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EC175 Revised 1949 Soil Fertility Practices

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Contents

Cover picture shows bundles of barley from a fertilizer test plot on sandy dryland soil. From left to right the treatments were: check; 0-30-0; 20-0-0; and 20-30-0.

Soil Fertility Practices

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DURING THE past two years Nebraska farmers have become increasingly conscious of methods for maintaining soil fertility. Optimum moisture conditions, high prices for farm products, improved crop varieties and cultural practices as well as new kinds of commercial fertilizer materials, have all contributed to this increased interest. In many instances the fertility of the soil has decreased to the point where maximum yields can no longer be obtained without the addition of nutrient materials. However, in other instances effective fertility practices have increased good yields to better yields and returned a greater profit to the producer.

Soil loss through erosion processes has probably accounted for greater removal of fertility elements than has crop production in most areas of Nebraska. Certainly erosion control measures should be included in any long-time program of building and maintaining the fertility of Nebraska soils.

THE PLANT NUTRIENTS

ALTHOUGH AT LEAST 14 different elements are needed by growing plants, only a few are required in major quantities. Three of these (carbon, hydrogen, and oxygen) are obtained from carbon dioxide of the air and from water. The remaining 11 are obtained from the soil. Eight of the 11 (potassium, magnesium, sulfur, copper, boron, manganese, zinc, and iron) are generally present in sufficient quantities and suitable forms in Nebraska soils for the use of field crops. In no tests conducted by the College of Agriculture experiment station to date have straight potassium fertilizers given profitable increases. In Nebraska, profitable responses are most likely to be obtained from potassium when combined with nitrogen and phosphorus, but seldom has the combination increased the yield over nitrogen and phosphorus alone. Iron deficiency is frequently noted in ornamental shrubs, strawberries, some grasses, and trees. This is especially true in the limy (calcareous) soil areas of the western half of Nebraska.

The remaining three nutrient elements of the 11 obtained from the soil are nitrogen, phosphorus, and calcium. In Nebraska, soils deficient in calcium are the acid upland soils in the eastern part and certain sandy soils in various sections of the state. The

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calcium deficiency can be corrected by the application of pulverized limestone or other forms of lime.

Thus, for Nebraska soils, nitrogen, phosphorus and calcium are the only elements of the 14 essential elements which may be deficient over very large areas. Of these, an inadequate supply of nitrogen is most likely to limit yields in most sections of the state.

Nitrogen fertility has been drained from Nebraska soils in the past several years at an accelerated rate due to increased production of cash crops for war and for relieving postwar world food shortages. The long drouth previous to the war contributed to the present shortage of nitrogen available for crop use in many soils because of curtailed use of legumes in the rotation during that period. These conditions, together with the economic factor, have resulted in a demand for nitrogen fertilizer which far exceeds the supply at the present time.

Some Nebraska soils are deficient in available phosphorus, while others, although farmed for many years, are well supplied. Before the supply of available phosphorus is depleted to the point where crops suffer, the supply should be replenished through the application of commercial phosphorus fertilizer. There are no soil building crops which add phosphorus to the soil. Phosphate supplements have proved economical in recent years on the irrigated calcareous bench and bottomland soils of central and western Nebraska, some of the glacial and the more acid upland loessial soils of southeastern Nebraska, the calcareous ridge tops of northeastern Nebraska, and sandy soils in various sections of the state.

It is the purpose of this circular to discuss soil fertility problems in general and to make recommendations based upon present knowledge gained through testing programs and field observations.

LEGUMES AS A SOURCE OF NITROGEN

LEGUMES ARE CAPABLE of utilizing atmospheric nitrogen by means of the bacteria that live in the nodules on their roots, and when they are plowed under all of the nitrogen in their roots and tops is incorporated in the soil. Only a few of the more important factors in the production of legumes for improving soil fertility are outlined in this circular.

Some legumes, such as soybeans and field beans, may be grown regularly in the rotation without adding any appreciable amount of nitrogen to the soil. This is due to the fact that most of the nitrogen fixed by these crops is transferred to the beans which, of course, are removed. On occasions improved crop growth has been noted following soybeans. It is believed that this is due to

the beneficial effect the soybeans had on soil tilth, and the fact that little nitrogen was removed from the soil by the crop rather than any additional supply of nitrogen left in the soil by the crop.

