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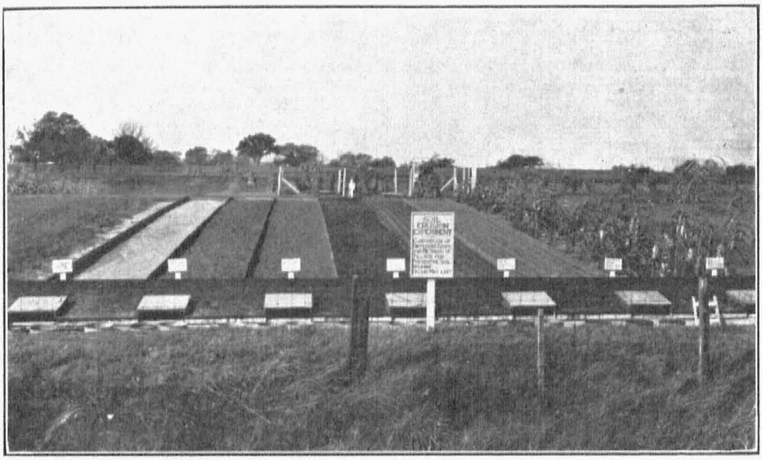
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
F. B. MUMFORD, *Director*

Cropping Systems in Relation to Erosion Control

M. F. MILLER



Erosion measurement plots at the Missouri Experiment Station where, dating from 1917, measurements have been made on the amounts of soil lost by erosion from land under different cropping and cultural systems.

COLUMBIA, MISSOURI

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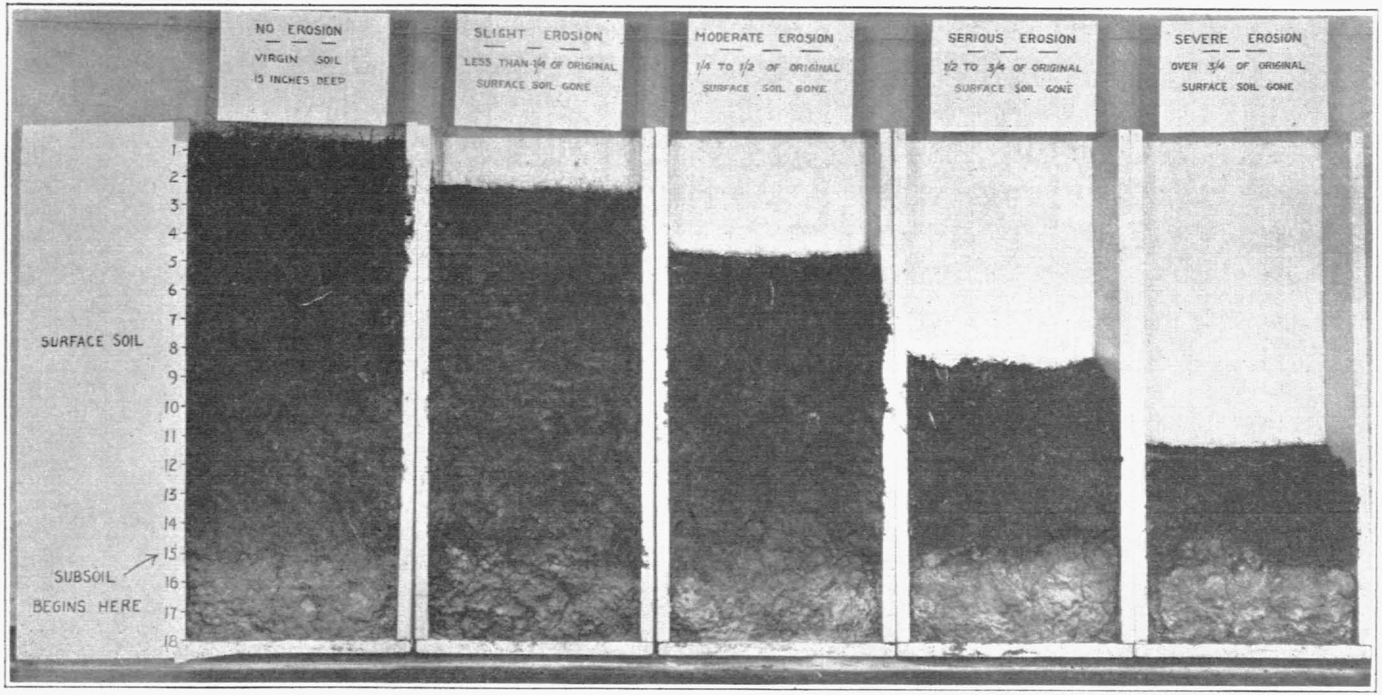

Fig. 1.—EROSION REMOVES FERTILE SURFACE SOIL FROM MISSOURI'S FARM LANDS. Samples of soil taken from different places in what was once one of the best soil areas in Missouri. The sample shown at the left is from a field which has been well cared for and little or no erosion has occurred. The other samples were taken from fields where less care has been taken. Excessive corn farming has resulted in varying degrees of loss of the surface soil and the sample at the right has had three-fourths of the surface soil washed away. Most of the serious erosion losses are due to improper cropping systems.

Cropping Systems in Relation to Erosion Control

M. F. Miller

A state-wide survey of the erosion conditions in Missouri was recently completed. This survey, which was made by the Federal Soil Conservation Service, in cooperation with the Department of Soils of the University, revealed the fact that the soil losses resulting from erosion are much more serious than have generally been recognized. According to this survey one-half of the total area of the state has lost at least one-half of the surface soil, and this has taken place in about three generations. If erosion should continue at this same rate for another three generations the remaining surface soil from this great area would be removed, thus exposing the subsoil over one-half of Missouri.

This erosion survey was made by comparing the depth of the surface soil in old feedlots, cemeteries and church yards, where it had never been plowed, with the depth of the adjacent farm land on the same slopes. While the results are naturally in the nature of estimates they are undoubtedly approximately correct and serve to call attention sharply to the dangers which erosion presents. They show the great importance of developing proper systems of erosion control if the soils are to be conserved.

It is well known that different crops vary widely in their influence upon erosion losses. Generally speaking, the clean tilled crops are less effective in controlling losses and the sod crops most effective. Other crops have influences intermediate between these two extremes. It is of importance, therefore, that the comparative influences of the various crops in controlling erosion, both when grown alone and when combined in cropping systems, should be better understood.

SOIL EROSION MEASUREMENTS AT COLUMBIA

In 1917 the Department of Soils of the Missouri College of Agriculture began a series of studies to determine the influence of various crops and cropping systems upon soil erosion losses. Fourteen year's results have been reported in Research Bulletin 177*. This is a technical bulletin, however, and it is the purpose of this follow-up report to apply these results, along with certain others, to the matter of field practice in the use of cropping systems for erosion control. It should be understood that a great deal is yet to be learned regarding the best systems of cropping for Missouri conditions and that the suggestions made are rather general ones for the use of individual farmers. No attempt has been made to prepare detailed suggestions for different soil types.

*Miller, M. F. and Krusekopf, H. H. 1932. The Influence of Systems of Cropping and Methods of Culture on Surface Runoff and Erosion. Missouri Agr. Exp. Sta. Res. Bul. 177.

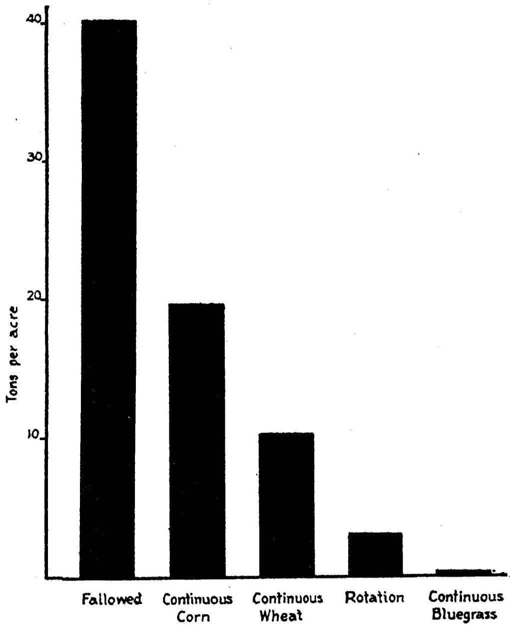

Fig. 2.—Chart showing relative amounts of erosion from land in different cropping and cultural systems (Columbia measurements).

It should be stated that the amount of erosion which may take place under a given crop is determined not only by the crop itself, but by the length and degree of slope of the land, the permeability of the soil to water and by certain other factors, particularly the nature of soil granulation. However, it is relatively simple to measure the comparative influences of different crops on erosion losses for a given soil type and for a selected length and degree of slope. This has been done in the experiments at Columbia and the figures given below illustrate the erosion losses as influenced by different crops and cropping systems. The wide differences shown by these various systems in relation to runoff and erosion, should have a general application to all soils and slopes.

TABLE 1.—AVERAGE OF 14 YEARS MEASUREMENTS OF RUNOFF AND EROSION, MISSOURI EXPERIMENT STATION, COLUMBIA. (SOIL TYPE—SHELBY LOAM. LENGTH OF SLOPE 90¾ FEET. DEGREE OF SLOPE 3.68 PER CENT.)

Cropping system or cultural treatment	Average annual erosion per acre in tons	Percentage of total rainfall running off the land
Bare, cultivated, no crop	41.0	30
Continuous corn	19.7	29
Continuous wheat	10.1	23
Rotation-corn, wheat, clover	2.7	14
Continuous bluegrass	0.3	12

It will be observed that the amount of erosion from bare, uncropped, cultivated land was about 40 tons per acre annually. Where corn was grown on the land and kept cultivated throughout the season the erosion was reduced to approximately 20 tons, or about one-half of that from the bare, cultivated land. In other words, while corn is known to allow much erosion to take place, the losses are still not nearly as severe as where no crop is grown and the land simply kept cultivated and free of weeds. Continuous wheat, grown in the same experiment, reduced the erosion to about one-half that from corn, or a total of 10 tons per acre, while continuous grass reduced the erosion to a negligible amount, or less than one ton of soil per acre.

