field work on strip cropping was started in 1932 and has been conducted concurrently with the experimental work on the controlled plots. A 3.5-acre field which had been bench terraced and severely gullied was used for this work. Slope varied from 5 per cent to 35 per cent; the soil lacked uniformity but was predominantly a sandy loam. The old terraces were replaced with "Nichols" type terraces (4) and the area has been continuously strip cropped for nearly five years. Three systems of row direction were tried on the above field to determine the limiting slope on which equipment could be used efficiently and at what slope excessive erosion would result from different row directions.

During the first year of the experiment, the key-terrace system was used (4). Rows were run parallel to the key terrace. All terraces above and below the key terrace were crossed with rows at different angles. The following year a 45 degree system was brought into effect; after careful study of a topographic map of this field it was seen that the majority of rows would incidentally be at an angle of 45 degrees to the slope. Equal width strips of cotton and soybeans as summer crops and oats and vetch as winter cover crops were rotated in both of the above instances. During the third year the contour system was brought into use and is still being used. The contoured cotton rows on the terraces were so spaced that the terrace channel was between two rows of cotton.

The upper 2.2 acres of the field had slopes up to and including 20 per cent; this area was cropped in the following manner. In the fall the area that was in soybean stubble, consisting of approximately one-half the area between terraces and just below each terrace, was planted to either hairy vetch or

Austrian winter peas. The area that was in cotton on the terraces and extending above until joining the bean strip was planted to fall oats. Legumes were turned in the Spring and the land was planted to cotton. Oats were followed by soybeans and thus the rotation continued from year to year. On the lower portion of the field having 20 to 35 per cent slopes, the same rotation was followed except that Spanish runner peanuts were substituted in 2-foot rows for cotton as excessive erosion occurred when planted to cotton. (Cotton was planted on the tilled areas on all slopes in 1932 and 1933). By this system of rotation there was never more than approximately one-half the area between terraces freshly plowed at the same time.

It was found that with any system used the steeper the grade of the rows the easier it was to control the machinery; however, more erosion occurred. The 45 degree system was the most efficient for the use of machinery and least efficient for erosion control. With an efficient operator, the machinery was operated fairly satisfactorily on contoured rows up to 20 per cent slope. Short rows were eliminated by any of the three systems. Even with the contour system the odd shaped areas were always in a legume or feed crop. Observations indicated that erosion losses were held to a minimum.

Observations in the field and data from the controlled plots show that a wide strip crop is not necessary and that strip-width should be increased with the slope. Likewise the placement of the strip relative to the terrace is of major importance. The non-cultivated strip should extend above the terrace channel far enough to prevent the rapid movement of runoff and soil into the channel.

The cotton belt of the Southeast is characterized to a large extent by small terraced fields located on rough or broken topography; climate and soil conditions are rather unfavorable for permanent pastures and extensive commercial production of small grains and hay.

A consideration of the above conditions and of the limited experimental results indicate that there are certain advantages and disadvantages to strip cropping. The advantages may be listed as follows: (a) decreases the distance of soil movement on the field, (b) reduces the rate and amount of runoff, (c) decreases the amount of eroded material sedimented in terrace channels, thus decreasing terrace maintenance, (d) forces crop rotation and promotes the growing of small grains, hays and other roughages for local consumption, and (e) dispenses with "point" rows in the cultivated areas. The disadvantages of strip cropping may be listed as follows: (a) makes necessary a rotation practice on between-terrace areas, thus breaking the field into small patches, (b) tends to produce more hay, forage and grain than is necessary for home consumption in a region where low yields prohibit profitable commercial production,

(c) makes weed and insect control more difficult, and (d) involves the use of a larger variety of adaptable, soil conserving crops than is available at present for summer use on the vegetation strips.

It is evident that a considerable amount of experimentation must be conducted to answer the several practical problems arising from strip cropping before such an erosion control measure can be logically recommended as a general field practice in the Southeast.

