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The Management of Nebraska Soils

The University of Nebraska Agricultural College Extension Service
and United States Department of Agriculture Cooperating
W. H. Brokaw, Director, Lincoln

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The Management of Nebraska Soils

P. H. STEWART AND D. L. GROSS [1]

The agricultural lands of this country are its greatest natural resource. History points out that nations with vast areas of good farm land are most likely to prosper and survive over long periods of time. Local communities, too, prosper and flourish in proportion to the productiveness of the surrounding land. Schools, social life, and business develop best in areas where the land is productive and properly managed and conserved. Unlike timber, oil, coal, and mineral resources, which are largely held under the control of a relatively few people, corporations, or the government itself, agricultural lands are in the possession of millions of individuals, each free to manage his fields as he sees fit.

FIG. 1.—Most Nebraska soils are deep, fertile, easily tilled, and well adapted to crop production.

[1] The authors wish to acknowledge valuable counsel and suggestions from Dean W. W. Burr, J. C. Russel, F. D. Keim, T. A. Kiesselbach, E. B. Engle, and M. D. Weldon in the preparation of this circular.

Use has been made of bulletins and technical articles written by members of the Nebr. Agr. Exp. Sta. staff and the Conservation and Survey Division of the Uni. of Nebr. and others. Readers who desire more complete information are referred to the publications listed at the close of this circular.

History shows that since Colonial days, our agricultural development has consisted largely of the cultivation of lands in the east until soil fertility was reduced and then of movement westward to new virgin lands, leaving worn-out soils behind. Two generations of farming in the west have now appreciably reduced the fertility of these new lands. There are now no new areas of virgin land available. Indeed, we have spread out already too far into areas of poor soils, breaking out and destroying native grasses on fields not suited to farming, and thereby creating a land-use problem. Depleted and eroded soils cannot now be abandoned for new, cheap lands. The nation faces a new period in its agricultural development, one of soil conservation, erosion control, proper rotations, and a greater use of grasses and legumes in the farm program.

As a new nation, we exported to the old world vast quantities of agricultural products. The land was new and little thought was given to fertility and soil maintenance problems. We sold, particularly in grain and cotton crops, the virgin fertility of our fields. Often the prices received by the farmer did not pay him actual production costs, to say nothing of the mining of our soils of their fertility in producing the export crops. The period of low crop prices following 1929 forced many farmers to maintain an excessively high acreage of grain crops in an effort to secure a sufficient income to pay current costs. This had a tendency to speed up soil depletion through soil washing, wind erosion, and the lack of grasses and legumes in the rotation.

The individual farmer, even though he keeps his own farm lands in a high state of fertility, is interested in and affected by the management of other local farms. The reduction in land values by soil erosion and weed infestation throws a heavier burden of taxation on the well-maintained farms, if schools, roads, and other activities of a progressive community are to be maintained. Local communities and governments, as well as the national government, are therefore vitally interested in seeing that agricultural lands are properly managed and conserved. It is the responsibility of national government to develop policies under which the individual land owner will find it possible and profitable to manage his lands under a permanent, long-time soil conservation program.

Nebraska, in common with other states, has suffered by the depletion of soil fertility. The reduction in acres in legumes and grasses, and the depletion of the organic matter in the surface soils, has likewise had its effect on the run-off of precipitation, soil blowing, and damage from drouth.

In order to know what elements of fertility may become deficient and how soil fertility may be restored and maintained, we should understand the composition, character, and management of soils. In the following pages, some fundamentals of soil fertility are given, followed later by a discussion of practical soil-management practices.

What Is Soil?

The soil is not a simple thing. For centuries it has been developing under the forces of nature. By the aid of ice, wind, water, freezing,

thawing, chemical action, and plant growth, Mother Nature has been centuries in developing a soil. Many changes are still going on in a slow, invisible, but extremely important way.

An ordinary air-dry soil consists chiefly of two important parts. More than 90 per cent of its weight is made up of more or less finely pulverized rock material, which varies from extremely small to relatively large particles. The remainder consists chiefly of organic matter in a more or less decomposed condition. Virgin eastern-Nebraska upland soils contain approximately five per cent organic matter, while virgin western-Nebraska soils contain about one-half as much. Under similar climatic conditions sandy soils contain relatively less organic matter than finer-textured soils.

Although the mineral and organic-matter content represents the principal bulk of an air-dry soil under field conditions, there are other constituents which are important. Soil moisture is, of course, essential for plant growth. Water within the soil dissolves and acts as a carrier for the plant-food materials.

Bacteria, fungi, earth worms, and other forms of both plant and animal life have their abode within the soil. These play an important part in the physical and chemical changes which are essential to a productive soil.

Soil Texture

The word "texture" when used for describing a soil, refers to the size of its mineral particles. Terms used to describe the different sizes, beginning with the largest and going in order to the smallest, are: fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt, and clay.

If the characteristics of a particular group of soil particles, such as silt, predominate in a soil, the name of this group is often used with the term "loam" to describe the soil—as, for instance, silt loam, very fine sandy loam, or clay loam. The term "gumbo" is commonly used in referring to soils which contain a high percentage of clay. The best farming soils of Nebraska classify as silt loams.

The texture of a soil determines to a great extent its fertility, its ability to hold water, and the care with which it must be cultivated and managed. It is on the surface of the millions of particles in a soil that bacteria live, water clings in a film, plant nutrients dissolve, and tiny rootlets feed. These activities have much to do with the productiveness of a soil.

Fine-textured soils absorb water slowly and bake and crack easily. They must be handled with care to prevent them from becoming puddled and cloddy. Sandy soils absorb water rapidly, do not bake or crack readily, and are easy to till. They are, however, lower in plant nutrients and hold less water than finer-textured soils. Sandy soils, being more open, warm up sooner in the spring than clay soils. A plentiful supply of organic matter tends to make a clay soil more open and friable, while in a sandy soil it acts as a binder and increases its water-holding capacity.

Soil Structure

The word "structure" is used to refer to the arrangement of the individual particles of a soil. Ordinarily in clay and silt soils, the tiny particles are grouped into grains or granules. When in this condition, the soil is said to have a granular or crumb structure, each group of tiny particles having somewhat the qualities of a sand particle. This crumb or granular structure is the ideal condition for silt and clay loam soils.

FIG. 2.—A poor prospect for a good seedbed due to plowing when the soil was too wet.

If fine-textured soils are cultivated when wet, the granular structure is disturbed as the tiny grains are forced together into a more or less solid mass. A soil in this condition is said to be puddled. When the correct amount of water is present, soils may be tilled without disturbing the granular structure; in fact, stirring with such tools as a moldboard plow may improve the structure. The structure of a soil may also be improved by wetting and drying, freezing and thawing, the action of plant roots, and the addition of organic matter.

Plant Food Elements

Most of the plant-food elements within the rock particles of a soil are not available for immediate use by the plant. They must be acted upon chemically and dissolved in the soil solution before they are available to the plant roots. Ten elements are usually considered necessary for normal

plant growth. In the following sentence, the first letter of each word is the same as that of one of the essential plant food elements.

"Could	Pied	Piper	See	Mice	In	Our	Nebraska	Country	Homes?"
A	H	O	U	A	R	X	I	A	Y
L	O	T	L	G	O	Y	T	R	D
C	S	A	P	N	N	G	R	B	R
I	P	S	H	E		E	O	O	O
U	H	S	U	S		N	G	N	G
M	O	I	R	I			E		E
	R	U		U			N		N
	U	M		M					
	S								
Elements from the soil.						Elements from water and air.			

Fortunately, of these ten, only three or four are likely to be so deficient as to affect plant growth. Nitrogen, phosphorous, calcium, and potassium, in the order named, may be present or available to plants in such small amounts that crop yields are reduced.