One of the most striking results of this study is shown by the manner in which a good crop rotation reduces erosion losses. It will be noticed that the crop rotation used was corn, wheat and clover. When it is observed that the loss under continuous corn was around 20 tons per acre annually, that under continuous wheat 10 tons and under continuous sod practically nothing, one would expect that the average yearly loss from this three-year rotation would be $20 + 10 + 0 = 30 \div 3$, or 10 tons. However, the actual annual loss per acre under the rotation was only 2.7 tons.

The reasons for this very effective influence of the crops in rotation, as compared with their influence when grown singly, is due to various factors. In the first place, under continuous corn the land is practically bare the year round, while in the rotation the clover sod preceding corn is not plowed until early April, while wheat follows the corn in October. As a consequence, the corn land is exposed to serious erosion for only about six months during the regular corn year, that is from April to October. Again, instead of the wheat alone occupying the land for the wheat years, clover is sown with it in the spring so that during the months of May to October clover is growing in the wheat and in the wheat stubble, which materially reduces the erosion. Finally, the influence of the clover is to add organic matter to the soil and to make the land loose and granular so that it will absorb water more readily and erode much less than land that has not been in clover. All of these things have a very pronounced effect in making a good cropping system very effective in erosion control.

The influence of the rotation, particularly the effect of the clover, is well shown when one compares the erosion losses under continuous corn with the erosion losses under rotated corn, for the six months of the growing season during which time both plots are handled exactly alike. The figures show that for these six months the erosion for continuous corn is 4.7 times that from the corn following clover. Moreover, the run-off water from the continuous corn land was 2½ times that from the

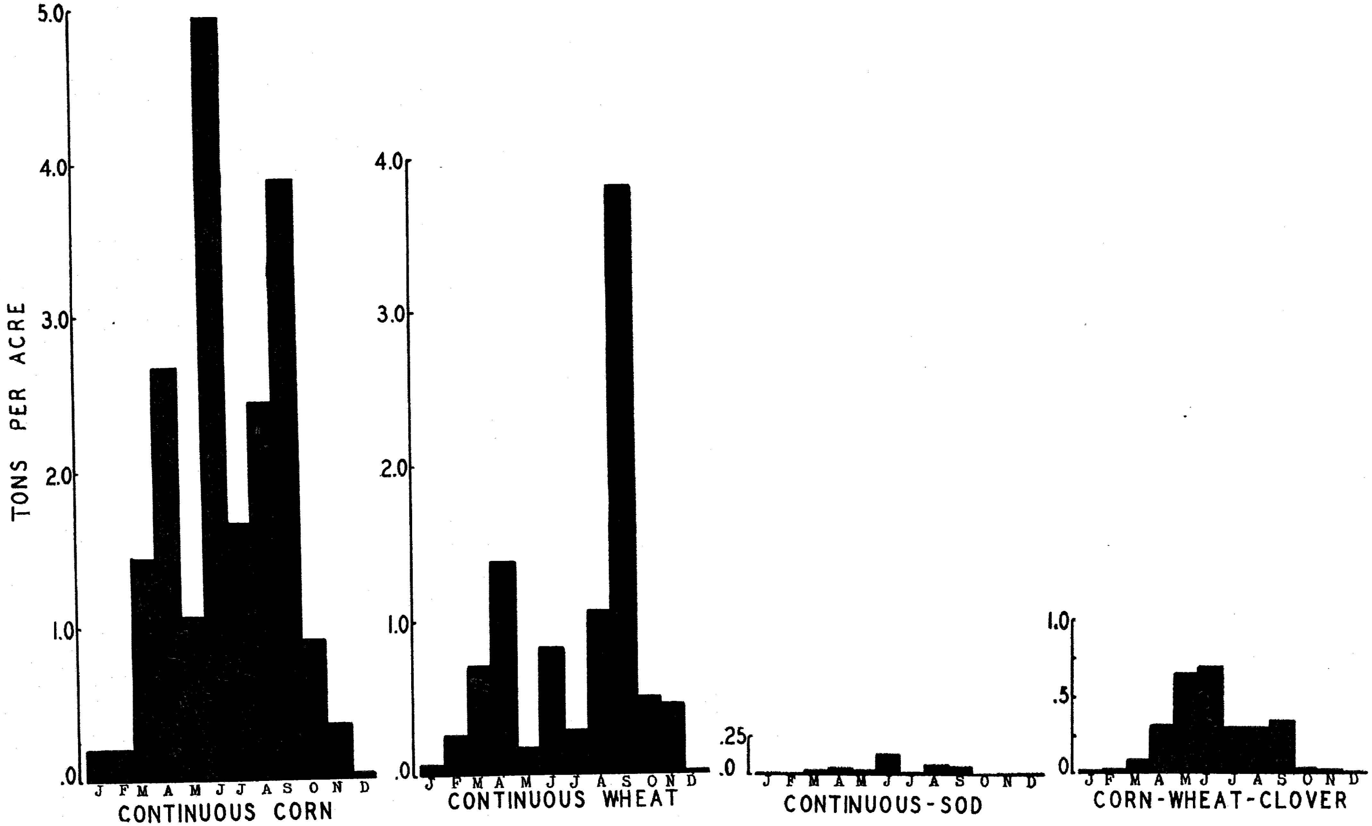

Fig. 3.—Chart showing the average number of tons of soil eroded per acre, during each month of the year, from land in corn, wheat and sod, when these are grown continuously on the same land as compared with the losses when these are combined in a good cropping system. (Columbia data.)

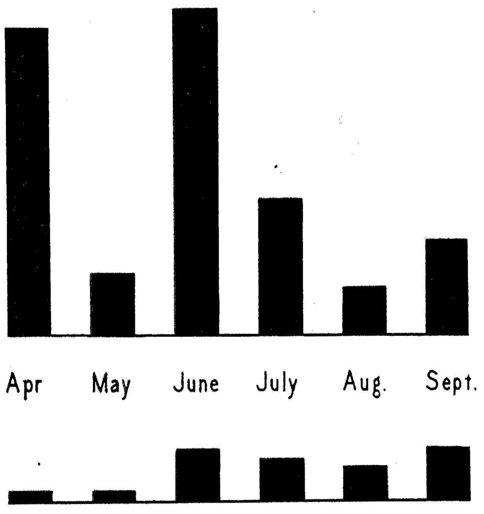

Fig. 4.—Each column represents the average amount of erosion from corn land for the six months of the growing season. The upper columns represent erosion from continuous corn and the lower ones from corn following clover in a good cropping system. Note the much smaller amount of erosion from the corn following clover (Columbia data).

rotated corn. These differences are largely due to the clover influence. This emphasizes the great importance of having in every good cropping system a crop of clover, or other good legume, at least every three or four years.

SOIL EROSION STUDIES AT BETHANY EROSION EXPERIMENT STATION

In 1930 a soil erosion experiment station was established by the federal government at Bethany, Missouri, in cooperation with the Missouri Experiment Station. One of the experiments carried on at this station is quite similar to the experiment which has been in operation at Columbia for measuring the influence of crops upon erosion and runoff losses. Several years data are available from this experiment and the results are given in Table 2.

It will be observed that the erosion from the bare land under continuous corn and that from the rotation is much greater than that from the Columbia experiment. The principal reason for this is that the slope of the land is twice as great at Bethany as at Columbia. However, the relative losses from the different cropping systems are somewhat similar at the two stations. At Columbia the corn reduced the erosion from bare cultivated land about 50 per cent, while at Bethany the reduction was

TABLE 2.—AVERAGE OF FOUR YEARS OF EROSION MEASUREMENTS UNDER DIFFERENT CROPS AND CROPPING SYSTEMS AT THE BETHANY EROSION EXPERIMENT STATION. (SOIL TYPE—SHELBY LOAM, DEGREE OF SLOPE, 8%, LENGTH OF SLOPE, 72.6 FEET.)

Cropping systems or cultural treatment	Percentage runoff	Tons soil eroded per acre annually
Bare soil kept cultivated, no crop	28.5	105.1
Continuous corn, kept cultivated	28.2	67.2
Corn, wheat clover rotation (Average of three plots)	13.8	12.9
Continuous alfalfa (limed and phosphated)	4.5	0.28
Continuous bluegrass	7.9	0.33

37 per cent. At Columbia the loss from the corn, wheat, clover rotation was 86.3 per cent of that from corn, while at Bethany this was 81 per cent. The loss from bluegrass was practically the same at both experiment stations.

No attempt is made in this report to summarize all available data dealing with the influence of cropping systems on erosion losses. Most of this data has been collected at the various erosion experiment stations of the country, such as the Bethany station, mentioned above, but official publication of most of this data has not yet been made.

THE INVESTIGATIONS OF J. E. WEAVER

The recent investigations of J. E. Weaver* and his coworkers at the University of Nebraska have added some excellent data dealing with the amount of vegetative material, both above and below ground, as this affects runoff and erosion. These investigations have been carried out with great care using sometimes natural rainfall and sometimes artificial rain or the influence of a water spray in securing quantitative measurements of water and soil losses. Brief reference is made in the following paragraphs to some of the characteristic data secured.

The influence of excessive grazing of grass lands is given particular attention in these investigations. For instance, during a 15-month period with a natural rainfall of 26.88 inches on a Carrington loam with a slope of 10 per cent, the following results were secured.

TABLE 3.—INFLUENCE OF EXCESSIVE GRAZING ON AMOUNT OF EROSION ON GRASS LANDS

	Percentage runoff	Tons soil eroded per acre
Native prairie ungrazed	2.5	0
Mixed bluestem and bluegrass pasture, overgrazed	9.1	Trace
Mixed bluestem and bluegrass pasture, almost bare through close grazing	15.1	5.08

*Weaver, J. E. and Harmon, Geo. W. 1935. Quantity of Living Plant Materials in Prairie Soils in Relation to Runoff and Soil Erosion. Conservation and Survey Division, University of Nebraska, Bul. 8.
Weaver, J. E. and Noll, Wm. C. 1935. Comparison of Runoff and Erosion in Prairie, Pasture and Cultivated Land. Conservation and Survey Division, University of Nebraska, Bul. 11.
Kramer, Joseph and Weaver, J. E. 1936. Relative Efficiency of Roots and Tops of Plants in Protecting the Soil From Erosion. Conservation and Survey Division, University of Nebraska, Bul. 12.