Alfalfa, sweet clover, and red clover are the principal leguminous crops used for the maintenance of nitrogen in Nebraska soils. Also, lespedeza has been used to a small extent in recent years in southeastern Nebraska for this purpose. Where managed properly these crops can be expected to leave large quantities of nitrogen in the soil for use by succeeding crops. A good stand of sweet clover, for example, permitted to make its full growth during the first year, will return as much as 100 to 150 pounds of nitrogen per acre when plowed under as a green manure crop in the spring of the second year. Annual sweet clover will provide about one-half as much nitrogen as biennial varieties when it is plowed under before seed is formed. If a seed crop is taken off the annual clover, however, only a small fraction of this fertility is obtained. It is a common observation that the fertility provided by an old stand of alfalfa lasts longer than that supplied by biennial sweet clover or red clover.

The optimum time to plow under legumes is somewhat dependent upon the results desired. For example, young sweet

A heavy crop of biennial sweet clover which is permitted to make its full growth during the first year will place from 100 to 150 pounds of nitrogen per acre in the soil when plowed under in the spring of the second year after 12 to 18 inches growth is obtained.

clover or alfalfa is tender and succulent. The percentage of protein (and nitrogen) is high and decay will be rapid in the soil. Older plants are more fibrous and woody, the percentage of protein is lower than in young plants and the rate of decay is slower. If a quick source of nitrogen is desired sweet clover or alfalfa should be plowed in the spring when 6 to 12 inches tall. At this stage of growth less moisture will have been removed from the soil than if the plants were permitted to become more mature, a factor which frequently is of importance. However, if a maximum amount of nitrogen which will last over a longer period of time is desired, the legume should be permitted to approach maturity. Also, the mature legumes will improve the tilth of the soil more than the legumes plowed at an early stage.

Legumes are recommended for the sections of the state where moisture is not likely to be a limiting factor in crop production. Overstimulation of crops may be encountered, however, immediately following a legume if drouthy conditions occur. Where climatic conditions are such that summer drouths can be expected frequently, it may be desirable to reduce the quantity of nitrogen left in the soil by pasturing or cutting the legume at intervals for hay. The annual variety of sweet clover, held back to a certain extent in this manner, may be practical in these areas (primarily dryland in central Nebraska).

On much of the upland and valley terrace land in eastern Nebraska, the soils are sufficiently acid to reduce stands and yields of alfalfa and the clovers. **Before seeding these crops, soil samples should be tested, and lime applied if the test shows a deficiency.**

Often legumes do not make satisfactory growth nor do they function effectively in their role as nitrogen fixers as a result of inadequate nodule formation or nodules formed by ineffective strains of bacteria. In such cases, growth of the legume does not result in soil improvement. Land to be seeded to legumes which has grown the same legume within the past five years will probably contain adequate bacteria of the proper strain to infect the root hairs of the young plants effectively. **In case, however, the particular legume has not been grown on the land previously or if for any other reason a question exists as to the soil's content of effective strains of the proper legume bacteria, seed inoculation with reliable cultures is advisable.** Inoculation of the seed is not an expensive procedure, and it is good insurance.

Nitrogen fertility resulting from the leguminous growth provides maximum response for one or two years' crop growth after sweet or red clover where these legumes are used strictly for adding nitrogen to the soil. Manure or commercial nitrogen fer-

tilizer supplement in the second or third year, particularly under irrigation, will often prove profitable. The effect of alfalfa upon succeeding crop yields usually is noted for a longer period of time than the effect of sweet clover.

In addition to their value as nitrogen fixers, the place of legumes in the rotation from the standpoint of control of crop diseases and pest attacks is very important. This is recognized in the older irrigated sections of the state and no doubt more consideration will be given to good cropping systems in the corn root worm infested areas of central and eastern Nebraska.

Legumes have proved to be helpful in maintaining the vigor of bromegrass when grown in association with this crop. The grass apparently receives additional nitrogen and does not become sodbound as long as a good legume stand remains. **Where a bromegrass and alfalfa or bromegrass and sweet clover field is pastured, a system of rotation grazing should be followed, which will prevent eradication of the legume.**

Leguminous crops in the rotation are of further value for the beneficial effect they have on the physical structure of the soil, particularly where a green manure crop is plowed under. This is of special significance for many irrigated areas where the soil is naturally compact and the intake of water is slow. These areas become increasingly compacted with continued cash crop production.

