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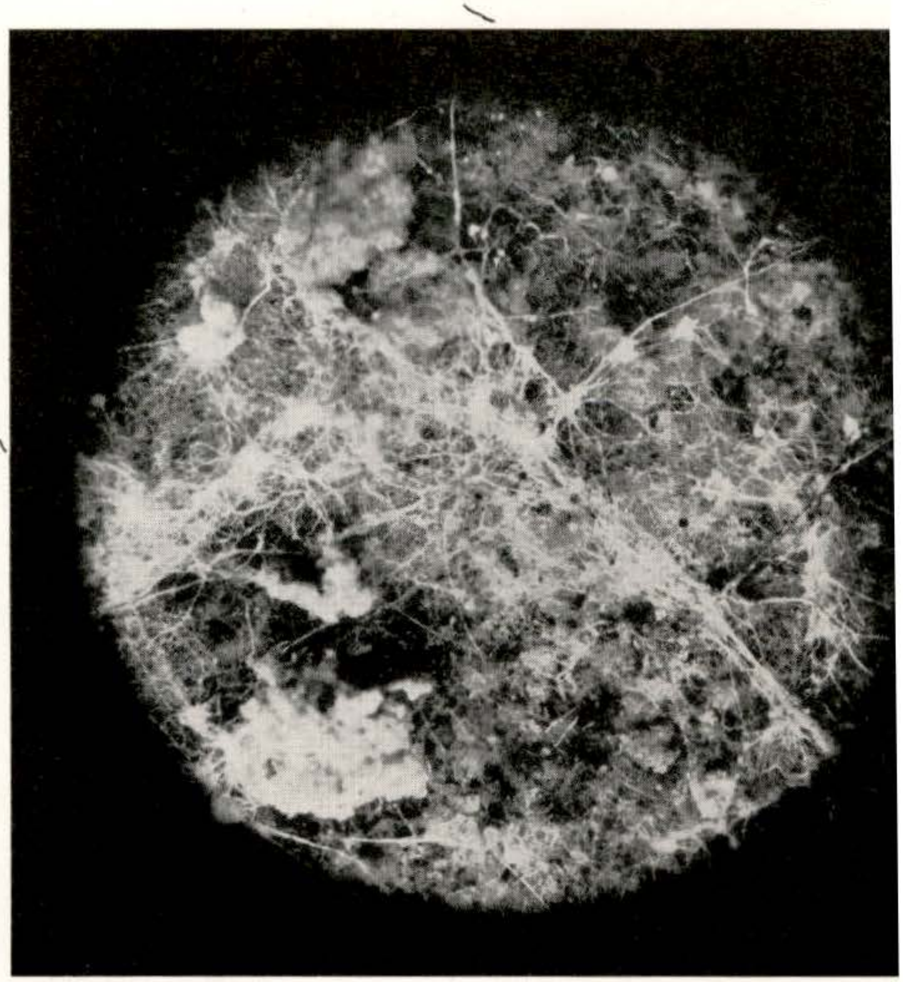

Mycelia from fungi growing in this soil have bound the individual soil particles together. Note large clump at lower left. Magnified 12 times.

NEBRASKA AGRICULTURAL EXPERIMENT STATION,
IN COOPERATION WITH SOIL CONSERVATION SERVICE OFFICE
OF RESEARCH, U. S. DEPARTMENT OF AGRICULTURE

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SUMMARY

Many of the cropping and tillage practices that a farmer uses are effective in crop productivity because of their influence on microbial activity. For example, when the soil is tilled, aeration is improved and aeration is favorable for the growth of the nitrogen, sulfur, and iron oxidizing organisms. When the soil environment lacks oxygen, it is unfavorable as an environment for many plants. Legumes are inoculated, planted and turned back into the soil to increase available nitrogen for the following crop. Every practice or management system influences microbial activity which in turn influences the decomposition of plant residues, the availability of nutrients and the soil structure. These all influence crop growth and the growth of the crops determines the soil cover and the erosion protection afforded.

Microorganisms and Their Effects on Crops and Soils[1]

T. M. McCalla and T. H. Goodding[2]

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Each spoonful of an arable Nebraska soil contains billions of living microscopic organisms. Multiply this by the number of spoonfuls of soil in an acre and you have figures that are astronomical. The bacteria in an acre of soil of average fertility would weigh as much as a medium-sized dairy cow. This seething mass of microorganisms constitutes a crop of 3 to 5 tons per acre-foot of soil that the farmer grows beneath the surface in addition to the crop that he grows above the ground. If this crop of microorganisms beneath the surface is not fed adequately, the crop above ground may suffer from competition, disease, or other adverse effects of the microorganisms. Without the microorganic life the soil would not be the dynamic, perpetual system that sustains all plants and indirectly all animal life.