Other measurements of such losses show similar results. The conclusion is reached that "where there is a good cover of grass there is no serious problem of erosion, but where the cover of grass is broken or removed by excessive grazing, erosion is the inevitable sequel," and that "pasture improvement is a chief weapon against erosion."

Some of Weaver's data showing the runoff and erosion from land in prairie sod, badly overgrazed bluegrass and from the bare soil, with a 10 per cent slope, is particularly interesting. In this experiment two inches of water was applied as artificial rain in one hour, followed about an hour later, by a half inch during a 15-minute period. The results were as follows:

TABLE 4.—RUNOFF AND EROSION FROM LAND IN PRAIRIE-SOD (WEAVER'S DATA)

	Per cent of runoff	Tons soil eroded per acre	Inches to which water penetrated in five days
Prairie sod	0	0	42
Overgrazed bluegrass	29.3	0.08	22
Bare soil	50.4	3.4	19

This is one of the few experiments on record in which the relation between runoff and depth of water penetration in the soil has been recorded. Again the striking influence of the virgin prairie sod in contrast with that of the overpastured bluegrass, particularly as it affects runoff, is clearly shown.

Weaver has done most interesting and valuable pioneer work in determining the comparative influence of the above-ground and below-ground parts of crops in holding the soil against erosion. In these investigations, blocks of soil, four inches deep and one half meter in area, bearing the growing crops, were incased in frames and carefully lifted, without disturbance, after which a wooden bottom was inserted. From some of the blocks the tops of the crops were removed, leaving only the below-ground parts, while in others the tops were left undisturbed, for comparison. These blocks were then placed in a slightly sloping position and a spray of water directed against them until such time as the four inch layer of soil was washed away. The time required to remove the soil from those blocks on which the tops still remained, as compared with that of the blocks with tops removed, was carefully noted. He has thus measured the protection against erosion offered by the roots and tops combined as compared with that offered by the roots alone.

Weaver finds that the time required to erode the soil when the tops are left on is usually from one to seven times that where the tops are removed, depending on the crop and the stage of growth. The ratio of the time of erosion without tops to that with the tops left on, he terms the "erosion ratio." Thus in a given case, young alfalfa sown in the fall and just starting in the spring with a height of two inches had an erosion ratio of 1:1.1, while in midsummer with a height of sixteen inches the ratio was 1:2.7. In other words, in the two inch stage, the tops added very little to the resistance to erosion, while with sixteen inches of top growth the resistance had increased to 2.7 times that of the roots alone.

The following table made up from a large mass of data presented by Weaver shows the erosion ratios, for various crops and other plants, at given stages of growth.

TABLE 5.—EROSION RATIOS OF VARIOUS PLANTS AT GIVEN STAGES OF GROWTH (WEAVER'S DATA)

Plant and Stages of Growth	Dry weight in grams		Erosion ratio
	Tops	Roots, etc., in surface 4 inches	
Turkey wheat, upland soil, rosette stage, 3″ high	18	17	1: 1.2
Turkey wheat, upland soil, early boot stage, 15″ high	123	41	1: 1.7
Turkey wheat, upland soil, early dough stage, 36″ high	354	42	1: 4.2
Oats, lowland soil, 17″ high	107	28	1: 1.9
Oats, lowland soil, 27″ high	229	49	1: 3.8
Oats, lowland soil, 34″ high	312	43	1: 5.3
Hogue's Yellow Dent corn, 9″ high	4	3	1: 1.0
Hogue's Yellow Dent Corn, 30″ high	70	15	1: 1.3
Hogue's Yellow Dent corn, 75″ high	430	65	1: 2.1
Sweet clover, June 20, 28″ high	233	66	1: 4.3
Rye in fall, October 25, 4″ high	69	37	1: 1.9
Sudan grass, July 1, 10″ high	58	20	1: 1.6
Sudan grass, July 12, 29″ high	191	44	1: 6.0
Sudan grass, August 5, 56″ high	489	77	1: 8.1
Rape, June 23, 25″ high	222	44	1: 6.6
Rough pigweed, 18″ high	192	50	1: 1.9
Field bindweed, 5″ high	122	23	1: 2.5
Yellow foxtail, dead	263	--	1: 8.1
Crab grass, dead	167	--	1:15.0

These data show the remarkable effect of the above ground parts of plants in protecting the soil from erosion. The effectiveness of complete cover is clearly indicated. Crops sown thick or those that have reached a stage at which a mass of material covers the soil are very effective in lessening erosion. Crops like Sudan grass, once they have reached a good growth are especially effective in this respect. The roots of the dead foxtail and crabgrass samples used in these experiments, were also dead, so that the erosion ratio is very high. It is probable, however, that this dead mat on the surface is in itself a very effective protector, even without living roots. Weaver states that prevention of erosion does not

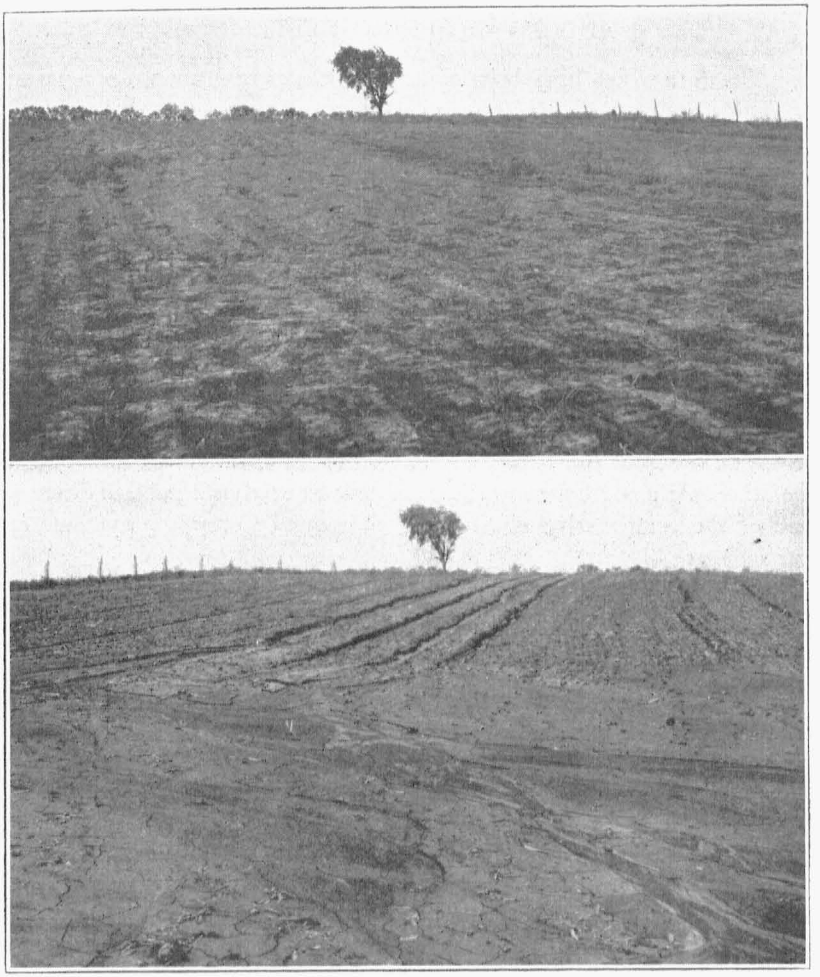

Fig. 5.—The field shown above had been in timothy sod in a regular crop rotation and the one shown below had been in corn for several years before plowing and preparing for corn. A heavy rain caused much greater erosion on the land which had been in corn than on the land which had been in a crop rotation. (Photo through courtesy of Soil Conservation Service.)

result so much from vertical thickness of cover as from one which is widely spread and continuous. He calls attention to the fact that a single leaf on the soil is effective as regards protection directly beneath it, and suggests that broadcasting should afford greater soil stabilization than drilling seed thickly in rows.

THE RELATION OF THE SOIL TO EROSION LOSSES AND TO CROPPING SYSTEMS

The data which have been given from the erosion measurements at Columbia and at Bethany apply to a single soil type—the Shelby loam, but with two distinctly different slopes. The soil at Bethany contains somewhat more organic matter than this same soil type at Columbia, but otherwise the soil on the two fields is fairly comparable. It is, of course, to be understood that data secured from one soil type will not apply directly to other soil types, since some soils are more readily penetrated by water than others thus causing differences in runoff and erosion. Moreover, soil types differ in texture, structure and the content of organic matter, all of which have an influence on erosion losses. In spite of these variations, however, it is reasonable to assume that the *comparative* differences in erosion under different crops or cropping systems, grown on different soil types, will have about the same relations one to the other. As a consequence, the data may be used as a general illustration of the comparative effects of such crops or cropping systems on erosion losses.

The amount of erosion which takes place under a given crop, when grown on a given soil, is not the only thing that determines the adaptability of the crop to the soil in question. The native fertility, the permeability of the subsoil, the depth of the surface soil, the texture and the soil reaction, are other things which determine the crop or crops to be grown on a specific soil type. On those Missouri soils which are deep and fertile, particularly where the slope is slight, cropping systems including much corn have a very prominent place. Soils of less fertility, or of greater slope, are less adapted to corn but better adapted to small grains, so that on such soils a part of the corn acreage should be replaced by these grains or by sod crops. On still less fertile soils and particularly where such soils are rolling to steep in topography, corn may have to be eliminated entirely and the land cropped to small grains and sod crops. Of course, on the very steep lands pasture crops and timber may replace the regular harvested crops. Those relations of the cropping system to the soil are very evident ones. There are, of course, other factors which determine the cropping system, but so far as erosion is concerned these are the most important.