Nitrogen

Nitrogen is the most likely of the ten essential elements to be deficient in Nebraska soils. A lack of nitrogen in the soil causes plants to have a stunted, yellow, unthrifty appearance. A plentiful supply tends to produce a rank growth, a dark green color, and late maturity. An excess amount of nitrogen in the soil decreases the resistance of the crop to certain diseases and may in the case of small grain cause lodging.

Nitrogen, unlike potassium and phosphorus, is not contained in the rocks and minerals of a soil but comes from the organic matter. All of the nitrogen in the soil came originally from the air, which is four-fifths nitrogen. However, plants cannot use nitrogen directly from the air but must get it from the soil. Legumes, such as alfalfa, soybeans, and the clovers, have bacteria on their roots in small growths known as nodules. These bacteria are able to use nitrogen from the air which later becomes available to plants. Other kinds of bacteria, in addition to those which grow on the roots of legumes, live in the soil and take a small amount of nitrogen from the air. All plants contain some nitrogen and when they decay in the soil this becomes available to other plants.

Phosphorus

Phosphorus comes from the mineral portion of the soil. It is deficient in many of the soils of the United States. The total amount of phosphorus in the soil is not great, approximately 0.065 per cent on the average in the upper six feet of eastern-Nebraska upland soil. In other words, in every 100 pounds of soil there would be about 1/15th of a pound or approximately an ounce of phosphorus. Western-Nebraska upland soils contain a

slightly lower percentage of phosphorus. Nebraska soils, on the whole, have at least as much phosphorus in the subsoil as in the surface soil.

Most Nebraska soils at the present time have an ample supply of phosphorus for crop production. Under irrigation in western Nebraska, certain soils are now responding to phosphorus fertilizers. As Nebraska soils become older, phosphorus may be depleted to the extent that phosphate fertilizers will pay in other parts of the state.

A plentiful supply of phosphorus in the soil hastens the maturity of crops, increases the early root development, strengthens the stalks and straw, and improves the quality and disease resistance.

Calcium

Calcium is deficient in many soils of the United States. Its presence may influence crop production as a plant nutrient and as a preventative of soil acidity. All crops require some calcium as a plant nutrient. Legumes in particular contain a large amount of calcium. Soils which lack calcium are commonly said to be sour or acid. Such soils do not grow satisfactory crops of legumes such as alfalfa and sweet clover.

An ample supply of calcium in the soil tends to promote bacterial and chemical action, good tilth, and the liberation of plant nutrients, particularly nitrogen.

Nebraska soils on the whole are well supplied with lime, which is a compound containing calcium. The glacial soils of southeastern Nebraska and some of the more sandy soils of the Outwash Plains area in north-central Nebraska are the most likely of Nebraska soils to be low in lime.

In eastern Nebraska where the annual rainfall is relatively heavy, there has been a tendency for the lime in the surface soil to leach downward. This has been particularly true on flat areas where there has been but little runoff and no sheet erosion. On such fields the surface soil may be low in lime while the subsoil may be plentifully supplied. It is a common observation that sweet clover, and to a less extent alfalfa and red clover, start easier and make their best growth on hillsides where the lime in the subsoil has been exposed by erosion.

Potassium

Potassium is deficient in some soils of the United States. Nebraska soils, however, are well supplied. In plant growth, potassium exerts a balancing effect on both nitrogen and phosphorus. It plays an important part in the manufacture of starch and is essential to the development of chlorophyll, the green coloring matter in plants.

Soil Testing

Many soil samples are submitted to the Agricultural College for testing. It is possible to take a sample of soil into a laboratory and by chemical tests determine the total amount of nitrogen, phosphorus, potassium, sulphur, calcium, and other elements that it contains. One cannot tell from this information, however, how well the soil will grow crops because cer-

tain elements, although present, may be in a form unavailable to plants. Because of the high cost and questionable value to the farmer, a complete soil analysis is seldom recommended.

Soil samples submitted to the Agricultural College should be taken carefully so as to represent the upper six inches of the field in question. A letter should accompany the sample giving full information as to the location of the field, its past rotation or cropping history, the character of the subsoil, the behavior of crops, and a statement as to the information desired. From this information, together with certain tests, fairly definite recommendations often can be made.

FIG. 3.—The field in the distance has been reduced in organic matter and nitrogen by continuous grain farming. The other two fields have been in clovers and manured.

The best way to determine the needs of a soil as to lime or fertilizers is actually to fertilize a small representative part of the field and compare the crop produced with that on the bordering untreated portion.

Losses Due to Cropping

Crops vary greatly in the amount of plant food which they take from the soil. In small-grain crops, the grain itself contains most of the nitrogen and phosphorus, while the straw contains most of the potassium and calcium. Table 1 gives a comparison of the plant food elements removed by the common Nebraska crops.

Legume crops use large amounts of nitrogen, calcium, and potassium. These crops are able to supply their own nitrogen by means of bacteria on their roots. Hay crops removed from the land and not returned to the farm as manure are as likely as grain crops to exhaust the phosphorus, potassium, and calcium content of the soil. When the entire crop is removed, corn takes a greater amount of fertility from the soil than do small grains. On the other hand, corn stalks contain relatively more nitrogen, potassium, and phosphorus than the straw of any of the small grains, and when left on the land the removal of plant nutrients by corn is materially reduced.

TABLE 1.—*Estimated pounds of fertility elements removed per acre by average yields of common Nebraska crops.*[1]

Crop	Av. yield	Nitrogen	Phosphorus	Potassium	Calcium
Corn	*Per A.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Grain	35 Bu.	32	5.7	6.6	0.3
Stover	1 T.	18	3.5	19.1	8.4
Total crop	.....	50	9.2	25.7	8.7
Winter Wheat					
Grain	20 Bu.	23	4.4	5.0	0.5
Straw	1 T.	10	1.1	12.4	4.1
Total crop	.....	33	5.5	17.4	4.6
Oats					
Grain	30 Bu.	19	3.5	4.5	1.0
Straw	¾ T.	9	1.3	18.7	4.5
Total crop	.....	28	4.8	23.2	5.5
Barley					
Grain	25 Bu.	22	4.4	7.5	0.3
Straw	1 T.	11	1.6	19.9	4.6
Total crop	.....	33	6.0	27.4	4.9
Alfalfa hay	2.5 T.	119	11.8	92.1	69.5
Red clover hay	1.5 T.	61	5.2	40.7	34.3
Sweet-clover hay, 2nd year	2.0 T.	93	11.5	41.5	52.5
Sugar beets	13 T.	68	9.2	69.0	8.5
Potatoes (Irish)	150 Bu.	31	5.9	37.3	1.8

[1] Computed from Henry & Morrison and other sources.

TABLE 2.—*Average monthly distribution of precipitation in Nebraska (30-year average).*

Month	Inches	Month	Inches
January	.68	July	3.51
February	.71	August	2.62
March	1.16	September	1.84
April	2.40	October	1.49
May	3.60	November	.68
June	3.93	December	.69

Some Climatic Factors

There is a wide climatic variation in different parts of Nebraska due to differences in rainfall, elevation, and latitude. Southeastern Nebraska receives, on the average, 32 inches of precipitation annually as compared to 16 inches in the extreme western part. Elevation likewise varies from approximately 1,000 feet above sea level in southeastern Nebraska to more than 5,000 feet along the western border.

The distribution of precipitation during the year has a very important bearing on the storage of soil moisture and on crop production. Fortunately, as is shown in Table 2, the larger part of the annual precipitation in Nebraska comes during the growing season when the need for water by crops is great.

The higher annual average rainfall in eastern Nebraska causes a greater damage from erosion. It also has some influence on soil tillage and the leaching of plant nutrients. Although moisture conservation is important in all sections of the state, it is of extreme importance in the western part where the practice of summer fallow is very commonly used to build up moisture reserves.