To carry out a successful farming system using the good features of soil conservation, fertility and crop rotation practices, provision must be made for the growing crops of microorganisms. When compared with the highly diverse population of microscopic organisms that live in the soil, cultivated crops like corn and soybeans can be considered as pure cultures.

It is the purpose here to point out the main kinds of microscopic organisms in the soil and some ways of managing and feeding them that will result in better land use and crop yields. This will result in better soil conservation by furnishing additional cover for the land.

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[1] Contribution of the Department of Agronomy, Nebraska Agricultural Experiment Station, in cooperation with the Soil Conservation Service Office of Research, U. S. Department of Agriculture, Lincoln, Nebraska.

[2] Bacteriologist, Soil Conservation Service Office of Research, and Professor of Agronomy, University of Nebraska, respectively.

KINDS OF ORGANISMS IN THE SOIL

There are many kinds and weights of organisms in the surface foot of soil and there are large numbers of each kind, as shown in Table 1. Each kind of organism plays some significant role in the decomposition of plant and animal residues, liberation of plant nutrients, or in the development of soil structure. Many groups are dependent on each other; consequently one kind may tend to follow another. They set up a series of reaction in the soil that follow one another in an organized sequence. In size the organisms vary from forms invisible with the ordinary microscope but visible with the electron microscope to those that can be seen with the naked eye. In shape they vary from tiny dots to weird twisted forms. They have the capacity to digest the materials in the soil because they produce enzymes which in different microbial groups form a gigantic, complex enzymatic system that extends throughout the soil. There are few things in the soil—even such resistant materials as hair and horn—that escape digestion.

Phages and viruses. These are the smallest forms of living matter in the soil. Some investigators do not class viruses as living. These minute organisms are so small that they are in the twilight zone between the living and the nonliving materials. The phages cause diseases of bacteria and the viruses in the soil cause diseases of higher plants.

Bacteria. These are the microorganisms that account for the largest numbers in the soil. There are many different types. In shape they resemble balls, cylinders, or corkscrews. Bacteria in the resting stage are resistant to heat, dryness, and other adverse environmental conditions. The spore formers, which constitute about 10 per cent of the soil bacteria, are highly resistant when in the spore or resting stage. Higher plants can combine carbon dioxide and water in the presence of sunlight and chlorophyll to make their own food, but bacteria are much like animals in that most of them must get their energy from carbohydrates, fats, proteins or other compounds synthesized in plants or animal bodies. In the process of obtaining their food from plant and animal residues, bacteria in the soil bring about the decomposition of these materials.

Some of the important soil bacteria are the ones that convert unavailable nitrogen of the soil organic matter to ammonia, and those that convert ammonia to nitrites and then to nitrates. Others are the bacteria in the root nodules of legumes that fix nitrogen. Most of the nitrogen that is returned to the soil from sources outside the soil is fixed by the legume bacteria. Many other bacteria play important roles in the soil. They make nutrients available or unavailable, modify soil structure, and change the air relations of the soil.

TABLE 1.—The microorganisms in the soil may vary from a very few up to very large numbers in some cases. Certain organisms occur in relatively small numbers. (From Elizabeth McCoy, University of Wisconsin.)

Kind	Avergae number per gram of soil	Average weight in pounds per acre-foot of soil
Bacteria	1,000,000,000	500—1,000
Actinomycetes	10-20,000,000	800—1,500
Fungi	1,000,000	1,500—2,000
Protozoa	1,000,000	200— 400
Yeasts	1,000	—
Algae	100,000	200— 300
Worms and insects		800—1,000

Closely related to the bacteria is a large group of organisms called Actinomycetes. These organisms are more complicated in structure than the bacteria. The characteristic odor that is evident in newly plowed soil in the spring is due to substances produced by the Actinomycetes. Some of the organisms belonging to this group produce plant diseases, such as potato scab. Many carry on the essential activities of decomposing organic matter and making mineral nutrients available for higher plants. A good soil may have 100 to 1,000 million bacteria in a gram of soil. Five per cent or more of this number are generally Actinomycetes. The growth of Actinomycetes on a cultural medium in the laboratory is usually of a leathery nature.