AMOUNT OF EROSION DURING DIFFERENT MONTHS

In planning any cropping system it is important to consider the amount of erosion that is likely to take place from cultivated land during each month of the year. One should plan the cropping systems in so far as possible, so that the ground is covered with a thick growing crop during those months when erosion is likely to be greatest. Naturally, the average monthly erosion depends primarily upon the amount of torrential rainfall, and this differs somewhat from region to region even in the same state, but where the total monthly rainfall records are available these may be very helpful in planning cropping systems. The experiments at Columbia show the following monthly erosion losses from bare cultivated land, as an average for fourteen years; the monthly rainfall is shown along with these for comparison.

TABLE 6.—MONTHLY EROSION FROM BARE CULTIVATED SOIL BY MONTHS. MISSOURI EXPERIMENT STATION, COLUMBIA; OVER A 14-YEAR PERIOD.

Months	Total tons soil eroded per acre	Average monthly rainfall in inches
January	2.6	1.37
February	5.0	1.44
March	28.4	3.26
April	64.2	4.22
May	30.8	4.73
June	104.8	5.01
July	30.3	2.78
August	132.2	4.47
September	139.2	5.21
October	23.3	3.57
November	12.8	2.46
December	0.9	1.83

It will be observed that at Columbia the months of most severe erosion are June, August, and September. The winter months show very little erosion while the other months of the year show moderate losses. A cropping system in which rolling land is cultivated or left bare during these three months of excessive loss would be almost certain to result in serious erosion. For instance, on such land, corn would allow much erosion throughout these three months and if this crop appeared two or three times in a four or five year cropping system the erosion would usually be excessive. Again, land plowed in late July or early August for wheat, as is often recommended, would be especially susceptible to the August and September erosion. This would be particularly true if the land were worked down soon after plowing. If it were left in the rough condition of the furrow slices the danger would be less. In any cropping system, if the land can be kept covered during these erosive months, with the exception of an occasional crop of corn, or other similar crop, the erosion should be largely controlled. Therefore, in most parts of Missouri, care should be taken to consider the relation of the different crops in the system to the months of heavy erosion losses.

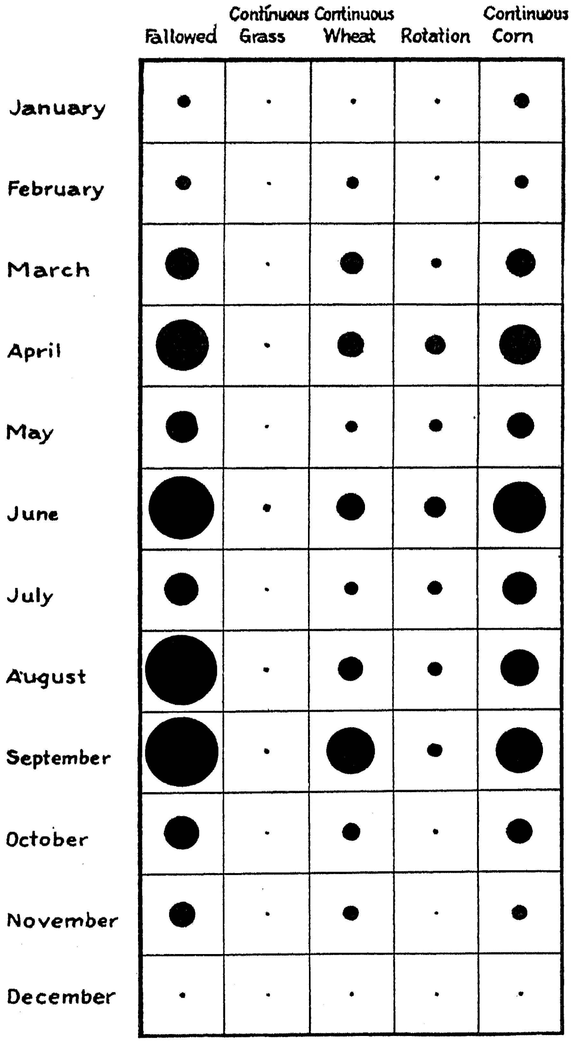

Fig. 6.—The circular areas show, in a comparative way, the average amounts of erosion which took place at Columbia from different cropping or cultural systems during each month of the year.

THE EFFECT OF INDIVIDUAL CROPS ON SOIL EROSION

From what has been indicated and from the data given it will be understood that crops vary widely in their influence on erosion losses. Some allow much erosion, some practically none, while other crops hold an intermediate place. Although sufficient erosion measurements have not been carried out to determine the exact relation of all crops to erosion, the following general classes or groups of crops may be listed.

Crops allowing much erosion	*Crops allowing moderate erosion*	*Legume sod crops allowing little erosion*	*Grass sods allowing little erosion*
Corn	Wheat	Alfalfa	Bluegrass
Cotton	Oats	Red clover	Red top
Tobacco	Barley	Alsike clover	Timothy
Soybeans (in rows)	Rye	Sweet clover	Orchard grass
Potatoes	Soybeans (drilled)	Korean lespedeza	

The crops named are the more important ones grown in Missouri. There are others of lesser importance which would fall into these various classes but their acreage is small and in some cases little information is available as to their relation to erosion.

Crops Allowing Much Erosion.—The crops allowing much erosion are naturally those which are intertilled. Such crops leave the surface of the soil bare during the growing season and in some cases during the entire year. Their above-ground parts stand erect and offer little surface protection. They have no mat of roots at the surface to hold the soil. Even when such a mat tends to form it is partly destroyed by the tillage necessary to control the weeds. Those intertilled crops which are grown with the rows wide apart allow more erosion than those with the rows close together. Moreover, in Missouri, the season of the year when cultivation is most active usually coincides with the periods of heavy and torrential rains. This is a very important influencing factor. Many farmers think that because the soybean is a legume it is very beneficial to the soil. This is true if it is grown on level lands, or in a manner which prevents erosion, and if it is then properly utilized by feeding it back on the land. However, where soybeans are grown in rows at corn planter widths, and cultivated, they allow practically the same amount of erosion as does corn. Under such methods on rolling land, soybeans may do more harm than good. In other words, the nitrogen carried away in the eroded soil may be much greater than that added to the land by the nitrogen fixing action of this crop. The following data from the experiments at Columbia bear on this point.

TABLE 7.—COMPARISON OF EROSION FROM CONTINUOUS SOYBEANS VS. CONTINUOUS CORN, WHERE THE SOYBEANS WERE FOLLOWED BY A RYE COVER AND THE CORN LAND LEFT BARE.

	Average annual erosion. Tons per acre	Erosion loss from soybeans as percentage of loss from corn
Years 1924-27		
Continuous corn	20.68	
Continuous soybeans in rows at corn planter widths	19.52	94.5
Years 1928-31		
Continuous corn	21.46	
Continuous soybeans drilled with grain drill	9.39	43.7

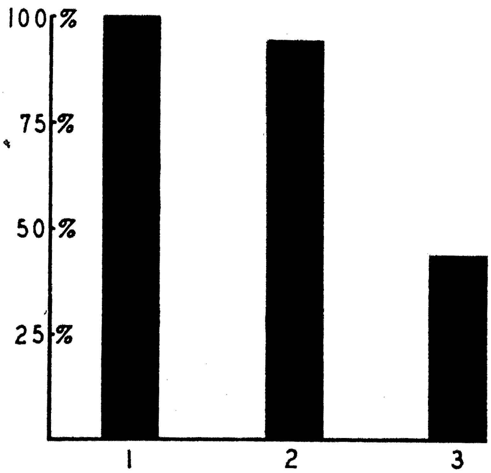

Fig. 7.—Erosion losses from corn as compared with soybeans. Erosion from corn considered as 100 (Columbia data).
1. Erosion from continuous corn.
2. Erosion from continuous soybeans, sown in rows and followed by a rye cover crop.
3. Erosion from continuous soybeans, sown solid with a drill and followed by a rye cover crop.

Without the rye cover the soybeans sown in rows would doubtless show greater erosion than corn.

It will be observed that in spite of the fact that the soybeans were followed by a winter cover crop each year, while the corn was not, the erosion from the beans grown in rows and cultivated was 94 per cent of that from continuous corn. If the rye cover had not been used, there is no doubt that the erosion would have been greater than that from the corn. On the other hand, when the beans were sown with a grain drill the erosion was reduced to 43 per cent of that from corn. In all of these cases the corn and soybean rows ran up and down the slope. If it had been possible in this experiment to have had rows running across the slope, or with the contour, experience indicates that the losses in all cases would have been considerably less. As a matter of fact, the man who is growing soybeans on rolling land, even that which is gently rolling, should drill the beans on the contour if he expects to control erosion satisfactorily. This is particularly true with soils having heavy subsoils. Where the beans must be sown in rows and cultivated, the rows should certainly be placed on the contour, otherwise more fertility will be lost through erosion than will be gained by growing the legume. Of course, the real benefit to the soil from growing soybeans can only be expected when they are fed and the manure returned, when they are hogged down or pastured, or when they are grown after a small grain and turned under. Whenever, they are removed from the land, leaves and all, and nothing returned, they have little positive value even where erosion is controlled. When they are grown on level land or when the erosion is controlled by proper handling, and when through feeding or green manuring, much of the fertility in the crop gets back to the soil, they are very beneficial.

Crops Allowing Moderate Erosion.—The various small grain crops cover and hold the soil fairly well after they have made a growth of a few inches. Even the dead stubble, after the crops have been harvested, is fairly effective, particularly since there are usually more or less weeds present. These crops are really intermediate between cultivated and sod crops in this respect. However, the time at which the seedbed is prepared is very important in determining the erosion that may take place. In many parts of the grain belt some of the most torrential rains occur in the early fall when land is being prepared for wheat. At Columbia the measurements show that under continuous wheat approximately one-half of the total erosion occurs during the months of August and Septemver. The early seedbed preparation which has been rather generally recommended may, therefore, cause so much erosion as to make it necessary to compromise on this matter and prepare the seedbed later, even if a roller may be necessary to get it well settled. Where wheat follows corn the land is usually not worked up until just a few days before wheat sowing and this saves considerable erosion.