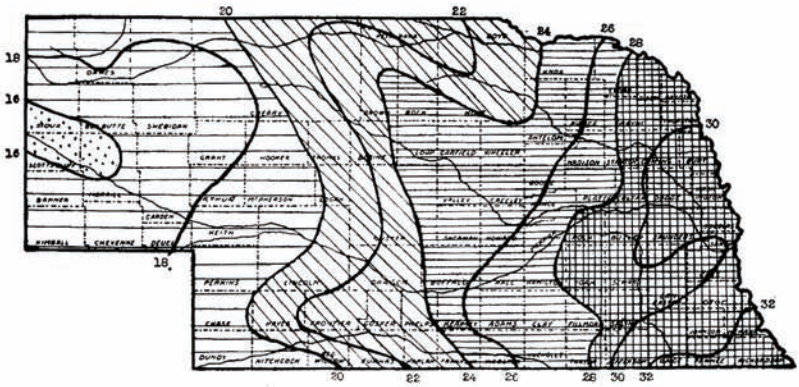

FIG. 4.—The average annual precipitation for Nebraska.

Regional Soil Differences

The best crop and soil management practices for any particular locality depend on the average climatic conditions and the nature of the soil itself. Soil survey maps are now available for most Nebraska counties. These valuable publications show in detail the various soils of the county. A description of each soil type and suggestions for its best use and management are also given. These maps may be secured from the University of Nebraska, Conservation and Survey Division; the Bureau of Soils, U. S. Department of Agriculture, Washington, D. C., or from your senator or congressman.

The State of Nebraska may be divided into seven general soil areas on the basis of the origin of the soil and the topography of the land. These areas are shown in Figure 5. Table 3 shows the extent of each area in square miles.

The Drift Hill area in the southeastern part of Nebraska is of glacial origin. Occasional deposits of stones, boulders, and gravel identify it as an ice-formed area. The topography is rolling with rather gently curving slopes. The surface soils of the uplands in the glacial area are not as well

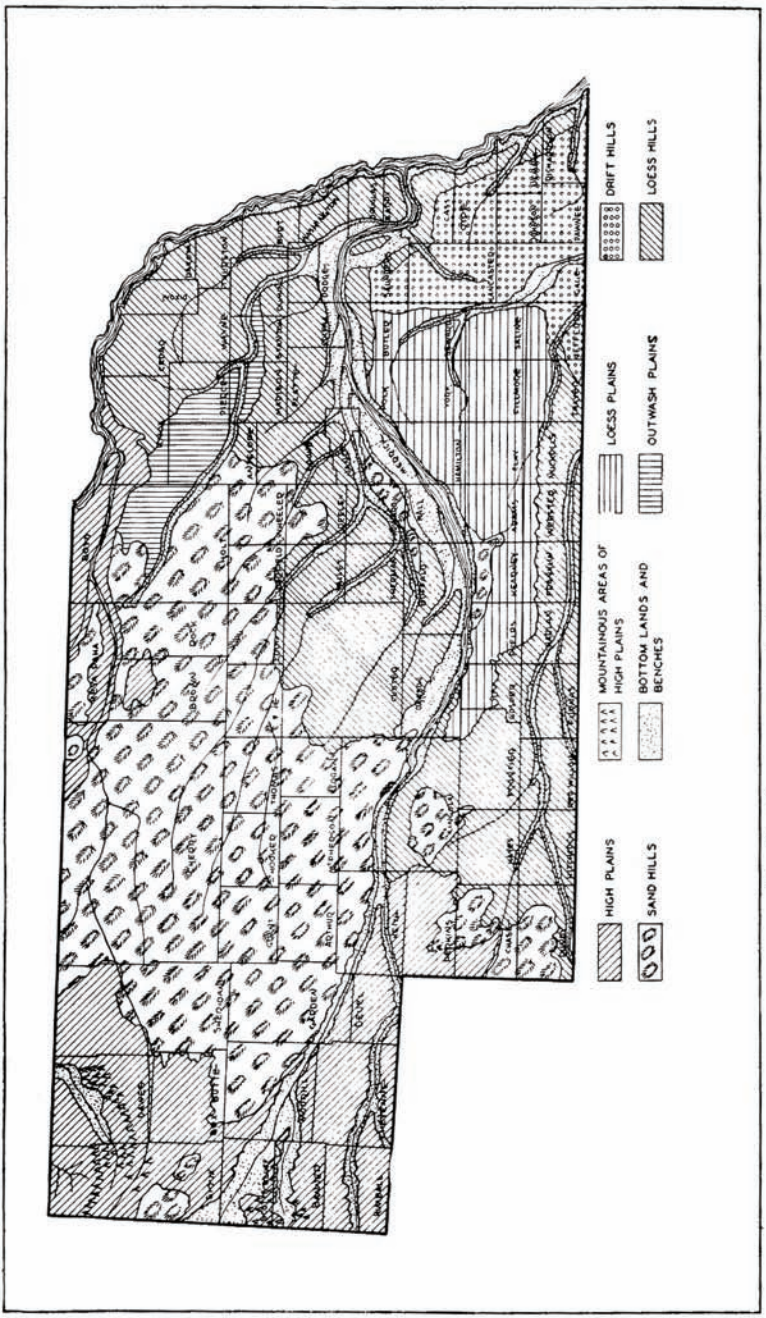

FIG. 5.—The seven general soil areas of Nebraska.

supplied with lime as are those of other areas, with the exception of the Outwash Plains. Soils of the glacial area are inclined to gully easily if care is not used in their management. There are also, in some local communities, exposures of underlying soil-forming material which contains a higher percentage of clay than the surface soils. These exposed areas are commonly spoken of as "gumbo spots." The soil of the glacial area is, on the whole, fertile and productive if properly managed.

The Loess Hill area extends along the Missouri river in a narrow band east of the drift hills, while north of the Platte river it extends westward to the sand hills with a portion stretching across the Platte river far into southwest Nebraska. A narrow belt of loess hills is also found bordering the Republican river along the Kansas line.

TABLE 3.—*The seven general soil areas of Nebraska*

Soil areas	Approx. extent in square miles	Percentage of state area
Drift Hills	6,700	9
Loess Hills	13.400	17
Loess Plains	14,100	18
High Plains	15,000	19
Bottom Lands and Benches	5,900	8
Outwash Plains	2,410	3
Sand Hills	20,000	26
Total	77,510	100

The soil-forming material of the loess area is thought to be of windblown origin. The soil of this area is notable for its depth, fertility, water-absorbing capacity, good tilth, ease of tillage, and general productivity. It does not tend to gully as easily as the glacial soil although sheet erosion is a problem requiring attention.

The soil of the western portion of the loess hill area and that bordering the sand hills contains a higher percentage of sand than the soil of the eastern part. In the west, the soil is also lighter in color in both the surface and subsoil. That portion of the loess hills south of the Republican river is steep and rolling. Canyon lands bordered by level irregular table lands make up much of the area of southwest Nebraska and this region might be classified as loess plains and canyon lands.

The Loess Plains stretching in triangular shape from Seward county west into Gosper county is an extensive level area. The soil-forming material of this area is thought to be of the same origin as that of the loess hills. The soil is very fertile. Because of the level topography, erosion is not usually a problem and large farm machinery can be used to advantage. In parts of the loess plains, a clay pan has been developed by the percolation of water carrying small soil particles into the subsoil where they have lodged, making a tough clayey layer which prevents rapid penetration of

FIG. 6.—A view of the Loess Hill area bordering the Missouri river.

water into the subsoil. Small grains, because of the fact that they ripen earlier, do relatively better than corn on such clay pan soils.