Erosion Losses from Contour and from Slope-Planted Crops.—In general, the runoff from land planted on the contour is less than that from land planted with the slope. Likewise, soil losses usually increase as the runoff increases. During the growing period of a cotton crop, planted in 36-inch rows, seasonal soil losses from contoured and from slope-planted plots were determined. The seasonal losses from plots with contour-rows ranged from 4,178 pounds per acre on 5 per cent slope to 67,338 pounds on the 20 per cent slope. The losses from plots with slope-planted rows varied from 11,412 pounds per acre on the 5 per cent slope to 121,046 pounds on the 20 per cent slope. The rainfall during the period was 13 inches; about 7.5 inches of the total fell as erosive rains. Data for this experiment are presented in Table 22. On an average for all slopes, about twice as much soil was lost from the slope-planted cotton plots as was lost from the plots where the cotton was planted on the contour.

TABLE 22.—Seasonal Soil Losses from Cotton Planted on the Contour and with the Slope on Cecil Clay[1].

Direction of rows	Slope of land in per cent			
	5	10	15	20
	Soil losses in pounds per acre			
With slope	11,412	58,580	86,160	121,046
On contour	4,178	29,696	47,212	67,338

[1] Season April 1st to August 1st, 1931; total rainfall for period = 12.97 inches; 7.36 inches of rainfall producing all of the erosion losses.

Experiments were conducted when vetch was planted in 18-inch, contoured rows on one plot on each slope and when the companion plots were planted to vetch in 18-inch rows running with the slope. Artificial rains were applied to the vetch when it reached maturity. After this trial was completed, the vetch was removed at the soil surface with a hand knife without disturbing the soil. Tests were then made to determine the erosion control value of the stubble. Later, all plots were plowed and the same quantity and rate of rain was applied. Results of these experiments are reported in Table 23.

TABLE 23.—Soil Losses from Cecil Clay with Rows on the Contour and with the Slope[1].

Slope of land in per cent	Direction of rows	Surface condition		
		Mature vetch	Vetch stubble[2]	Freshly plowed
		Soil losses in pounds per acre		
0	Slope	63	458	
	Contour	95	191	611
5	Slope	81	1,093	
	Contour	65	194	2,059
10	Slope	90	1,516	
	Contour	82	239	2,371
15	Slope	569	6,733	
	Contour	268	2,393	7,903
20	Slope	604	9,256	
	Contour	284	5,823	19,150

[1] Losses from 1 inch of artificial rainfall applied in 8.5 minutes in all cases; surface soil partially saturated by rainfall immediately preceding the runs.

[2] Vetch removed by cutting near the ground with a knife without disturbing the soil.

The soil losses from mature vetch in both contoured and slope-planted rows were comparatively small in all cases. However, on the steeper slopes soil losses were about twice as much from slope-planted plots as from the contour-planted plots. After the vetch had been removed, the remaining stubble was much more effective on the contoured rows than the stubble on the slope-planted rows.

Relation of Slope to Erosion.—Runoff and soil losses, as previously stated, depend upon many interrelated variables. The severity of the losses increased with the slope of the land. This is in accordance with the findings of Bartel (1). The slope of land which can be tilled in practice without excessive erosion losses (the so called critical slope) varies quite widely with soil conditions, rainfall and farming practices.

Seasonal soil losses from different slopes under varying amounts of vegetative protection and rainfall with variations in surface shape are reported in Table 24. A part of these data is shown in Figure 9. A study of these data reveals the following:

(a) The seasonal soil losses from vetch, rye and alternate strips of cotton and soybeans were comparatively small on all slopes. The critical slope was probably never reached on any slope studied. This was due to vegetative protection of the cover crops and to the combined effect of surface shape, soil structure, and plant coverage on the strip-cropped plots.

(b) Losses from interplanted corn and velvet beans and from cotton were much greater than those from the crops mentioned above. The rate of soil movement increased rapidly between 10 and 15 per cent slopes and the soil losses were excessive in

TABLE 24.—Seasonal Soil Losses Produced by Natural Rainfall on Cecil Clay when Fallow and when Planted to Various Crops[1].