Fig. 8.—Clover is one of the very best crops to include in a cropping system for erosion control. Not only does it keep the land covered for two years, but it brings about better water penetration and soil granulation which greatly decrease erosion losses.

Rye has much the same influence in controlling erosion as has wheat. It is usually sown about the same time and is on the ground for about the same period. Winter barley is commonly sown earlier than oats or wheat and in many cases it starts early enough to hold the land pretty well against the late September rains and those that follow. It also makes a rapid fall growth which increases its effectiveness.

Of the various small grains, oats is the least effective in controlling erosion. Usually the land lies over winter in corn stalks or stubble, where oats is to follow, and the oats does not begin to hold the ground until April. The crop is harvested in July and where followed by wheat, as is usually the case, one must reckon with the losses already mentioned in the preparation of the wheat seedbed.

In the case of most small grains occurring in a rotation, clover, lespedeza, or a mixture of clover and grass usually follows. These young plants growing up in the small grain in early summer help very decidedly in holding the soil during the fall and winter months. They add a great deal to the effectiveness of small grains in rotation as compared with small grains grown alone. As a matter of fact, small grains grown in rotation are always much more effective in controlling erosion than where they are grown almost continuously, as in some wheat sections.

The Legume Sod Crops Allow Little Erosion.—The legume sods are very effective in controlling erosion. Alfalfa which is a perennial and the red and sweet clover which are biennials, cover the ground for long periods. While they do not make as close a cover as good bluegrass or redtop, the differences in the erosion between alfalfa, red clover and bluegrass, as shown in the data, are not very great. The granulating effects of these crops in lessening the erosion from the crop following has already been indicated.

A comparatively new sod legume which is becoming very widely used in Missouri is the Korean lespedeza. When once well established on the ground, particularly where it is allowed to reseed a couple of times, it grows very thickly and is excellent for holding the soil from the time it is well set in May until early winter. If it is not pastured too closely, or if it is not cut for seed, the thick dead mat of material remains on the ground over winter and appears to be quite effective in controlling such erosion as takes place during these months. Where cut for hay or pastured closely it does not hold the soil so well. Thus far little actual data is available on the erosion losses under lespedeza, but at the Bethany Erosion Experiment Station the measurements for 1934 show a loss of only 1.6 tons of soil per acre, while land in corn lost 60.8 tons per acre during the same year. It seems quite evident, therefore, that when properly used the lespedeza can be depended upon to function very effectively in erosion control. It offers a good deal in this respect.

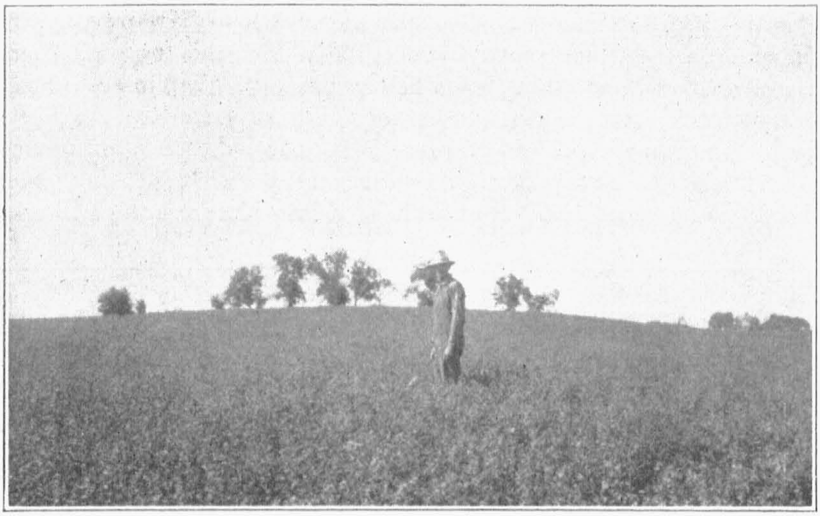

Fig. 9.—Experiments show that alfalfa practically equals bluegrass in controlling erosion. Like bluegrass it is not well adapted to short rotations but it has a most important place on good rolling land, which, under excessive corn farming, rapidly washes away.

One of the great advantages of the various sod legumes, with the exception of alfalfa, is that they work satisfactorily in rather short rotations. Where they are sown alone or mixed with grass they have a very pronounced soil conserving influence. The principal difficulty in using the red and sweet clovers is found in the fact that many soils need lime for their satisfactory production. On the other hand, their pronounced soil building properties, along with their effectiveness in erosion control, give them a great importance in many parts of the country. The use of alfalfa on the better lands as a hay crop, where it may be left down for several years, outside of the regular cropping system, the use of red and sweet clovers on the better lands, where they can be grown with or without liming, and the use of Korean lespedeza on the average to thinner lands, and in some cases on the better lands, offer a great deal from the standpoint of controlling erosion losses.

The Grass Sod Crops Allow very Little Erosion.—In general the grass sods are the most effective crops known for erosion control. This is because they cover the ground well, they have a thick mat of roots in the surface of the soil, most of them present a porous mass of organic matter at the surface to protect the soil and to absorb the rain, while they remain on the ground the year around. Bluegrass on land good enough to grow a thick stand of it, and when not pastured too closely, is generally considered the most effective for Missouri conditions. In the extreme southern border of the state, Bermuda grass may be more effective than bluegrass at its best. Close pasturing of bluegrass, particularly on land of low fertility, greatly reduces its value in this respect. There is also another thing which should be recognized with reference to bluegrass pasture. This is that gullies very frequently start in the cattle paths or in the principal water courses in pastures and these often assume considerable proportions before the farmer realizes what is taking place. Too often farmers think that once the land is in bluegrass this will take

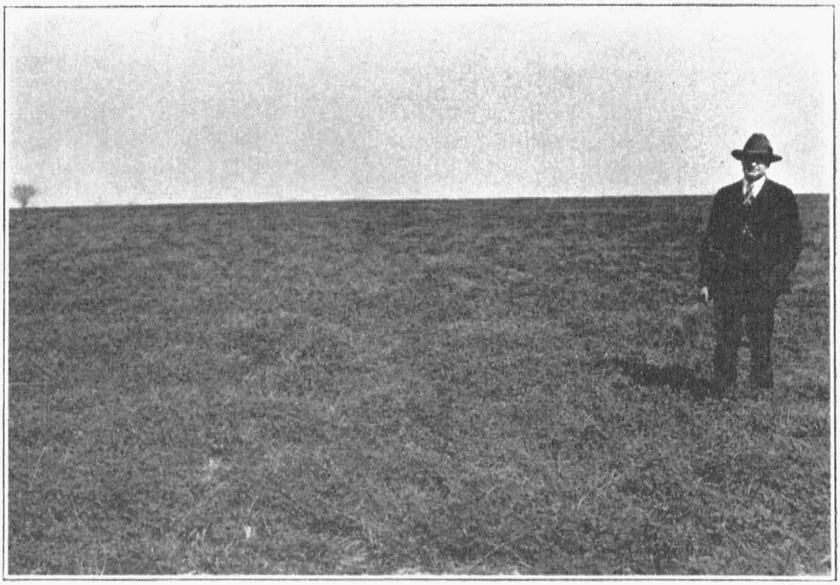

Fig. 10.—Sweet clover, like red clover, may be used to keep the ground covered two seasons, particularly where it is pastured. On lands adapted to it this crop has marked possibilities not only for erosion control but for soil improvement.

care of all erosion, and they neglect the gullies which often develop. Once such gullies have assumed a fair size they are very difficult to fill by the use of dams, since there is so little soil washed in from the sod. It is important, therefore, to watch the incipient gullies in pastures and stop them before they develop into large ones.

Redtop covers the ground well and is generally adapted to poorer soil than bluegrass. It has an important place in erosion control on such lands, either alone or mixed with Korean lespedeza, or with some other grass. It is particularly valuable for sowing in gullies where these are deep enough so that the soil is rather moist. It is also valuable for seeding in terrace outlet ditches. Timothy makes a somewhat less compact sod than either bluegrass or redtop, but it does very well in holding the soil. It is particularly suited to use in a cropping system where it is sown with clover. Orchard grass has a place on poor land as well as on good land, particularly where Korean lespedeza is sown with it. There are large areas, especially in the southern part of Missouri where a mixture of orchard grass and lespedeza is very satisfactory as a pasture and as a soil binding crop.

THE OLD STANDARD FOUR AND FIVE YEAR CROPPING SYSTEMS

The cropping systems which have been greatly used in many parts of the country are those containing corn, one or two years, followed by one or two crops of small grain and one or two years of clover and grass. Wherever such plans are adapted they offer marked opportunities not only for erosion control but for soil conservation in other ways. Naturally the relative amounts of corn and of clover or grass must be determined by the fertility of the land and by its susceptibility to erosion. The following systems represent those which are adapted to the best uplands of Missouri, sometimes with and sometimes without lime, or to lands of moderate fertility where lime or lime and fertilizer are applied.

For the Best Uplands

1. Corn, corn, oats, wheat, red or sweet clover
2. Corn, corn, oats, red clover and timothy two years

For Average Uplands

1. Corn, oats, wheat, red or sweet clover
2. Corn, oats, barley, red or sweet clover
3. Corn, oats or wheat, red clover and timothy two years
4. Corn, soybeans, wheat, red or sweet clover

The systems which include two years of corn must necessarily be limited to good land that is not subject to severe erosion, or if it is, terracing or contour farming, or both, should be used. The first two systems suggested for average uplands are most satisfactory where the land is only moderately rolling. The more rolling the land the greater should be the acreage of sod crops, and the le s the acreage of corn. The system which includes soybeans should be limited to rather level land where erosion is not serious, or the soybeans should be sown with a grain drill, if possible, or if in rows they should be sown on the contour.* In the red clover and timothy mixture, these two crops are often sown together, even where they are to be left on the ground but one year, since the chance of getting a stand of timothy is somewhat better than that of clover and the timothy is used thus as an insurance against complete failure.