The High Plains area in western and northern Nebraska is not one connected district but is composed of a number of high plains divided by river valleys. The soils have been formed from underlying parent material which varies considerably in its composition and character. High Plains soils are therefore variable, depending upon the character of the parent material from which they were developed.

The Bottom Land and Bench areas of Nebraska are widely scattered, bordering the streams of the state in strips of varying widths. These areas consist of first and second bottom or bench lands. The great Platte valley is the outstanding area, although important portions are found along other streams. The soils of these areas vary widely in fertility and texture, and in productive value. Alkali, poor drainage, and gravelly subsoils are local problems, but on the whole the bottom and bench-land soils are among the most valuable in the state.

The Outwash Plains area, lying to the northeast of the Sandhill section, might be considered a part of the High Plains but it differs con-

FIG. 7.—An oat field on the High Plains of western Nebraska.

siderably from that section in most of its characteristics. The Outwash Plains region is not definite in outline or uniform in character. Gravel, sands, and silts are intermingled in a very irregular way, making a spotted area. In parts of this section, gravel subsoils which underlie thin layers of silt cause the land to be drouthy. In other parts of this area, the soil contains a high percentage of sand. The problems of soil blowing, soil moisture, and the maintenance of soil fertility are important ones in this area and must be given careful consideration by the land owner.

FIG. 8.—Roundup time on a Sandhill ranch. (Photo by Conservation and Survey Division, University of Nebraska.)

The Sand Hills occupy the north-central part of the state with scattered outlying areas. The region is one of irregular ridges of hills interspersed with dry and wet valleys. This section of the state is largely grazing and hay land, making one of the greatest cattle-raising regions of the United States. The wet valleys are used largely for wild-hay production and to a lesser extent for grain crops and alfalfa.

Maintaining Soil Fertility

Nebraska's most important soil fertility problem is the maintenance of the organic matter. This problem overshadows all others. It should be the first consideration of the land owner who wishes to keep his farm in a high state of fertility.

Since nitrogen comes principally from the organic matter of the soil, a marked reduction in organic matter results in reduced crop yields due to a nitrogen shortage. In some cases, grain yields on eroded hillsides and on continuously grain-farmed level lands are less than one-fourth or one-fifth of those on similar soils where the organic matter content has been maintained.

Many actual analyses, made by the Department of Agronomy, of cultivated soils show that level fields which have been under cultivation for about 40 years have lost on the average approximately 30 per cent of their nitrogen content, compared to a loss of more than 50 per cent on eroded lands. Some fields have lost more than 70 per cent of their original nitrogen content. On the other hand, a few particularly well managed farms show an organic matter content nearly as high as that of virgin soil.

FIG. 9.—An eastern-Nebraska corn field yielding 14 bushels per acre on land cropped continuously to grains, whereas adjoining well-maintained fields made 40 bushels or more.

FIG. 10.—This field has lost more than 60 per cent of its organic matter due to erosion.

Methods of Soil Maintenance

The fertility of Nebraska soils may be maintained by growing soil-building crops, such as alfalfa and the clovers, by keeping livestock and returning the manure to the land, and by the judicious use of crop residues such as corn stalks and straw. Rented farms, on which these practices are too often neglected, are more likely than owner-operated farms to be reduced in fertility and to be injured by soil washing.

Fortunately, there are a number of soil-building crops such as sweet clover, red clover, and alfalfa, which are well adapted for use in the state. Rye, soybeans, and possibly lespedeza may also be used under special conditions.

Sweet Clover

Sweet clover is the outstanding soil-building crop for Nebraska. In a 10-year period, its production increased from 30,000 to 1,126,000 acres.

Sweet clover has several advantages as a crop for soil building purposes. Seed is relatively cheap and on most soils stands are easily secured. The large, fleshy tap roots penetrate the soil to a depth of 4 to 6 feet, leaving a large amount of organic matter. Following two years of sweet clover

FIG. 11.—Two years of sweet clover on a rundown field do wonders towards restoring it in fertility and tilth.

the soil is greatly improved in tilth, being loose and mellow. Crops which follow sweet clover are less likely to suffer from drouth than those following alfalfa. Growing sweet clover on soil not only adds nitrogen and organic matter, but other plant foods such as phosphorus seem to be made more available. It is not at all unusual to have the yield of grain crops doubled or even trebled following a crop of sweet clover.

From the standpoint of organic matter and nitrogen, an acre of good second-year sweet clover is estimated to be equal to 20 tons of average barnyard manure. Even when plowed under in the spring of its second year, a normal sweet clover crop will add from 100 to 150 pounds of nitrogen per acre, which is equal to that contained in 10 to 15 tons of manure. This would be enough nitrogen to produce two or three 35-bushel corn crops.

Kinds of sweet clover.—There are three types of sweet clover on the market in Nebraska: the white-blossom biennial, the yellow-blossom biennial, and Hubam, an annual white-blossom variety. Occasionally dealers sell, under the general name of sweet clover, a small yellow annual variety which has no value in Nebraska. There are several rather distinct selections of both the white and yellow blossomed biennial varieties. Experience has shown that either the yellow or white blossomed biennial type is satisfactory from the soil-building standpoint.

FIG. 12.—Where moisture conditions are favorable the practice of seeding sweet clover with small grain is an excellent one.

It is not advisable to plow biennial types of sweet clover in the fall of their first year since this is not likely to kill the plants. Plowing them in the spring of the second year should be delayed at least until the plants are well started; otherwise they may not be killed.

The Hubam variety is ordinarily not recommended because of its low soil-building value. However, since this annual variety can be plowed under in the fall, it may be used to a limited extent under some conditions such as on heavy "gumbo" land, which is thus improved in tilth by exposure to winter weathering.

Sweet clover management.—In eastern Nebraska, sweet clover is commonly sown with small grain and plowed under the following spring for corn. This practice can be carried on successfully only when moisture conditions are reasonably satisfactory. The question arises as to what benefit sweet clover is to the soil when plowed under in the spring of its second year as compared to a crop left on the land for the full two seasons of growth. It has been shown that sweet clover develops the greater part of its root system in the late fall of the first year of growth, and in the early spring of the second season. Sweet clover contains the maximum amount of nitogen when it reaches a height of about 20 to 24 inches, in its second year. In eastern Nebraska this normally occurs in late May. Although the growth of sweet clover increases greatly after this time, the total amount of nitrogen per plant or per acre does not materially increase. It is estimated that a 6-to-8-inch growth of second-year sweet clover, if plowed under in early May, adds from 70 to 80 per cent of the nitrogen supplied by comparable stands allowed to grow for the full second season.

FIG. 13.—A six-to-eight-inch crop of second-year sweet clover will add about 75 per cent as much nitrogen as matured growth. This field is being plowed too late if it is to be planted to corn.

It has been shown that mowing or heavy pasturing of first-year sweet clover during the late summer and early fall decreases very materially the rate and amount of growth the following spring. Where one is primarily interested in getting a heavy early spring growth for plowing under in May, care must be used in managing the crop the previous fall. In this case, it would be well to delay pasturing or cutting sweet clover until the growth has practically ceased in the fall.

Where the soil is reasonably high in fertility and in good tilth, the plan of plowing under a second-year growth in early May is very practical. However, where one has a badly run-down soil which may also be in-

clined to be sticky, cloddy, and hard to manage, it is very desirable to allow the sweet clover to remain on the field for the full second year's growth. This will improve the soil greatly in tilth and organic matter as well as in nitrogen content. In areas where stands are difficult to establish, it is well to allow the sweet clover to grow for two full seasons so as to add the maximum amount of both nitrogen and organic matter.

Many farmers make the mistake of allowing sweet clover to grow from 20 to 30 inches high in the spring of its second year before turning it under for corn. This heavy growth is very likely to dry out the soil excessively, making it difficult to get a satisfactory seedbed and stand. When handled in this way, the corn crop is more likely to be injured from drouth than where the sweet clover is plowed under when 6 to 8 inches high.