Yeasts. These single-celled organisms are like bacteria except they are larger and their structure is more highly developed. The yeasts make up only a small per cent of the total organisms in the soil. The importance of yeasts in the soil is not known.

Fungi. The fungi are an essential part of the soil microbial flora. Although fungi may be outnumbered by bacteria per gram of soil, they have a greater mass of growth. These organisms form a maze of tiny threads called mycelium that may enmesh soil particles into granules. Fungi grow best in an aerated soil. Many of them cause plant diseases. However, they decompose organic matter mainly and during the decomposition of plant and animal residues they synthesize some organic matter as cell tissue.

Algae. These are microscopic plants that form chlorophyll in the presence of sunlight. They are found in surface layers of soil that is moist, and where light is available they grow as green plants. In the absence of light they grow as other soil microorganisms. Algae change carbon dioxide from the air into organic matter in the presence of sunlight. They take their nitrogen and mineral nutrients from the soil. There may be as many as 100,000 algae per gram of soil under

optimum conditions. The development of algae may result in the soil turning green at the surface in moist, shady areas. This is not injurious to plants.

Protozoa. These organisms are the simplest form belonging to the animal group. Although they are unicellular and microscopic in size, they are larger than most bacteria and more complex in their activities. Soil may contain as many as 1,000,000 per gram. Protozoa obtain their food from organic matter in the same way as bacteria.

Larger organisms. In addition to these microscopic forms there are larger organisms in the soil such as nematodes, earthworms, and insects. All of these play an important part in changing the soil condition and in promoting or hindering crop production.

NUTRIENTS NEEDED BY MICROORGANISMS

Soil microorganisms have very diversified growth requirements. Some organisms such as the nitrifying bacteria can use ammonia and nitrites for sources of energy and can synthesize new protoplasm in a simple mineral medium. Most soil microorganisms require organic substances such as crop residues or certain organic compounds in the crop residues in addition to inorganic nutrients for building new cell material. Higher plants build their own organic substances from carbon dioxide and water in the presence of sunlight and mineral nutrients. The organic substances required from crop residues by the different soil microorganisms vary considerably. Some organisms use cellulose. Others can not use cellulose until it is converted to sugar. Thus it is necessary for certain organisms to prepare the food for other organisms.

Soil microorganisms need about the same mineral nutrients as do crop plants. Important elements that may be deficient in the soil are nitrogen, phosphorus, potassium and calcium. These are frequently supplied to deficient soils as commercial fertilizer and lime. A few other mineral nutrients are needed in smaller amounts. These are magnesium, sulfur, iron, manganese, copper, zinc, and molybdenum. These are present in sufficient quantity in many soils.

Sometimes there may be competition between the microorganisms and plants for the mineral nutrients in the soil. The plant may suffer because of this competition.

SOIL ENVIRONMENT

Many factors in the soil environment influence the number and activity of soil microorganisms. Factors of considerable importance are temperature, moisture, aeration and acidity or alkalinity.

Temperature. During a Nebraska winter microbial activity in the soil is largely at a standstill. In the spring, after temperatures reach 50° to 60° F., microbial activity begins to pick up. The optimum temperature for a high state of activity is about 85° to 90° F. In order for microorganisms to decay plant material and develop nitrates at a rapid rate the soil must be warm. Microbial growth is retarded at high as well as at low soil temperatures. Temperatures higher than 100° F., retard or stop the activity of many soil microorganisms.

Moisture. Moisture influences the decomposition of plant and animal residues. When the soil is too dry there is little or no microbial activity. When the soil has optimum moisture the beneficial groups of microorganisms are most active. In a wet soil unfavorable groups such as anaerobic [3] organisms may be active. They may convert nitrates to gaseous nitrogen, sulfates to sulfides, and use up all the oxygen in the soil. Sometimes wet soils are unfavorable for certain plants because of this type of undesirable microbial activity.

Aeration. Generally a well-ventilated soil supports the growth of beneficial microorganisms that convert nutrients to available forms essential for high crop productivity. Soils possessing good structure are usually well aerated. Soil aeration may be improved by good tillage practices. In a soil not adequately aerated, microorganisms compete with each other for the oxygen and some may convert oxidized compounds such as nitrates into a form not available to plants. Sulfates may be converted to hydrogen sulfide, and iron may be converted to a reduced form. Too much moisture may intensify the shortage of oxygen by slowing down the movement of air through the soil.