*Large acreages of soybeans are sown on the northeast Missouri prairie (Putnam silt loam). The very heavy subsoil beneath this soil causes much runoff even on slight slopes so that soybeans, sown in rows, are causing much erosion in this region.

Fig. 11.—Soybeans induce much erosion. This picture, taken in the spring, shows the amount of erosion that has taken place from land that was in soybeans the previous year. Improperly handled, on rolling land, a soybean crop will result in excessive erosion losses.

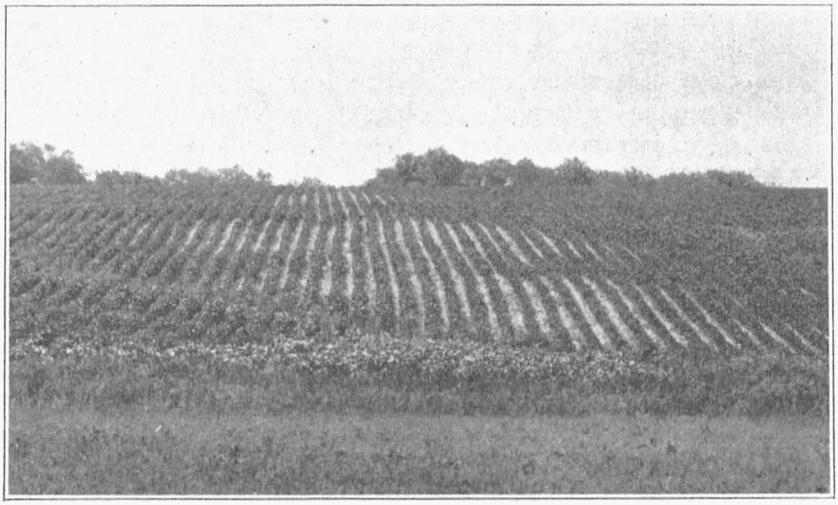

Fig. 12.—The wrong method of sowing soybeans, in rows up and down the slope. If erosion is to be controlled the rows should be planted on the contour, or better still the crop should be drilled with a grain drill, if possible. Even in this case it is best to sow them on the contour. (Photo through the courtesy of Soil Conservation Service).

THE OLD STANDARD THREE YEAR CROPPING SYSTEMS

Some of the most widely used cropping systems in the Cornbelt are the three year systems. These provide for one-third of the land in corn, one-third in small grain, and one-third in clover, or clover and grass. A system which provides for one-third of the land in corn is best suited to moderate or good land and where the farm is at all rolling additional systems of erosion control should be used, such as contour farming and terracing. There are only two common systems of the three year rotations, which are as follows:

1. Corn, oats, red or sweet clover
2. Corn, wheat, red or sweet clover.

The first of these is most largely used in the better parts of the northern and western sections of the Cornbelt where the land is good and where both corn and oats make satisfactory yields. The dark prairie soils of northwest Missouri are quite well suited to such a system although lime is often necessary in order to make the clover succeed. The second rotation is more commonly used in the eastern and southern parts of the cornbelt where wheat is more profitable than oats. In Missouri this rotation has possibilities in the wheat growing sections of the state, particularly in the border Ozark Region. In many of these wheat sections there are large numbers of farmers of German extraction who are accustomed to cutting and shocking corn, thus making it more simple to follow with wheat. The corn, wheat, clover rotation is the better one for erosion control, since the land is covered with wheat following corn from October on until the next July. In the case of the corn, oats, clover system, on the other hand, there are only corn stalks on the land during the fall, winter and early spring months.

THE ONE YEAR CROPPING SYSTEMS

Experiments by the Department of Field Crops of the College of Agriculture show that Korean lespedeza may be grown following a small grain, the same year, thus giving a double cropping system, or what has been termed a "one year rotation." In such a system both a grain crop and a crop of lespedeza are grown the same season. The first may be used for grain, hay or pasture; while the second may be utilized for hay, seed, pasture, or a combination of these. These systems include the following:

1. Wheat followed by lespedeza
2. Oats followed by lespedeza
3. Barley followed by lespedeza
4. Rye followed by lespedeza

In the case of the wheat-lespedeza system, the lespedeza sod may be thoroughly disked in the fall following the removal of a seed crop or

BROAD SCHEMATIC PLAN INDICATING THE GENERAL RELATIONSHIPS

Quality of Land	Slopes 0-3 ft. in 100	Slopes 3-6 ft. in 100
First Grade Land (Excellent)	On level areas as much as 3/5 of the cropped land may be in tilled crops, the remainder in small grain and the most effective sod legumes (alfalfa, sweet and red clover). On 2-3 per cent slopes reduce tilled crops to 1/2 the cropped land.	On 3-4 per cent slopes, 1/2 of the cropped land may be in tilled crops, the remainder in small grain and sod legumes (alfalfa, sweet and red clover). On the 5-6 per cent slopes reduce tilled crops to 1/3 or 1/4 the cropped land.
Second Grade Land (Good)	On level areas, 1/2 the cropped land may be in tilled crops, the remainder in small grains, legumes and grass (alfalfa, red and sweet clover, soybeans and timothy). On 2-3 per cent slopes reduce tilled crops to 1/3 or 1/4 the cropped land. Soybeans sown solid or on contour.	On 3-4 per cent slopes, 1/3 the cropped land may be in tilled crops, the remainder in small grains, legumes and grass (alfalfa, red and sweet clover, lespedeza and timothy). On 5-6 per cent slopes reduce tilled crops to 1/4 or 1/5 the cropped land.
Third Grade Land (Medium)	On level areas, 1/3 the cropped land, may be in tilled crops, the remainder in small grains, legumes and grass (red and sweet clover, soybeans, lespedeza and timothy). On 2-3 per cent slopes reduce tilled crops to 1/4 or 1/5 the cropped land. Soybeans sown solid or on contour.	On 3-4 per cent slopes, 1/4 the cropped land may be in tilled crops, the remainder in small grains, legumes and grass (red and sweet clover, soybeans, lespedeza and timothy, red top or orchard grass). On 5-6 per cent slopes reduce the tilled crops to 1/5 or 1/6 the cropped land. Soybeans sown solid and on contour.
Fourth Grade Land (Poor)	Land should be kept in permanent pasture or in small grain and lespedeza.	Land should be kept in permanent bluegrass or red top and lespedeza pasture.

Note 1. It should be understood that these suggestions are meant merely to serve as a general guide in establishing cropping systems. They apply in general to soils which are around average in the ease with which they erode. On more erosive or less erosive soils the per cent of land in tilled crops should be decreased or increased accordingly.

Note 2. Tilled crops are those which are given intertillage such as corn, cotton, tobacco and soybeans, (when the latter are sown in rows at corn planter widths.)

Note 3. The following are examples of some of the cropping systems indicated.
Three-fifths in tilled crops—Corn, corn, corn, oats, sweet or red clover; corn, corn, soybeans, wheat, sweet or red clover.
One-half in tilled crops—Corn, corn, oats, sweet or red clover; corn, corn, wheat, sweet or red clover; corn, corn, oats and lespedeza, wheat and lespedeza.
One-third in tilled crops—Corn, wheat, sweet or red clover; corn, oats, sweet or red clover; corn, corn, oats, wheat, red clover and timothy two years; corn, oats and lespedeza, wheat and lespedeza.
One-fourth in tilled crops—Corn, oats, wheat, sweet or red clover; corn, soybeans (drilled solid), wheat, sweet or red clover; corn, oats and lespedeza, wheat and lespedeza, barley and lespedeza.
One-fifth in tilled crops—Corn, oats, wheat, red clover and timothy two years; corn, oats, red clover and timothy three years; corn, oats and lespedeza, wheat and lespedeza, three years.
Systems without tilled crops would include small grain cropping systems of oats, wheat or barley followed by lespedeza.

BETWEEN CROPPING SYSTEMS AND THE GRADE AND SLOPE OF THE LAND

Slopes 6-10 ft. in 100	Slopes 10-20 ft. in 100	Slopes over 20 ft. in 100
On 6-8 per cent slopes, 1/3 the cropped land may be tilled crops, the remainder in small grains, sod legumes and grass. On 9-10 per cent slopes reduce tilled crops to 1/4 or 1/5.	Land should be kept in grass and legume sod for hay or pasture. Some small grain and lespedeza may be used or 1/5 to 1/6 of the land may be in tilled crops on the lesser slopes.	Land should be kept in permanent pasture or forest.
On 6-8 per cent slopes 1/4 the land may be in tilled crops, the remainder in small grains, legumes and grass (alfalfa, red and sweet clover, lespedeza and timothy). On 9-10 per cent slopes reduce tilled crops to 1/5 or 1/6 the cropped land.	Land should be left in grass and legume sod for hay or pasture. Small grain and lespedeza may be used on the lesser slopes.	Land should be kept in permanent pasture or forest.
On 6-8 per cent slopes, 1/5 the cropped land may be in tilled crops, the remainder in small grains, legumes and grass (red and sweet clover, soybeans, lespedeza, timothy, red top and orchard, grass). On 9-10 per cent slopes reduce tilled crops to 1/6 or keep land in sod legumes and hay or small grain and lespedeza. Land too rolling to use soybeans, unless sown solid and contoured.	Land should be kept in grass and legume sod for hay or permanent pasture. Lespedeza and red top may be used on the steeper slopes.	Land should be kept in woods pasture or forest.
Land should be kept in permanent pasture, mainly red top, orchard grass and lespedeza or woods pasture.	Land should be kept in permanent woods pasture.	Land should be kept in forest.

Note 4. On all the first, second and third grade land, in regular cropping systems, particularly that between 3 and 10 per cent slopes, the use of terracing is important, or is necessary in reducing erosion to the most satisfactory level. On the steeper slopes or the lower grades of land where these are kept in permanent pasture, some terracing may be practiced, but it is of much less importance than on the cropped land.

Note 5. Strip cropping may be used very advantageously with the shorter cropping systems, particularly on slopes of 6 to 10 per cent.