FIG. 14.—Red clover is an excellent soil-conserving crop for eastern Nebraska.

A growing practice among eastern-Nebraska farmers is to plow sweet clover under shallow in early May and then list the field to corn, setting the lister to run somewhat deeper than the plow. Listing tends to reduce the damage from dry weather since the corn does not grow as rank as when surface-planted. Listed corn also stands up better. Where listed-corn machinery is available and where land is not so rolling as to wash excessively, this is a very good practice to follow. In parts of the state where normal moisture conditions are likely to be unfavorable to the practice of plowing sweet clover under in the spring of its second year, it is usually advisable to allow the crop to stay on the land for two seasons.

Red Clover

In eastern Nebraska, red clover is grown to a considerable extent as a soil-building crop as well as for hay, seed, and pasture. Red clover is much superior to second-year sweet clover as a hay crop. Because of the higher cost of red clover seed, its smaller root and top growth, and the rather local adaptation of the crop, it is much inferior to sweet clover as a crop to sow with small grain to be plowed under for corn the following spring. Tests indicate that when used in this way red clover increases the yield of grain crops about one-half as much as sweet clover. The

FIG. 15.—Alfalfa has a lasting beneficial effect on soil fertility.

usual and recommended practice is to use the second-year growth of red clover for hay or seed. When used in this way, it very materially benefits the land.

Alfalfa

Alfalfa is a very important soil-building crop. Because each seeding of alfalfa is usually grown for at least four or five years and often much longer if it maintains its stand and yield, this crop does not fit into a short-time rotation. On much of the upland of the state, alfalfa exhausts the subsoil moisture in about five years' time, after which its yield is greatly reduced, depending on the seasonal rainfall. The subsoil moisture is restored very slowly on such land after the alfalfa is broken out. For this reason the yield of a new alfalfa seeding on an upland field which was in alfalfa for several years, even though several intervening grain crops are grown, is likely to be low and unsatisfactory.

The excess available nitrogen in the soil of a newly broken alfalfa field greatly stimulates the growth of corn planted on such land. This increases the need of soil moisture, and often makes it difficult to produce a crop

FIG. 16.—Alfalfa roots may penetrate and dry out the soil to a great depth.

without injury from drouth, particularly in the drier parts of the state.

The practice of plowing alfalfa land shallow and listing it to corn tends to reduce the growth of the corn plants and avoids, to some extent, injury from dry weather. On newly broken alfalfa land, in the drier parts of the state, it may also be advisable to plant an earlier variety of corn at a somewhat thinner rate than usual. Small grain, cane, or sudan grass may be used advantageously in the south-central part of the state on first-year alfalfa land, following with corn the next year.

Winter Rye

On sandy land, winter rye is a very important crop for the prevention of soil blowing and if the rye is plowed under as green manure it may be used to build up the organic matter. Often rye or rye stubble can be used to an advantage as a protection from blowing for clover or alfalfa seedings.

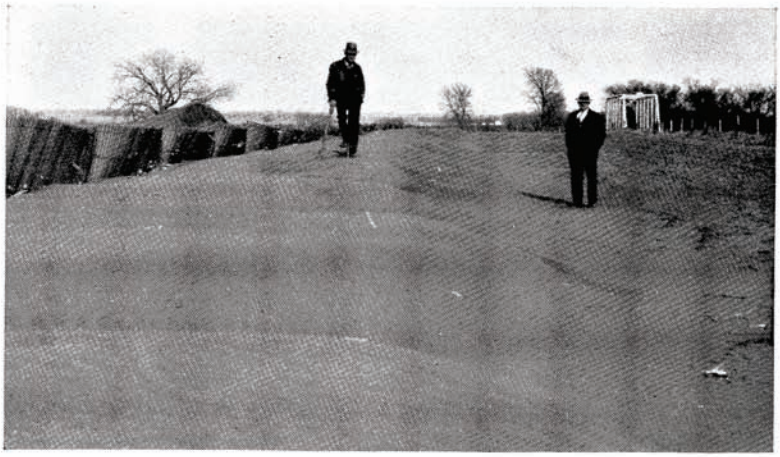

FIG. 17.—Rye may be used to an advantage on light soils that are inclined to blow.

Soybeans

Soybeans, being an annual crop, do not rank with alfalfa, sweet clover, or red clover as a soil-building crop. However, they do have considerable value and may be used to some extent in eastern Nebraska, grown as a seed or hay crop as well as for soil improvement. Soybeans do not compete well with weeds. When planted in rows and cultivated as one would corn, they tend to increase soil erosion on rolling land. Under such conditions, they are not satisfactory as a soil-building crop. As a cultivated crop, they need attention at the same time as corn. However, by using the harrow or in some cases the rotary hoe, the amount of labor can be reduced somewhat.

Soybeans offer some promise as a crop for sandy soil. They should be inoculated when grown on a field for the first time. Soybeans should

first be tried out on a small scale to determine their fitness for any certain locality before planting large acreages.

Lespedeza

Korean lespedeza may be used on badly depleted soils in southeastern Nebraska counties. It does not make as much growth as sweet clover, but may be of value on so-called "gumbo spots" and as an ingredient of pasture mixtures on thin permanent pasture lands. It is tolerant to acid soils. Except for its use on very poor soil areas, it does not appear to be as valuable as sweet clover, alfalfa or red clover.

Barnyard Manure

Barnyard manure is a valuable source of organic matter and nitrogen. It also contains considerable phosphorus and potassium. The liquid portion of manure contains a much higher percentage of nitrogen and potassium than the solid part. The use of plenty of straw about the barns and yards helps to save these elements. A ton of average fresh barnyard manure contains about 10 pounds of nitrogen, 2 pounds of phosphorus, and 8 pounds of potassium. There is much variation in the composition and value of manure, depending on the kinds of animals that produce it, the type of ration fed, and the nature of the bedding. Hog, sheep, and poultry manures are relatively high in nitrogen. Legume crops fed to animals or used as bedding make a much more valuable manure than that produced from small-grain straw. In addition to the plant nutrients which it supplies, manure helps to maintain the organic matter of the soil. This in turn increases the water-holding capacity, tends to reduce soil washing, and improves the tilth of the land.

On the average farm, much of the material in fresh manure is not returned to the land but is lost about the barnyard. Only about one-fourth of the organic matter of a crop fed livestock is returned to the field as manure. Even greater losses occur if the manure is allowed to rot and to be exposed to rains and leaching before it is hauled to the field. Pasturing crops in the field is one way to secure maximum benefits from manure. It is best, so far as possible, to haul and scatter manure on the fields as it is made. The practice of dumping manure into small piles in the field, to be scattered later, is not recommended.

On the average farm there is not enough manure produced to cover the fields as frequently as is necessary in order to maintain soil organic matter by the use of manure alone. This may be possible on a few farms where much livestock is fed. Legume crops must be grown on most farms to supplement the manure.

In regions of low rainfall or during dry seasons, there is always danger that manure will stimulate the growth of crops early in the season only to cause them to burn or fire during later periods of drouth when the need for water by the crop is greater than the supply. Light applications of manure will help to avoid this overstimulation. Using manure as a top

dressing on crops like winter wheat instead of plowing it under may also be an aid in avoiding excessive growth of the crop and later burning during dry periods.

Even in eastern Nebraska where moisture conditions are relatively more favorable, it is advisable to spread thinly what manure is available rather than to apply it heavily to a small acreage. More bushels of grain per ton of manure will result from this practice.

FIG. 18.—Straw should be used as much as possible as bedding about the yards and barns and returned to the soil as manure.