Crop	Soil surface	Amount of erosive rainfall	Duration of rainfall	Slope of land in per cent				
				0	5	10	15	20
		Inches	Hours	Seasonal soil losses in pounds per acre				
Vetch	Smooth	13.99	184	698	5,531	7,416	10,651	13,775
Rye	Smooth	13.99	184	1,933	6,731	7,258	11,900	14,007
Vetch	Smooth	20.00	164	773	3,784	6,394	14,767	19,675
Fallow	Smooth	20.00	164	927	27,564	90,218	135,179	182,662
Cotton-soybeans[2]	Bedded	13.95			5,517	7,528	11,354	14,473
Cotton	Bedded	13.95			6,975	14,139	51,193	47,348
Corn-velvet beans[3]	Bedded	13.39	155	235	3,403	13,147	34,922	43,228
Fallow	Smooth	13.39	155	674	29,131	73,784	92,073	118,197
Cotton[4]	Bedded	12.50	91	2,182	13,379	39,032	81,380	94,362
Cotton	Bedded	12.50	91	1,176	17,954	56,214	103,045	114,710
Oats	Smooth	35.15	307	1,618	9,898	23,075	52,894	60,136

[1] All crops planted on contour.
[2] Alternate contour strips.
[3] Interplanted in the same row.
[4] Cotton not chopped.

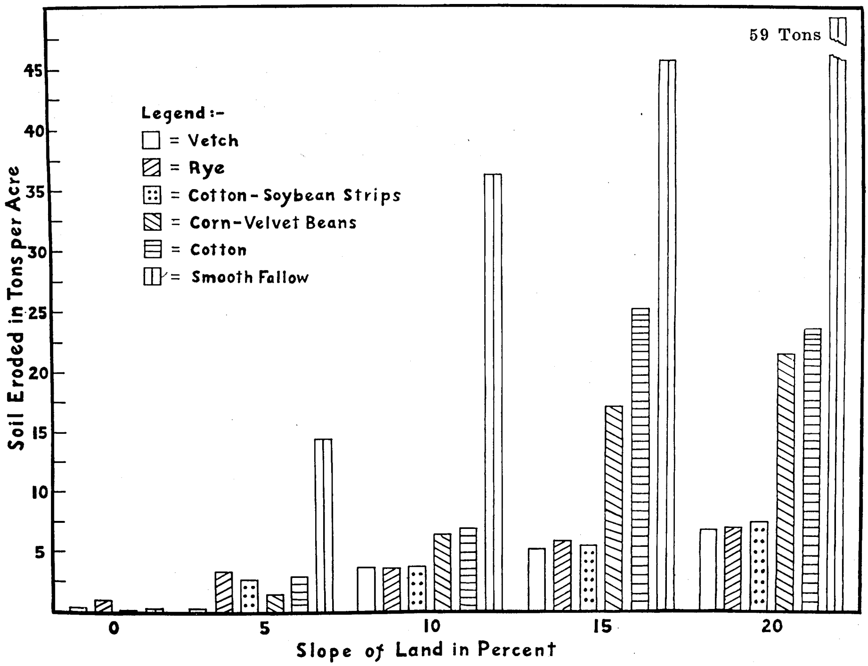

FIGURE 9.—Seasonal soil losses from different slopes under different vegetative coverage during growing seasons with comparable total rainfall.

all cases above the 10 per cent slope. A study of the data indicates that with these cropping practices the critical slope was between 10 and 15 per cent.

(c) Erosion losses from smooth fallow were comparatively high at 5 per cent and the rate of losses increased rather uniformly above this point. The critical slope was possibly reached at about 5 per cent.

(d) Soil losses are a function of slope under any given set of conditions. However, vegetation, surface shape and state of soil pulverization frequently exert a masking effect upon the slope factor. These factors are more important than slope in determining soil and water losses.