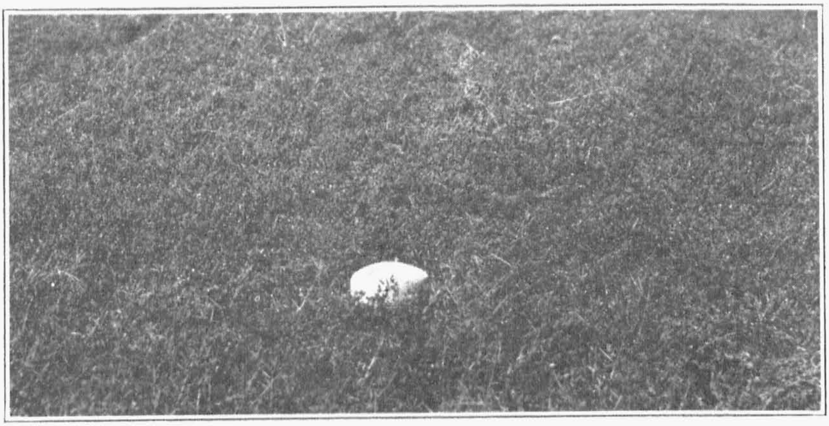

Fig. 13.—Korean lespedeza when well established covers the ground with a very thick mat of vegetation during those months of the year when erosion is most serious. It is adapted to a wide variety of soils and is very effective in erosion control.

following pasturing, and immediately sown to wheat. The wheat remains on the ground until harvest the next year, to be again followed by the lespedeza which reseeds itself naturally, even when a seed crop is removed. Thus the land is exposed to serious erosion for two to four weeks only, between the fall disking and the time when the wheat has secured a good start. No erosion measurements are available on this system as yet, but the erosion from wheat and red clover in the experiments at Columbia from October 1 to the next October 1 is only 3.1 tons per acre. It is probable that the erosion from wheat and lespedeza for the same period would be still less, since the Korean makes a somewhat thicker growth on the ground than does the red clover. However, heavy fall rains after the land has been prepared for wheat following the lespedeza may sometimes cause serious loss.

The oats-lespedeza, the rye-lespedeza and the barley-lespedeza systems would doubtless be quite similar to the wheat-lespedeza system in controlling erosion so that all of these offer important new opportunities for soil saving. A special advantage of these one year systems is that there is a legume on the land every year while most rotations have a legume only once in three to six years. Again, these are simple systems which can readily be changed from field to field so that they lend themselves to shifts and variations much better than the longer rotations Finally, they are adapted to lands that are scarcely good enough for corn and they have marked possibilities on many Missouri farms outside of the better corn sections. They may also be used on the better lands with

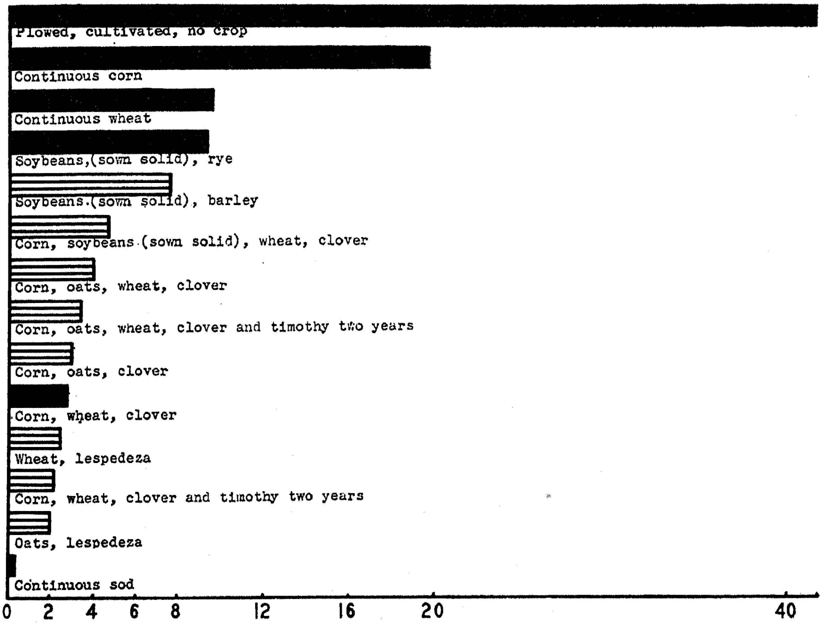

Fig. 14.—Chart showing relative amounts of erosion, in tons per acre annually, under different cropping systems. The solid bars represent actual field data; the open bars are interpolations or calculations from the field measurements (Columbia data).

very good results where two or three small grain crops in succession are desired. The use of lespedeza in place of red or sweet clover in the longer rotations has not as yet been well worked out.

BENEFICIAL EFFECTS OF GOOD CROPPING SYSTEMS

In considering the use of good cropping systems it must be remembered that these are not only effective in controlling erosion but they tend to supply more organic matter and nitrogen to the soil, thus maintaining a higher level of fertility than otherwise. At the same time the extra legume crops give more protein feed and, therefore, a much better balanced ration than where few legumes are grown. The higher fertility level will also result in higher acre grain yields which will partially maintain the total corn production per farm. Moreover, the higher yields will result in a lower production cost per bushel, of corn or other grain, and this coupled with the fact that the abundant protein from the legume feed will make each bushel of grain go further, gives more satisfactory results in every way. The arguments for a good cropping system are, therefore, very convincing. The history of the older countries and of the eastern farming states show that a stable agriculture is accompanied by well organized cropping systems. The sooner the farmers of the central and western cornbelt states adopt such regular soil conserving systems, the sooner will agriculture be placed on a stable and economic basis.

CROPPING SYSTEMS AND CONTOUR FARMING

In the southern states one of the most widely used methods of controlling erosion is that of planting and cultivating crops, primarily cotton and corn, so that the rows run across the slope, rather than with the slope. This is commonly called "contour farming." Almost every

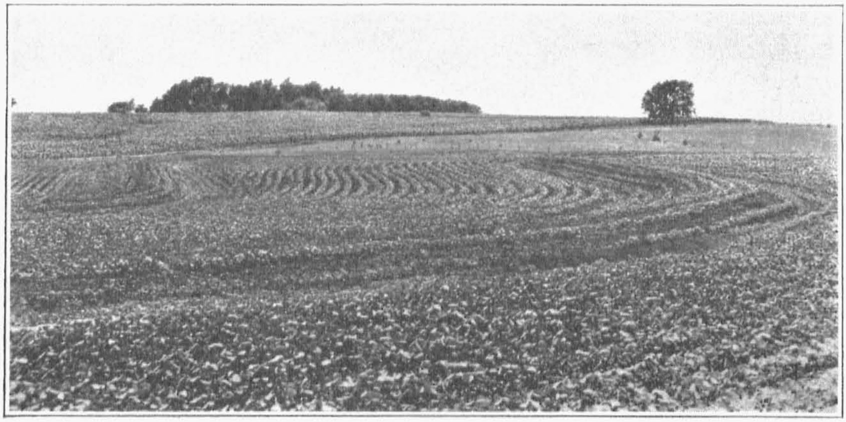

Fig. 15.—Soybeans on terraced land, sown in rows following the terraces. The rows are therefore approximately on the contours. Soybeans should never be sown in rows on rolling land unless the rows follow the contours. (Photo through courtesy of Soil Conservation Service.)

field of any size in the rolling parts of those states is cut up into smaller areas so as to fit the cotton rows to the slopes. Such systems of contour farming are just coming into use in Missouri, but there is no doubt that they have real possibilities for saving soil. Naturally, the large fields and the large farm implements used in most cornbelt states do not lend themselves so well to contouring as do the smaller fields and smaller implements of most of the cotton states and this is the principal deterrent to the wide adoption of such practices. Nevertheless the system has such great possibilities that it is important for farmers concerned in erosion control to consider its application to the land. As a matter of fact, the system is not nearly so difficult as most men believe. It is not necessary for instance, that the rows follow exactly on the contour and they can usually be laid out with the ordinary implements with little preliminary planning. Moreover, many farmers are finding it easier, and a saving of power, to use implements across the slopes rather than up and down them. This is particularly true where the slopes are rather steep.

It is, of course, not practical to use contouring on all fields. Some have such a great variety of slopes that it would mean cutting them into a large number of small fields, like the cotton fields of the South, which would not be adapted to the use of large implements. On the other hand, many fields slope in but two or three directions and lend themselves well to contouring, even when the fields are large. There are, of course, many variations between these two extremes. Nevertheless, there are many fields in which contour farming, along with a good cropping system, is practically all that is necessary in erosion control. It is in the interest of all farmers on rolling land to consider the possibilities of contour farming, even if only to the extent of sowing the various small grains on the contour, where this is at all possible. It must be remembered that in any good cropping system, where the cultivated crops are somewhat limited, the inconvenience of contour farming is not particularly serious.

THE USE OF COVER CROPS

In some parts of the country wide use is made of crops which are sown for the purpose of covering the ground during the fall, winter and spring months. This practice is followed to a certain extent in parts of Missouri. The fact that the proportion of the year's erosion which takes place during these fall, winter and spring months is not as great in Missouri as it is in some parts of the United States, has reacted against their use. Nevertheless, the saving is sufficient on all rolling lands to make their use of marked importance.

The cover crops which are best adapted to Missouri conditions are rye, wheat or barley, among the small grains, and Korean lespedeza, vetch, and the common clovers among the legumes. Of the small grains, rye has been most commonly used since it is hardy and somewhat better adapted to lands of low fertility than the other small grains. On the medium to good lands wheat or barley may be used with equal or greater satisfaction. All of these crops if sown fairly early, provide a good amount of fall and spring pasture which is an added argument for their use. Certain of them may be used after corn, soybeans, tobacco, potatoes, or cotton. In general, where cropping systems on rolling land do not provide for a regular small grain or other thick growing crop, to follow corn, an attempt should be made to use one of these as a cover.