Crop Residues

It is a common sight during the spring months to see the horizon lighted by burning straw piles and windrows of corn stalks. Nearly one-half of the nitrogen and phosphorus of a corn crop is contained in the stalks. While the mineral elements such as phosphorus and potassium are not lost to the land when stalks are burned, the nitrogen is lost and much potential organic matter is destroyed. Whenever possible, corn stalks should be pastured off or cut up and plowed under to furnish organic matter to the soil.

The best use of large amounts of straw in sections of the state where small grains are grown extensively is a difficult problem to solve. The use of fresh unrotted straw as a top dressing on winter wheat has failed, on the average, to increase yields, and may, at least for a few years, decrease the yields of succeeding crops. When carried on for a series of years, straw spreading may pay. Straw is valuable when used as bedding about the sheds and barns and then applied as manure.

The advent of the combine, which leaves the entire straw crop on the field, brings up the problem of the disposal of this material. It appears to be the opinion of the majority of farmers in central and western Nebraska that burning the stubble gives better results than turning this heavy growth under, when measured in yields of immediately succeeding crops. When a heavy straw growth is turned under, the soil is inclined to remain loose and open and often, due to a lack of moisture, there is very little rotting. Straw and stubble are valuable from the standpoint of preventing soil blowing. The use of tools designed to leave some stubble on the ground for protection from soil blowing is worthy of consideration in the western part of the state. More data and experience are needed on which to base recommendations as to what practice is likely to give the best results over a long period of time.

Soil Moisture

Moisture in the soil plays four important roles, namely, as a solvent and carrier of plan nutrients, as an agent in keeping the plants cool and turgid, as a constituent of plant food, and as a factor in soil tilth and tillage.

Plants take moisture from the soil by means of tiny root hairs which cling about the soil particles. Under normal moisture conditions, each soil particle is surrounded by a film of water. Plants do not have the power to remove this entire film. They may reduce the thickness of the film to a certain degree, at which point the power of the soil particles to hold the remaining water is equal to the power of the plants to remove it. When this occurs, the amount of water in the soil is said to have reached the wilting point for plants. The percentage of moisture still remaining in a soil after the wilting point is reached depends upon the texture of the soil. Heavy clay soils withhold from plants a higher percentage of water than do coarse, sandy soils. On the other hand, a greater amount of water available to plants may be held by fine-textured soils as compared to sandy soils. This is because of the fact that in a given volume of fine-textured soil there is a much greater number of soil particles, on the surface of which moisture clings in a film.

Movement of Soil Water

After heavy rains, a soil may be so saturated with water that the particles are unable to hold all of it against the downward pull of gravity. Under such conditions, the excess moisture, known as gravitational water, percolates downward through the soil until the surface tension of the soil particles in holding the moisture as a film is equal to the downward pull of gravity.

Water present in the soil in the form of a thick film about each soil particle has a tendency to move from regions of greatest to those of least moisture. This is called capillary movement. The speed at which the movement takes place, and the volume of water that moves in this way,

so far as supplying plant needs is concerned, is often overestimated. Except in sub-irrigated valleys where moisture is supplied by a water table relatively near the surface, the upward movement of soil moisture, in sufficient quantities to be of value to crops, is very small. On uplands the rise of water from below into the region occupied by crop roots has little practical significance. The distance that water will move by capillarity, as well as the speed of movement, depends upon the texture of the soil. In sandy soils capillary water moves more rapidly but for a shorter distance than in silt or clay soils.

As the tiny crop rootlets take up moisture from the soil, there is some movement of capillary water toward the point of extraction. However, in normally moist soil, water does not move appreciably toward the plant roots, but the roots extend themselves into the moist soil. It is for this reason that a moist surface soil and a dry subsoil tend to cause crops to root shallowly, while a moist subsoil and a dry surface tend to extend the roots more deeply. Plant roots cannot penetrate a layer of dry subsoil even though there is a plentiful supply of moisture below it.

Storing Soil Moisture

Although soil texture determines the water-holding capacity of a soil and influences to a great extent the rate of rainfall absorption, the structure of the soil, its chemical make-up, its organic-matter content, its vegetative cover or cultural condition, and the slope of the land play extremely important roles in the storage of soil moisture. In general, a sandy loam absorbs water more quickly than a silty or clay loam. On the other hand the finer-textured soils have a higher water-holding capacity. A sandy surface soil and a finer-textured subsoil are therefore usually ideal from the standpoint of moisture storage. The rate of rainfall absorption, particularly of the finer-textured soils, may vary greatly even between soils of approximately the same texture for the reasons stated above. Certain silt loams such as the loess for instance have been shown to absorb water nine times as fast an another silt loam, of a different origin.

The character of the soil makes a tremendous difference, therefore, in the amount of rain needed to store a substantial quantity of water in the subsoil. A high percentage of organic matter in the soil tends to reduce the loss of precipitation through runoff. It has been shown that fields under conditions corresponding to eastern Nebraska, when rotated with legumes and thereby kept up in organic matter, absorb as much as three inches more rain per season than do fields with a similar slope but reduced organic matter. The storage of water in the soil is influenced greatly by the amount and character of the precipitation. Slow, drizzling rains extending over a comparatively long period offer the greatest possibilities for maximum storage. Light showers falling on a warm, dry surface usually add nothing by way of water storage, because of subsequent rapid evaporation. Heavy, dashing rains may add but a small fraction of their total amount. The greater part of the rainfall in Nebraska comes as heavy rains of short duration, resulting in much runoff.

How Precipitation is Lost

Water which falls on the land as precipitation may be lost by runoff, percolation, evaporation, or by transpiration through the leaves of plants.

The slope of the land and the condition of the soil as to organic matter, tillage, and crop covering influence the amount of runoff. It has been estimated that the average loss of precipitation on rolling fields of the eastern third of Nebraska amounts to from 30 to 40 per cent of the season's precipitation. The general reduction in soil organic matter that has taken place in most cultivated Nebraska soils has materially increased, on rolling land, the percentage of annual precipitation lost as runoff.

A good grass covering has been shown to reduce greatly the runoff of precipitation even on steep slopes. Runoff from grass land may be as little as one-tenth of that from land planted to such crops as corn.

Before the advent of the white man, Nebraska was covered with grasses varying from the short types such as buffalo and grama in the west, to tall species such as bluestem and slough grass in the eastern portion. This valuable grass cover tended to hold the precipitation until it soaked into the soil. There was little soil erosion under such conditions. Rainfall was fed gradually into the streams, preventing floods and feeding numerous springs. Streams were clear and more steady of flow. Grasses covered the draws and swales, preventing gullies and catching the soil particles that were carried in the water.

Now conditions are changed. Most of the grassland has been broken out, even on steep slopes, and what remains is usually closely grazed. Dashing rains rush off the fields, carrying the soil with them. Gullies cut into the hillsides. Less water soaks into the soil. Springs flow only for a short time in the spring, if at all, and then dry up. Floods occur on the lowlands and streams are silted up. Grasses and legumes will need to play an important part in any soil and water conservation program.

The loss of precipitation by percolation downward through the soil is not an important factor on most of the cultivated soils of Nebraska. Very sandy soils and those with coarse gravelly subsoils may lose through percolation a large part of the water received from precipitation or irrigation.

The loss of water by evaporation represents a considerable portion of the total annual precipitation. Evaporation at the soil surface immediately after rains accounts for a goodly portion of this loss. During hot weather the surface soil becomes heated to a considerable depth, causing some of the water in the soil to vaporize and work its way upward to the surface where it is lost. Cracks in the soil facilitate this loss.