Acidity or alkalinity. Certain organisms become inactive in acid soils. The bacteria that occur in the root nodules of legumes and Azotobacter which fix nitrogen independently of legumes may lose the ability to fix nitrogen in an acid soil. Where lime is deficient, nodulation of legumes is often difficult to obtain until lime is added to the soil. In general, fungi are more active in acid soils than are bacteria. In more alkaline soils the Actinomycetes become active. Soils that are excessively alkaline may be devoid of the proper kinds of microorganisms or the activity of the microorganisms may be limited or directed along lines that are unfavorable for plant growth.

LEGUME BACTERIA

In most instances legume bacteria are minute, rod-shaped organisms that live in the root nodules. The bacteria in association with the plant tissue take nitrogen from the air and convert it into a form

[3] Anaerobic refers to microorganisms that grow in the absence of atmospheric oxygen.

that can be used by the plant. This process is termed nitrogen fixation. Millions of bacteria in each nodule are engaged in fixing nitrogen. Under favorable conditions the bacteria in the nodules of legumes may fix as much as 200 pounds of nitrogen per acre annually (Figure 1).

FIGURE 1.—Well-nodulated sweetclover will supply large amounts of organic matter containing nitrogen taken from the air. It may be necessary to inoculate the seed, lime the soil, and add other fertilizers in order to get maximum nitrogen fixation in the nodule. (Photo courtesy of F. L. Duley.)

Inoculation important. In obtaining the most benefits from legumes in Nebraska it may be necessary to inoculate the seed with the right kind of organisms, in addition to adding lime and phosphorus to certain soils. If the soil has not grown nodulated legumes in recent years, or if the soil has not had a recent application of lime, it is desirable to inoculate the seed at planting time. In Nebraska, probably all small-seeded legumes should be inoculated except in a rotation where they are grown frequently. This is cheap insurance that the right kind of organisms of high nitrogen-fixing ability will be present. Precautions set forth in the manufacturer's directions should be observed carefully. Inoculate with a desirable strain of bacteria. Legume bacteria are usually divided into inoculation groups. Use only the inoculation that includes the bacteria for the legume to be inoculated.

Without bacteria of the proper kind the legume will increase fertility no more than a nonlegume such as oats or wheat. Some strains of legume bacteria are undesirable and have been shown to produce nodules in which little, if any, nitrogen is fixed (Figure 2). These undesirable strains produce small nodules scattered over the entire root system. Nodules developed by desirable strains are fewer in number and are located on the tap root and first lateral roots of the host plant.