Among the legumes, the clovers act as cover crops the first winter after seeding, although their growth is not always sufficient to make them very effective. Korean lespedeza, where a thick stand is secured and where it is not cut for seed or pastured too closely, will act quite effectively as a winter cover even though the plants are entirely dead after the first heavy freeze. Vetch makes a fairly satisfactory winter cover and green manure crop in orchards, or following crops like potatoes, although it is usually necessary for the farmer to grow his own seed to make this very economical. However, it does not make a very large fall growth. Crimson clover has possibilities on the more sandy and open lands, particularly in the southern part of the state, although the fall growth is rather small for a good cover. All legume covers have the advantage of soil building and of supplying protein feed which adds to their value for economic purposes.

CROPPING TERRACED LAND

The discussion thus far has had to do with systems of cropping without mention of their relation to terracing. It should be said, however, that the data given, both from the Columbia and the Bethany measurements, represent the losses which would be expected between terraces. In other words, the length of slopes on which these experiments were conducted, were approximately the same as the distances beteen terraces on these lands. As a consequence, the soil eroded represents that which, in the case of non-scouring terrace channels, would be accumulated in the channel above the terrace, while in the case of self-scouring terrace channels, this soil would largely be removed from the field. Moreover, experiments have shown that the longer the slope the greater the erosion per acre so that for longer slopes, without terraces, the losses would be still greater than those between terraces. In the case of the non-scouring terrace channel this, of course, tends to fill and it is customary to throw this on top the terrace the next time the terrace is graded. Recent experiments at the Bethany Erosion Experiment Station indicate that under a good cropping system and by the use of a one-way plow between terraces by means of which the furrow slices are thrown only up hill, this movement of soil down the slope may largely be prevented.

The present idea with reference to the use of cropping systems with terraces is that only good cropping systems be used, that is, systems which in themselves go a long way in controlling erosion. Moreover, the modern plan is to plant and cultivate the crops, in so far as possible with the terraces. In this case the crops are planted largely on the contour which in itself greatly lessens the amount of soil washed into the terrace channels and usually proves more satisfactory than cultivating across the terraces. But whether the crops are planted with the terraces or not it must be remembered that a good cropping system is essential. For the most complete erosion control, therefore, particularly on lands which are quite erosive, a good cropping system, terracing and contour farming should go together. Where the land is not so erosive a good cropping system without terraces may be sufficient, particularly where contour farming is practiced.

THE GENERAL PRINCIPLE OF STRIP CROPPING

In certain parts of the United States there has developed a system of erosion control which consists of plant crops of varying soil binding properties in comparatively narrow strips across the line of slope or on the contour. The principle is to alternate thick growing crops with cultivated crops, the former serving to catch the soil washed from the areas

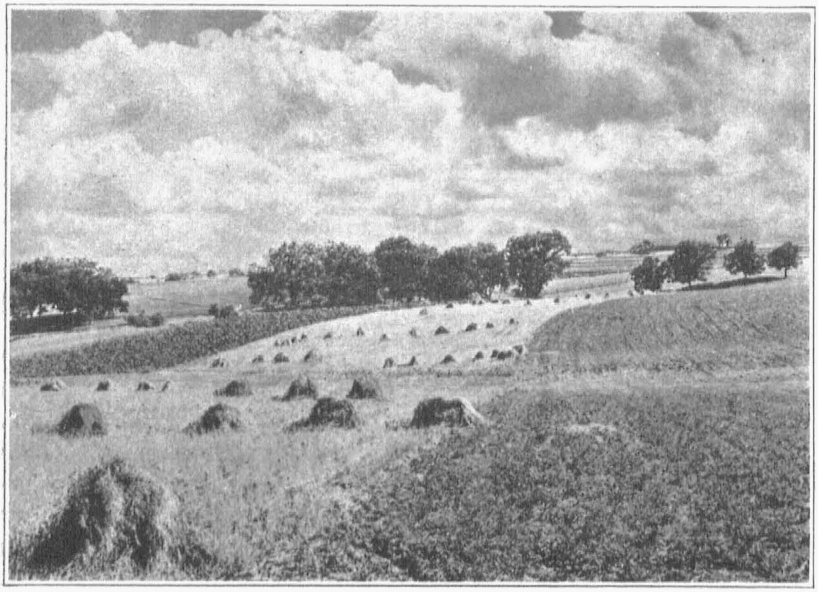

Fig. 16.—An example of strip cropping on the Erosion Experiment Station at Bethany, Missouri. (Photo through courtesy of Soil Conservation Service).

occupied by the latter. In most cases the plan provides that the strips shall be approximately equal in width so that they may be rotated from year to year. Such a plan is known as strip cropping. In some cases thickly sown crops, such as sorghum, Korean lespedeza or alfalfa, are grown in rather narrow strips between the regular strip crops, or terraces may be placed on these borders. In general, the width of strips ranges from 75 to 200 feet, the more erosive the soil the narrower the strips should be, or the closer together should the thick growing strips be placed.

Naturally, the crops selected and the relative sizes of the areas of each should fit as nearly as possible the farmer's need for cash crops or feed. Moreover, the number of the strips should correspond with the number of crops in the desired rotation. Thus a rotation of corn, soybeans, wheat and clover contains the two erosive crops, corn and soybeans and the two thick growing crops, wheat and clover. In visualizing how these strips might run across a field the corn might first be placed at the top of the slope, the wheat next, then the soybeans and the clover below. The soil washed from the strip of corn would largely be caught in the wheat, that from the soybeans would accumulate in the clover. This is the ideal arrangement. However, if these strips are rotated regularly they will not always be in such an ideal position and some years an erosive crop will occupy the lower part of the slope. Even in this case, however, one of the thick growing crops is below an erosive one. The relation of these various crops on the slope through one round of the rotation is shown below.

Direction of slope ↓	*First year*	*Second year*	*Third year*	*Fourth year*	↓ *Direction of slope*
	Corn	Soybeans	Wheat	Clover	
	Wheat	Clover	Corn	Soybeans	
	Soybeans	Wheat	Clover	Corn	
	Clover	Corn	Soybeans	Wheat	

It will be understood that such a scheme of cropping does not entirely prevent erosion. However, with a thick growing, or screen crop, below each erosive crop, practically every season, the amount of soil that will be washed from the field will be greatly lessened. Since the crops are sown on the contour this is also effective in lessening erosion. Strips of permanent sod at the ends of the crop strips aid in turning with implements and also in going from one strip to another. Permanent sod and drainage ways should be provided in the natural water courses, unless terraces are used, when, of course, the terrace outlet should take care of this runoff.

Such plans of strip cropping are still in the experimental stage in most parts of the country. Very little of this has been attempted in Missouri. Thus far the most extensive use of such systems has been in connection with the demonstration areas of the Soil Conservation Service. There is no doubt that these have marked possibilities for controlling erosion, particularly for special crops, such as truck crops, on steep slopes, or even for general crops on the moderate slopes. They have the disadvantage of making grazing almost impossible until after the harvested crops are removed, while in fitting the strips to the contours or slopes some point rows are often necessary. In some cases more or less permanent, but narrow buffer strips of grass, or clover and grass, or alfalfa, are placed between the regular rotated strips to assist in holding

Fig. 17.—This photograph shows the edges of two plots of land, both in wheat. That on the right received fertilizer and that on the left received nothing. The much larger growth and cover of the fertilized wheat greatly decreases erosion losses below those of the unfertilized land.

the soil. Naturally these must be plowed up occasionally and reseeded, or other strips seeded down. There are various other modifications of these systems which have been proposed and considerable demonstrational work is being done by the Soil Conservation Service in fitting such systems to different soil types and conditions. It is probable that such systems, or modifications of them yet to be worked out, will find an important place on many Missouri farms.

THE EFFECT OF FERTILIZING OR MANURING CROPS ON EROSION CONTROL

Little quantitative data are available showing the exact influence of fertilizers and manures on erosion control. The data which have been secured show that such treatments markedly lessen erosion losses. The reasons are obvious since both manures and fertilizers stimulate crop growth, usually both tops and roots, thus giving a better surface cover and more roots to hold the soil. Moreover, the greater crop growth induced by these treatments removes more water from the soil, increases moisture penetration and lessens runoff. On soil of medium to low fertility, the use of manures and fertilizers will, therefore, have a most pronounced effect in lessening both runoff and erosion. In fact on such soils, these treatments are practically essential if erosion is to be satisfactorily controlled. Such a benefit from these treatments is not usually taken into consideration in judging their agricultural value, but the evidence shows that it is very important.

SUMMARY

I. Soil erosion measurements show the following general relationships between erosion and cropping and cultural practices.

1. The average monthly erosion is determined by the condition of the land's surface and the nature of the crop cover, as well as by the amount and distribution of the rainfall from month to month.

2. Erosion from cultivated, uncropped land totals approximately twice that from land in continuous corn. However, erosion from continuous wheat is only about half, and that from a good rotation is less than 20 per cent, that from continuous corn. The erosion from continuous sod is almost negligible.

3. In general these results show that under ordinary conditions cropping and cultural systems may be so adjusted as largely to control erosion losses.

II. The results of these erosion measurements warrant the following recommendations regarding erosion control.

1. The standard rotations consisting of one or two years corn, one or two years small grain, and one or two years clover, or clover and grass, represent some of the most effective cropping systems known for controlling erosion.

2. The various combinations of small grain crops and Korean lespedeza offer a great deal in the control of soil erosion under Missouri conditions.

3. When soybeans are sown in rows on rolling land this crop may cause so much erosion as to result in very serious soil losses. In such case the crop should be sown with a grain drill and if possible on the contour.

4. The use of winter cover crops such as barley, rye, or wheat, lespedeza, vetch and various clovers, are recommended for use wherever possible in order to lessen erosion losses during the fall, winter and spring months.

5. The planting of row and drilled crops on the contour instead of merely with the fence lines offers a great deal for controlling erosion in the case of all soils of rolling topography.

6. A system of cropping known as "strip cropping," which has recently been introduced into Missouri, provides that the crops in a rotation be planted in rather narrow strips, 50 to 100 feet wide, across the slope. This is very effective in controlling erosion.