The greater part of the water loss from within the soil, however, takes place through plants. A single corn plant has been shown to transpire through its leaves as much as 30 gallons of water during its season of growth. A large wild sunflower plant may use nearly three times this amount. The greater part of water used by plants is transpired through the leaves. The extent of loss through transpiration depends upon the

number, size, and kind of plants on a given area of land and upon weather conditions. On a hot, windy day, when the air is very dry, a single corn plant may use as much as one and one-half gallons of water. On the other hand, less than a quart of water may be used by the same plant on a cool, moist day. It has been estimated that the average water requirement of a normal, eastern-Nebraska corn crop amounts to approximately nine inches of rainfall.

There is considerable difference in the depth to which the roots of various crops extend. Certain plants like the potato feed largely in the upper two feet of soil. Corn and winter wheat may send their roots to a maximum depth of five to seven feet and nearly exhaust the available moisture in the upper four or five feet. Alfalfa is known to root to a depth of 30 feet or more, and on some soils may remove most of the available moisture to a depth of over 20 feet.

The transpiration of soil water by crops is a necessary function in plant growth. Water removed from the soil in this way serves a useful purpose in crop production. It must be remembered, however, that weeds if present also remove great quantities of water. A heavy growth of weeds may exhaust all of the available soil water to a depth of five feet or more.

Practical Ways of Conserving Moisture

The loss of precipitation other than that used by crop plants may be retarded by mulching, tillage, strip and contour farming, and terracing. Although mulching with straw or paper is no doubt of greater efficiency than tillage in preventing water loss, its practical use is confined largely to garden crops and small acreages of potatoes used for home consumption.

Tillage, from the standpoint of moisture conservation, functions largely through the destruction of weeds. The cultivation of weed-free land is of little value, so far as conserving moisture is concerned, except in so far as it puts the surface of the soil in a favorable condition to absorb rainfall. Tillage also prevents cracking, which is a problem on some soil types.

When winter wheat is to follow small grain, early tillage following harvest is very important during seasons when there is sufficient soil moisture to promote the growth of weeds and volunteer grain. Early plowing or listing, or early disking followed by later plowing may be used to prevent weed growth. Land tilled early must be kept free of weed and volunteer growth up to seeding time in order to accumulate the maximum amount of water and available nitrogen. At the Nebraska Experiment Station, winter wheat on early tilled land has yielded, on the average, approximately twice as much as that on land prepared late.

Summer tillage.—The practice of tilling uncropped land every second or third season for the purpose of storing moisture is a common one in western Nebraska. In regions of low rainfall, this practice has proved to be a profitable one under normal conditions. Ordinarily, the land is plowed or listed in May or June and tilled thereafter until seeding time for

fall wheat. The number of tillage operations necessary depends largely on the weed growth, which in turn is influenced by the rainfall.

The amount of water that it is possible to store depends upon the rainfall and those factors already mentioned, such as soil type, slope, and weed growth. At the North Platte Experiment Substation, it was found that under the most favorable conditions as much as 33 per cent of the rainfall of one season was carried over to the next. Under the least favor-

FIG. 19.—This difference in winter wheat on early plowing (left) and late plowing (right) is due to soil moisture and nitrates.

able conditions but 10 per cent was carried over. These experiments were conducted on a fairly level, very fine sandy loam soil having a deep, porous subsoil of relatively high water-holding capacity.

Weed-free row crops such as corn, potatoes, or beans approach summer-fallowed land when measured in yields of following crops. Corn planted in every other or every third row may be used in place of complete summer fallow. Results at the North Platte Experiment Substation show that from 50 to 75 per cent as much corn can be grown in this way as from regularly planted fields. The returns from the corn help to pay fallowing

costs and the stalk growth tends to prevent soil blowing and the drifting of snow. Each farmer must decide for himself whether summer fallow fits into his type of farming better than the use of row crops which, on the whole, tend to make a more diversified type of farming.

Erosion Control Practices

Too little attention has been paid to soil conservation practices. Wind and water erosion have severely injured many farms and fields by carrying away the surface soil with its centuries-old accumulation of organic matter and nitrogen. The loss to soils by erosion is probably twenty times that lost by the removal of crops. If we are to have a permanent agriculture, we must pay more attention to soil-conservation practices. Foremost in importance is the proper use of grasses and legumes as permanent crops for certain fields and in the rotation on others. The use of grasses and legumes may be supplemented by the proper arrangement of fields, the use of terraces and other soil-saving practices.

Strip farming, which is simply planting crops in long, narrow, alternating fields, is of great value from the standpoint of controlling both wind and water erosion. In dry-land areas, where summer fallowing is common, it has been the usual practice to lay out large fields of as much as a section of land. The absence of any vegetative covering gives the wind an unretarded sweep across such areas, which results usually in the loss of snow and, if the season is dry and windy, the surface soil itself may be carried away.

Numerous farmers in western Nebraska now lay out their fields in strips ten to twenty rods wide. Several long, narrow fields may be handled as efficiently and satisfactorily as single, large fields. These strips should run at right angles to the prevailing direction of winter and spring winds. Alternating strips of fallow and winter wheat, or of fallow, winter wheat, corn, spring grains, sorghums or potatoes, depending on the crops customarily grown on the farm, may be used. Strip farming does not necessarily call for any change in crop acreages. More thought should be given to strip farming practices in areas where soil blowing is a problem.

Strip and contour farming and terraces may often be used effectively in conserving soil moisture and in preventing water erosion. Strip cropping, with fields laid out at right angles to the slope, is particularly valuable on steep but rather long, uniform slopes. Strips of grasses and legumes between strips of cultivated crops are particularly effective in holding both soil and runoff. Strips of small grains, particularly fall grains, are also beneficial.

Contour farming consists of working fields at right angles to the slope of the hills. Where the lister or furrow opener is used for planting corn, contour farming is especially effective. Basin listers, designed to throw up small dirt dams in the lister furrow in contour farming at certain intervals. are being developed and tried. These may prove very useful where the lister rows deviate slightly from the contour or where the rows follow gentle slopes.

Terraces are being used to an increasing extent for the purpose of conserving soil and rainfall. They consist of broad ridges with a very gentle grade constructed across the slope. They intercept the runoff water on hillsides and carry it away without erosion and with little soil loss. They are very effective in controlling and even eliminating small gullies on the hillsides. Although terraces in themselves do not conserve a great amount of rainfall, they serve as a guide for contour farming which tends to hold the rainwater where it falls. Terraces also act as a protection to contour farming in that they intercept the water which may concentrate in low places and otherwise may cause ditches or gullies to form. Although terraces have a very useful function they are not adapted to all conditions of slope. They are most useful and practical on even slopes of 3 to 8 per cent. On uneven slopes, and on slopes greater than 10 per cent they are difficult to farm over. It is usually not advisable to build terraces on cultivated land unless the land is to be farmed on the contour.

Special Soil Problems

Irrigated Soils

Farmers on irrigated land have the important advantage of being able to control, to a large extent, the moisture necessary for maximum crop yields. Irrigated land, however, presents many soil problems not common to non-irrigated farms. Chief among these problems is the matter of drainage, particularly on the lower lying farms. Unless provisions are made for drainage canals with adequate laterals to carry off the surplus water, seepage may become a problem on certain areas. Seepy land, in addition to being unfit for cultivation, usually develops an alkali condition.

Many western-Nebraska irrigated soils are inherently lower in fertility than eastern-Nebraska soils. Irrigated fields usually produce heavy crop yields and this together with some loss of plant food materials through drainage water brings about a rapid depletion of fertility. The acre costs of raising crops under irrigation are high. It takes extra labor to prepare and tend the land. Water and land costs are high. This means that the farmer on irrigated land must pay special attention to the soil-management practices necessary for maximum yields.

Experiments conducted on irrigated land at the Scottsbluff Experiment Substation at Mitchell, show that the annual yields of grain crops, beets, and potatoes rapidly decrease on fields which are neither manured nor seeded to alfalfa or sweet clover. The yields of crops in a rotation system which does not include manure or legumes are, on the average, too low to show a profit, regardless of what single crop or combination of crops is used.