Effect of Erosion on Yields.—It is a generally accepted belief that yields are materially reduced by erosion. The North Carolina Station (1) has reported that the annual loss of plant food from sheet erosion may be seven times as great as that removed by a crop of cotton and four times as great as that removed by a crop of corn. Chemical analyses made at the Missouri Station (6) show that the amount of nitrogen, phosphorus, calcium and sulphur in the eroded material from corn or wheat land may be equal to or exceed the amounts taken off by these crops. Sheet erosion has so depleted large areas that crop production can no longer be conducted profitably; large areas of formerly productive lands have been gullied almost beyond redemption (3). Little reliance can be placed upon yields on the erosion plots at Auburn due to the fact that the experiment was not designed to study yields.

SUMMARY

Results of six years' experimentation on the measurement and control of the sheet erosion process on Cecil clay are reported. A set of ten controlled plots, each 15 feet by 50 feet was used; two plots were located on each of a 0, 5, 10, 15, and 20 per cent slope. Suitable equipment and methods were used to (a) measure the amount, rate and nature of soil material eroded from the plots, (b) measure the rate and amount of runoff, (c) supply uniformly distributed artificial rainfall at any desired rate and amount, and (d) record the intensity, quantity and duration of natural rainfall. Experiments were conducted under wide variations of soil condition and vegetative cover.

The moisture content of the soil influenced the rate and extent of absorption and hence influenced runoff and soil movement during any given rain. A large portion of seasonal erosion losses invariably resulted from a few heavy rains which occurred when the soil was approximately saturated.

Rainfall intensity was more important than the quantity of rainfall in determining the amount of erosion when other conditions were held constant and when the rate of rainfall exceeded the rate of infiltration to an extent that appreciable runoff occurred.

With a given intensity of rainfall, the duration had a marked effect upon erosion—the greater the duration, the greater the soil losses. Losses from intermittent rains of a given quantity were decidedly less than those from rains of continued duration, provided the rate of rainfall exceeded the rate of absorption. This was due to the inability of the soil to absorb the quantity of water during a given time. The exception to this was on smooth fallow, in which case the soil losses per unit of runoff decreased because the loose or slaked soil was readily carried off by the first part of the rain.

Pulverization and tillage practices which increased the rate and amount of absorption were very effective in controlling sheet erosion provided the rate and amount of rainfall did not exceed the rate and amount of absorption. When the rate of rainfall greatly exceeded the rate of infiltration, excessive soil losses usually resulted from such tillage practices.

Aggregate analysis of sediments eroded from Cecil clay under a wide variety of conditions showed that the unit particles involved in the sheet erosion process, in the case of structural soils, were aggregates rather than textural separates. In general, soil material is moved layer by layer in the sheet erosion process. The relative loss of colloidal material may be excessive under a condition or combination of conditions which results in small quantities of runoff or in runoff of low velocity or both.

Winter cover crops and other vegetative control measures functioned in reducing sheet erosion losses and soil movements by (a) filtering out the large soil particles and water stable aggregates, (b) decreasing the quantity of runoff, (c) decreasing the velocity of runoff, (d) minimizing the turbulence of runoff and hence lessening the abrasive or dispersive action of sediment-loaded water, and (e) by decreasing the mechanical dispersive action of beating rainfall.

Annual soil losses from land continuously in cotton were reduced to about one-half by the use of vetch as a winter cover crop. Rye, used as a winter cover crop, was nearly as effective as vetch in reducing erosion losses.

Various width strips of soil conserving crops were effective in reducing erosion and in decreasing the distance of soil movement on between-terrace slopes. It seems that if strip cropping is practiced, it should be used as a supplement to terraces rather than as a substitute for terraces.

Contoured, row-crop plantings had a pronounced soil and water saving ability when compared to slope plantings. The amount of soil eroded from slope-planted cotton was about twice as much as that from contour-planted cotton.

Erosion losses increased with increased slope under all conditions studied. The so called "critical slope" or point above which a given soil cannot be cropped without excessive erosion losses is more dependent upon such factors as plant coverage and tillage practices than on topography itself.

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