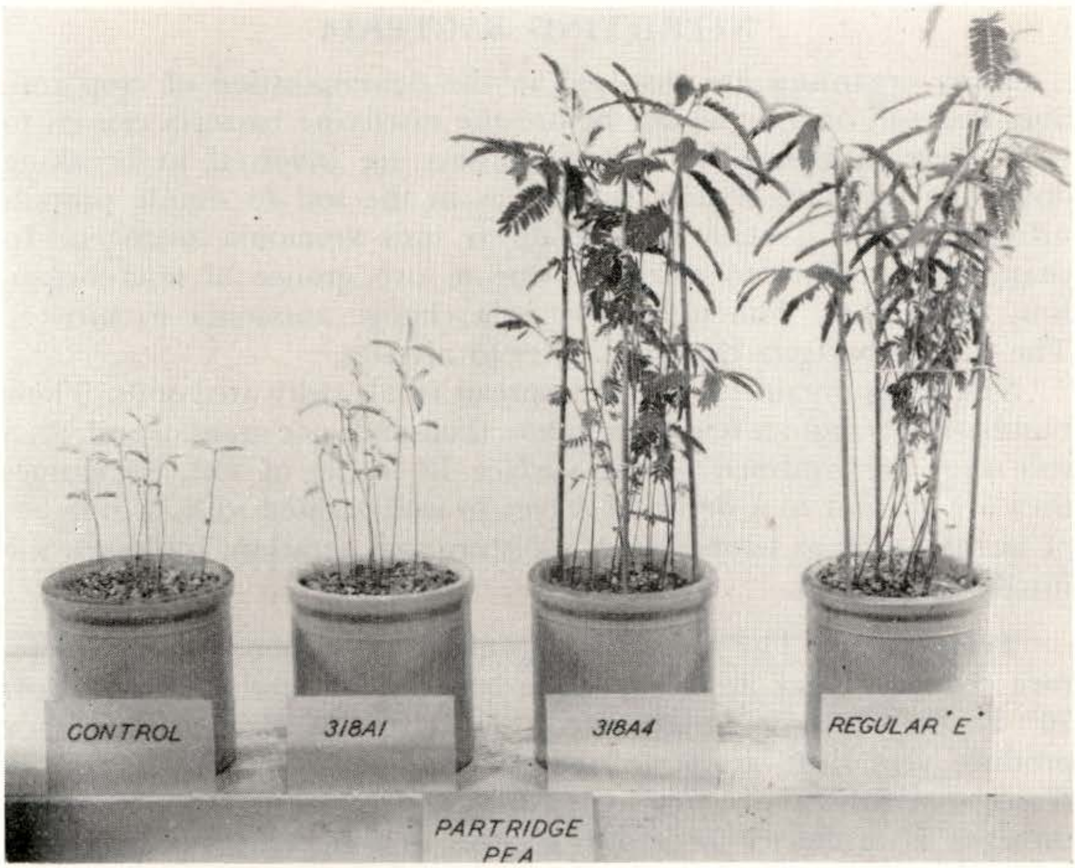

FIGURE 2.—Influence of inoculation on partridge pea. Plants grown in sand watered with nutrient solution. Culture 318A1 produced nodules that did not improve the growth much over the uninoculated (control). Culture 318A4 and Regular "E" produced good nodulation of the desirable type. (Photo courtesy of Nitragin Company.)

Legume bacteria infect the root hairs at early seedling stage. By the time the plants are one to two weeks old they may have a number of nodules fixing nitrogen. A legume plant nodulated with a desirable strain of bacteria has a dark green color and makes vigorous growth provided the soil supplies other necessary nutrients. Soil fertility conditions, with respect to all elements except nitrogen, should be corrected before the legume is planted. Sometimes a small amount

of supplemental nitrogen may be necessary for carrying the plant through the seedling stage until it is capable of fixing its own nitrogen supply.

When bacteria of the proper kind are applied to the seed of a legume and the seed is planted in a soil supplied with all nutrients except nitrogen, nitrogen fixation will occur. The nitrogen fixed will improve the growth of the legume crop. When the land is turned to another crop, the nitrogen in the legume will be released by decomposition and become available for plant growth.

NITRIFYING BACTERIA

Many organisms are involved in the decomposition of crop residues and soil organic matter before the nitrifying bacteria can go to work. Several groups of microorganisms are involved in breaking down the complex organic substances in the soil to simple protein nitrogen. This is then broken down into ammonia nitrogen. In changing ammonia to nitrate nitrogen, two groups of microorganisms participate. The nitrite bacteria change ammonia to nitrites. The nitrate bacteria change nitrites to nitrates.

Nitrifying organisms are widespread in all cultivated soils. Their numbers vary from a few up to many thousands per gram of soil. As a rule they are confined to the surface 18 inches of soil. Sometimes they are present to a depth of 6 feet in well aerated soils. A number of factors, such as temperature, moisture and aeration, influence the nitrifying bacteria.

Temperature. The nitrifying organisms are responsive to temperature changes. They are most active between 70° and 100° F. Below 70° F., they become progressively less active. At 50° or lower they produce very little available nitrogen, and their activity practically ceases at slightly above freezing (Table 2). Since little or no available nitrogen is produced for growing crops in cool weather, there may be evidence in early spring of nitrogen deficiency in some crops. Management practices that lower soil temperature will decrease the

TABLE 2.—Production of nitrate nitrogen at different temperatures in soil at Lincoln, Nebraska. Initial content 4 p.p.m.; soil at moisture equivalent.[1] (From J. C. Russel, University of Nebraska.)

Temperature	After 8 days	After 29 days
°*F.*	*p.p.m.*	*p.p.m.*
44°	2.6	2.2
73°	4.9	9.1
94°	14.4	30.1
118°	13.8	11.1

[1] Moisture equivalent is approximately the moisture content at field capacity.

activities of the nitrifying organisms. For example, heavy applications of straw mulch will lower soil temperature, which in turn will depress the activity of the nitrifying organisms. Light applications of straw mulch have little or no adverse effect on soil temperature or nitrate production.

Moisture. The optimum moisture content for maximum nitrification is about 60 per cent of the water-holding capacity of the soil. Nitrification [4] practically ceases at low moisture content. However, if the soil is too wet nitrates may disappear from the soil by denitrification [5]. Prolonged periods of wet weather or overirrigation may result in loss of nitrogen by denitrification. Since nitrates are water soluble they may also be lost from the soil by leaching.