Legume crops must be used frequently in the rotation system of irrigated lands. Experiments show a yield of 19.3 tons of sugar beets following alfalfa, and 21.2 tons following pastured second-year sweet clover,

as compared to 12.1 tons on unmanured land. Likewise, potatoes following alfalfa yielded 409 bushels compared to 207 bushels on land neither manured nor seeded to legumes. Sweet clover seeded with small grain and pastured off the second year seems to have about the same soil-building value as four years of alfalfa when measured by the yields of succeeding crops. The yields of corn, beans, and small grain, like those of sugar beets and potatoes, are greatly increased by the inclusion of alfalfa and sweet clover in the rotation. Small-grain crops under irrigation are relatively unprofitable in themselves and should be grown chiefly as nurse crops for legumes. Thus they supply some return from the land while

FIG. 20.—The farmer on irrigated land must pay special atention to the matter of soil fertility.

alfalfa and sweet clover are getting established. Small grains may be of great value when used to prevent thin sandy land from blowing. On such fields they may be seeded to supply a stubble into which alfalfa or sweet clover can be drilled the following spring.

Barnyard manure can be applied freely to irrigated land without fear of overstimulation and subsequent burning of the crop. An application of 12 tons per acre at the Scottsbluff Substation has increased the yield of sugar beets 6.8 tons per acre as an average for 13 years. When used this way, manure is estimated to have a value of from $3 to $5 per ton. Manure on other crops may also be expected to make relatively profitable returns.

Water Erosion

Water erosion is the cause of extensive damage to Nebraska soils. The loss of the surface soil by sheet erosion and the formation of gullies need constant attention. Soil erosion by water is discussed in detail in other publications, to which readers are referred for further information.

Liming

It has already been pointed out that the soils in parts of the Drift Hill and Outwash Plains areas may need lime for the successful establishment of stands of legumes, especially sweet clover and to a less extent alfalfa. In some local areas of level upland soil in the Loess Hill region of north-

FIG. 21.—The growth of sweet clover is on a limed strip on sandy soil in the Outwash Plains area.

east Nebraska, there also seems to be some deficiency of lime in the surface soil. Some farmers dealing with light sandy soils in the area around Norfolk have experienced considerable difficulty in establishing stands of sweet clover and alfalfa. In a number of instances, the application of lime on such soils has been of great benefit in starting legume crops.

Where lime is deficient in the soil, promising stands of sweet clover and alfalfa may be secured early in the season, but later the plants tend gradually to disappear, leaving only partial stands. Among legume crops, sweet clover has been observed to be the most sensitive to a lack of lime in the soil, followed in order by alfalfa, red clover, and soybeans. It is a common observation that sweet clover makes its best stand and growth on hillsides where the limy subsoil has been exposed by sheet erosion.

Laboratory tests for acidity, unfortunately, are not completely dependable in diagnosing need for lime under Nebraska conditions. It is, there-

fore, suggested that lime be applied on a representative portion of the field whenever soil tests and the behavior of sweet clover or alfalfa indicate that soil acidity may be the cause of failure to get stands.

Ground limestone is usually applied at the rate of about 2 tons per acre. A lime spreader is the best implement to use to spread limestone. A manure spreader is sometimes used by putting a thin layer of straw or manure in the bottom, on which a 4-inch layer of limestone is spread.

Crushed limestone is available at quarries at Blue Springs, Weeping Water, Nehawka, Louisville, and Auburn. Refuse lime from beet-sugar factories and other sources can be secured at Norfolk, Ames, Grand Island, Columbus, and Omaha.

FIG. 22.—A limestone quarry at Weeping Water, Nebraska.

It is advisable that limestone be spread a year in advance of seeding fields to legumes, as this allows time for soil reactions to take place. County Agricultural Agents usually have local information as to the need of lime and are glad to assist in conducting lime demonstrations where these seem desirable.

Commercial Fertilizers

Phosphate fertilizers are now being used extensively on sugar beets and to a less extent on other crops in the irrigated section of the North Platte river valley. However, not all soils of that area respond to phosphate fertilizers. Soils low in organic matter, which have not been manured and which are strongly alkaline are the most likely to respond profitably to phosphate fertilizers.

Treble superphosphate (42 to 46 per cent available phosphoric acid) is commonly used in the North Platte valley, this being applied at the rate of 100 to 150 pounds per acre with a fertilizer drill. Some sugar beet growers in the Grand Island territory report profitable yield increases from the use of phosphate fertilizers.

Nitrogen fertilizers may be profitably used to a limited extent on truck crops. They may be used very successfully on lawns. The high price of commercial nitrogenous fertilizers prevents their profitable use on ordinary crops.

Alkali Soils

It has been pointed out that the water of the soil dissolves many of the mineral salts. Under certain conditions, an excess amount of soluble salts may accumulate in the surface soil, causing what is known as alkali or alkali spots. Alkali is most likely to develop in poorly drained areas where water carrying a large amount of mineral salts evaporates from the surface of the soil. This water may come from seepage or from a shallow water table and upon evaporating leaves a deposit of the mineral salts. Alkali soils are usually in poor physical condition. Good drainage is the first consideration for the improvement of alkali lands. There are two general types of alkali. Certain forms of salts, such as sulphates and chlorides, when concentrated on the surface of the soil form a white encrustation and are known as white alkali. Salts in the chemical form of carbonate react on the organic matter of the soil, forming a dark solution and encrustation. This is known as black alkali. Black alkali is much more destructive to vegetation than white alkali but fortunately it is much less common in Nebraska.

A heavy application of barnyard manure is often beneficial to white alkali soils. Sweet clover, provided stands can be established, is one of the best crops to use to improve alkali land. Other crops such as sugar beets, alfalfa, barley, oats and rye may be grown on this type of soil, depending upon the amount of alkali present.

Sandy Soils

The fertility of sandy soils is likely to be low. Although sweet clover and alfalfa will very materially improve their fertility, it is often difficult, due largely to soil blowing, to establish satisfactory stands. A number of different ways of seeding legumes may be suggested for the consideration of farmers who have to deal with sandy soils.

The use of light seeding of small grain as a nurse crop for legumes is probably the most common method of seeding. Seeding early in the spring on a firm seedbed is essential for the success of this plan. Some prefer to postpone seeding until after the windy spring months have passed and then sow the legume crop alone on land cultivated a number of times to kill the weeds.

During years with favorable moisture conditions, August seeding may be tried. It is often advisable to sow a bushel of spring grain per acre as a fall nurse crop to help hold the winter snow and to prevent soil blowing the next spring. The spring grain winterkills but nevertheless it affords much protection. Early spring seeding into the clean stubble of previous crops of millet, cane or sudan, which has been cut high, often gives good results.

If summer and fall moisture conditions are favorable, seeding alfalfa or sweet clover into corn following the last cultivation may be successful. The land should be left as level as possible when the corn is laid by. The standing stalks catch the winter snow and prevent soil from blowing the following spring.

If straw is available, this can be spread very advantageously over sandy fields of newly seeded alfalfa or sweet clover. Many have used this method successfully. seeding first a small area for which straw is available and adding to it gradually.

On very light, sandy soil of low fertility, sweet clover may be winter-seeded into small-grain stubble or into weed growth which will offer it some protection. It may thus get a foothold and from later seed crops gradually make a full stand, provided the land is allowed to remain uncropped for several seasons.

If available, manure spread on the land a year in advance of seeding will often help to secure stands of alfalfa and clovers. Strawy manure may also be used as a top dressing on newly seeded fields, in which case it supplies both fertility and protection. Strip farming, as suggested previously, should be practiced on sandy soils as a means of preventing soil blowing.

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