Aeration. Nitrification is a process that takes place in the presence of air. Soil conditions that are not favorable for the movement of air into and out of the soil may retard the production of nitrates by bacteria. Although tillage of the soil is aimed at keeping the crop free of weeds, good aeration of the soil is also accomplished and this promotes the activity of the nitrifying bacteria.

Influence of lime. Lime and acidity, related reciprocally, have an important effect on the activities of the nitrifying organisms. The organisms do not grow well below pH 5.0, which is an acid condition. Optimum soil reaction for their activity is near neutral. A growing crop may be green after lime application, not necessarily because of the effect of calcium on the crop, but because the lime has stimulated the nitrifying bacteria to produce nitrates (Table 3). The addition of lime may stimulate a rapid breakdown of the reserve organic matter. This causes more rapid depletion of the nitrogen in the soil. William A. Albrecht of the Soils Department of the University of Missouri has stated that "calcium is an agency to encourage complete combustion of organic matter." Any treatment of the soil may indirectly affect plant growth and soil cover by first affecting activities of the soil microorganisms. The microorganisms in turn may produce some product such as nitrate that plays an important role in producing plants for soil cover.

TABLE 3.—Production of nitrate nitrogen as milligrams of nitrogen per 50 grams of soil from Putnam silt loam as influenced by lime treatment in the laboratory.

Treatment	0	2 weeks	4 weeks	8 weeks	12 weeks
None	0.33	1.13	4.50	2.10	1.83
Lime	0.37	1.90	7.50	4.20	3.70

[4] Nitrification is the process of changing ammonia to nitrates by bacteria.

[5] Denitrification is the process of changing nitrates or other combined forms of nitrogen to gaseous nitrogen.

Nitrogen "tie-up". If too much straw is added to the soil, the nitrates may largely disappear for a time (Table 4). Certain microorganisms consume the carbon in the straw and the available nitrogen in the soil to obtain a balanced diet. Until their activities slow down or cease, there may be little or no available nitrogen left over for the plant. This does not mean that the growth of the nitrifying bacteria is depressed, but that the available nitrogen they produce is used by the microorganisms in the decomposition process.

TABLE 4.—Disappearance of nitrates from Nebraska sandy soil when wheat straw is added.[1]

Treatment	Incubation, weeks		
	2	4	8
		p.p.m. NO_3-*N*	
Wheat straw	3	1	1
None	8	10	23

[1] This disappearance is due to the microorganisms changing the nitrates into cell material and is only temporary. After a time the nitrates thus tied up by the microorganisms decomposing the wheat straw will again be made available for plant use.

Residues. Many soil management practices influence the activity of the nitrifying bacteria. If plant residues containing a large quantity of nitrogen relative to the carbon content are turned back to the soil, they will produce upon decomposition a surplus of nitrates over the needs of the soil microorganisms. When legume residues decompose, either after being plowed under or left on the surface, they are excellent sources of available nitrogen. They usually contain an appreciable amount of nitrogen relative to the carbon content and the nitrogen is readily changed into an available form by the nitrifying bacteria. Crops following on such land usually do not suffer from a lack of available nitrogen, and yield abundantly if moisture is adequate and other fertility elements are balanced and present in sufficient quantity.

Placement of residues, either on the surface or in the soil, influences the activities of the nitrifying organisms. When residues are left on the surface as a mulch, the nitrifying bacteria are usually slightly less active than when the residues are plowed under. This is true with both legumes and nonlegume plant material. If straw is used, plowing it under usually results in a temporary depression of nitrates. If the residues are legumes, plowing them under increases the available nitrogen supply of the soil very soon after plowing.

Fallow. When land is fallowed in the Great Plains area, the nitrifying bacteria may produce 200 pounds or more of available nitrogen

per acre in a single season. This compares with a production of 20 to 100 pounds of available nitrogen on land in row crops in the Great Plains. During fallowing there is usually a sufficient accumulation of moisture to stimulate abundant nitrate production. Also there is no crop to use the available nitrogen. These two factors probably account for the greater production of nitrates under fallow than in crop land.

Fertilizers. Fertilizers, particularly lime, phosphorus, and potassium, stimulate the activity of the nitrifying bacteria. The response of a crop to a single-element fertilizer may often be complicated by the fertilizer's stimulus of the nitrifying bacteria. For example, the application of lime may cause the crop to show a deep green color because of increased nitrification.

Seasonal influence. The activities of the nitrifying bacteria have been attuned to needs of the higher green plants. In the soils of Nebraska during the winter there is little or no activity of the nitrifying bacteria. Neither do the higher plants grow. As spring comes the nitrifying bacteria start to produce available nitrogen slowly. Green plants also grow slowly early in the spring, but as the season warms up growth takes place more rapidly. As summer approaches the activity of the nitrifying bacteria slips into high gear. This coincides with the period of maximum nutritional needs for the development of the green plant, such as corn. If the surface soil becomes too dry during dry weather, the activity of the nitrifying bacteria practically ceases. The plant growth also slows down and comes into equilibrium with the available moisture.

Drainage and percolation. Nearly all of the available nitrogen is produced in the surface foot of soil. Since nitrates are soluble they are carried down with the percolating water. If there is much drainage of water through the soil, there may be considerable loss of soluble nitrogen and other plant nutrients. The roots of a growing crop will absorb much of the available nitrogen and transform it into plant tissue. Thus the available nitrogen is not lost in the percolating water.

Value in a good conservation program. In a soil conservation program it is of vital importance that the erosion control practices be in harmony with the biological activities of the soil, particularly the nitrifying bacteria. Practices that conflict with the production of available nutrients for the plant by these microorganisms may result in the ultimate defeat of a particular conservation method. Working with the nitrifying organisms in a manner that will produce sufficient available nitrogen for the crop will result in an ade-

quate cover for the land, either as a growing crop or as residues to be used later as a mulch (Figure 3). This will satisfy the first fundamental requirement of a good conservation program.

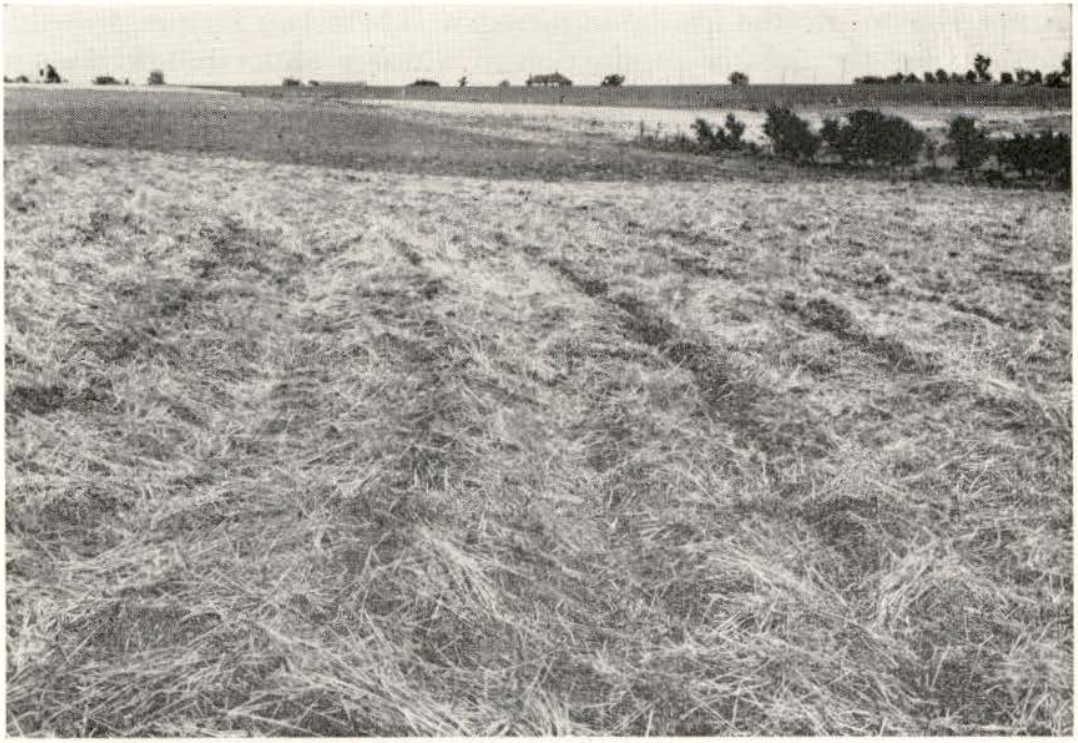

FIGURE 3.—For stubble mulching to control erosion a good supply of available nitrogen is necessary for the growth of good crops, the residues of which are used as mulching material. (Photo courtesy of F. L. Duley.)

Use of legumes in regions of limited rainfall. One of the problems in the use of legumes in regions of limited moisture supply is the overstimulation of plant growth caused by large amounts of nitrate produced in the soil. This excessive growth leads to a further reduction in the moisture supply. When legumes are followed by other crops such as corn, large amounts of nutrients are available in the early part of the season and the corn grows luxuriantly. If a moisture shortage comes later, the corn is too large and may "fire," and often may not produce as much as on less fertile land. Any practice that will reduce this overstimulation and also conserve moisture following a legume seems desirable in regions of limited rainfall. Since the use of stubble mulching reduces the amount of nitrates produced after a legume, it may be viewed as favorable rather than otherwise. It may permit the use of legumes which otherwise might be undesirable where moisture is often a limiting factor in crop production.

When legumes are plowed under there is more rapid decomposition than when the legumes are left on the surface of the soil as a

mulch. Nitrates are thus developed more slowly when legume residues are not plowed under. With stubble mulching following a legume, sufficient nitrates for high crop yields are usually developed. This range in the decomposition of legume residues permits some control over nitrification.

Regulation of decomposition by selection of crop residues and with stubble mulching or plowing. Either stubble mulching or plowing of legumes for a following crop allows a range of regulating the decomposition of residues and nitrate production. Higher or lower amounts of nitrates may be produced by the addition of nitrifying material or by regulating decomposition (Tables 5 and 6). This regulation is obtained by use of legumes or straw and by either plowing the residues under or leaving them on the surface. These alternatives or combinations of them allow the farmer to have some control over the nitrification. The methods or combination of methods selected depend upon the soil and probable rainfall. The use of stubble mulching, coupled with the use of a legume that fixes the proper amount of nitrogen to be nitrified, for example, may permit the use of legumes in dry areas that could not use them before because of "burning." The lower nitrate production plus the additional moisture that may be stored with the stubble mulch system may often increase crop yields in the drier areas of Nebraska and at the same time afford erosion control.

TABLE 5.—Production of available nitrogen in corn grown in a corn-oats-wheat rotation. The nitrate-nitrogen content of land about the time of maximum need for nitrogen by corn.

Disposition of residue	Depth in feet		
	0–1	0–3	0–6
	Pounds per acre of NO_3-N		
Subtilled, left on surface	22	44	69
Plowed under	32	62	95

TABLE 6.—Production of available nitrogen in first-year corn after first-year sweetclover. The nitrate-nitrogen content of land about the time of maximum need for nitrogen by corn.

Disposition of residue	Depth in feet		
	0–1	0–3	0–6
	Pounds per acre of NO_3-N		
Subtilled, left on surface	50	75	115
Plowed under	66	97	124

AVAILABILITY OF NUTRIENTS OTHER THAN NITROGEN

For every ton of straw or plant nutrients decomposed by microorganisms, a ton and one-half of carbon dioxide is produced which may form carbonic acid. This acid has a solvent action on the soil minerals that may change nutrients to an available form for plant use. When nitrogen and sulfur are oxidized in the soil, nitric and sulfuric acid are produced. These acids in localized areas undoubtedly have a dissolving action on the soil.

A large source of the nutrients for plants in Nebraska soils is bound up in organic matter and this is not available to plants. Under favorable conditions for microbial activity microorganisms change the nutrients in the organic matter to an available form. Conditions favorable for microbial activity usually coincide with conditions favorable for plant growth.

SOIL STRUCTURE

In the process of decomposing crop residues, some microorganisms such as fungi produce mycelia. These are threadlike structures which may bind soil particles together into units or aggregates that permit air and water movement through the soil. Certain decomposition products such as gums, waxes and lignins are effective as stabilizing agents in aggregation. Generally, to be effective in promoting aggregation the organic matter must be in the process of decomposition (Table 7). After the decomposition of crop residues has started water percolation is increased. After a time the effect begins to decline because the stabilizing materials decompose.

TABLE 7.—Percolation rate of water through Peorian loess as influenced by the decomposition of straw added at the rate of 8 tons per acre.

Days after addition of straw	Percolate, total inches for 6 hours
0	2.81
10	7.72
20	8.84
26	9.54
46	5.08

Crop residues that decompose and produce available nutrients may be used for maintaining soil structure. In a grass system of farming the microorganisms are being fed continually. This helps to maintain a desirable structure. Other systems of farming, such as continuous row cropping, are not as effective in maintaining structure.

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