INCREASING SOIL FERTILITY WITH MANURE

WHERE MANURE is used to supplement soil fertility under conditions of adequate moisture (irrigation), 10 to 15 tons per acre is recommended. If sufficient manure is not available to cover the fields needing treatment at these rates, lighter applications over a larger area will provide greatest results. In rotations including legumes the manure should be applied to the second or third crop following a legume. It will increase the yields for two or three years, since decomposition and release of nitrogen for crops continues throughout this period. Thus, the combination of manure and legumes maintains the organic matter and nitrogen content of the soil at a high level. However, if the available phosphorus supply of the soil is low, the application of a phosphorus fertilizer is essential.

If moisture is likely to be a limiting factor where manure is used to supplement soil fertility, light applications of four to six tons per acre every three or four years are recommended. These rates of application will not result in the overstimulation often noted on dryland where heavier applications were made, and will permit coverage of a greater portion of the farm.

Manure is an effective nitrogen fertilizer and, to some extent, phosphorus fertilizer for the irrigation farmer as well as the dry-land farmer. By also supplying organic matter, manure provides an additional beneficial effect on the structure of the soil.

The value of manure as a source of fertility has long been known. However, maximum use of manure has not been made and too often in the past it has been considered a waste product to be disposed of in the nearest ditch or gully. In many cases where its value as a fertilizer was recognized, the manure spreading operation was confined to the fields nearest to the farmstead. As a result, the distant portions of the farm were slighted, and in addition the treated fields were overstimulated in dry years. Manure is often wasted in the feed yards or in the fields where the processes of leaching and volatilization are allowed to remove portions of the fertility components. Failure to preserve the liquid manure due to drainage from storage piles or inadequate bedding in feed lots is responsible for loss of a large portion of the fertility elements.

Nitrogen, the element most likely to be deficient in Nebraska soils, is the element usually lost through careless handling of manure. Therefore, leaching of nitrates and volatilization of ammonia from the manure should be prevented to the greatest extent possible. Since it is possible to incorporate manure into the soil only during a few times of the year, proper storage of manure is important.

Judicious use of litter or bedding will do much to conserve good manure. The litter should be highly absorbent for liquids, free of weed seed, and comfortable to the animal. Small grain straw, such as oat straw, makes excellent litter. The straw quickly absorbs the liquid manure and since the straw is very high in carbohydrates, bacterial decay starts immediately if the temperature is optimum. In the decay of the straw, nitrogen is needed by the microorganisms. Ammonia present in the liquid manure will be quickly utilized by microorganisms, thus preventing its escape into the atmosphere. After two or three days the initial decay has taken place. Then the manure should be compacted to prevent movement of air. By eliminating air from the pile at this time, the formation of nitrate will be prevented and loss of nitrates by leaching will be prevented.

Under Nebraska conditions, one of the best methods for storing manure is in the feed lot. Adequate litter should be provided to absorb all the liquid (but there should not be an excessive amount). Within two or three days the livestock will compact the straw and manure, and if it is saturated with moisture, movement of air will be prevented. However, the manure should not become too wet or leaching will result. Manure removed from stables should be stored in piles which are compacted as discussed above. Movement of the manure should be avoided as much as possible as air will pass into the pile and losses of nitrogen will result. Hauling manure to the field and storing in small piles previous to spreading should be avoided. Hauling the manure directly from the feed lot and spreading just prior to plowing or disking is the best practice.

Ordinary barnyard manure contains about 10 pounds of nitrogen, five pounds of phosphate (P_2O_5) and 10 pounds of potash (K_2O) per ton. The analysis will vary depending upon the amount and kind of bedding used, the age and kind of livestock, and the feed which the animals receive. For example, poultry manure contains twice as much nitrogen and phosphorus as cattle or horse manure. Also, manure from feed yards is usually higher in nutrient elements than other manure from similar livestock, as more concentrated feeds, high in protein, are fed. If the feed is deficient in some element such as phosphorus, then the manure will be deficient in the same element. The animal's body adds no nutrient elements to the manure. Instead, the manure is a waste product from the animal which cannot be utilized by the body.

It is difficult to compare the value of manure with commercial fertilizers. Most of the nutrient elements in the manure must be

made available to plants through decay by microorganisms. Thus the total amount of the elements is not made available at once but is released by the soil organisms over a period of two or more seasons. The profit shown by the manure will depend upon the crop to which it is applied, the cropping system followed and management practices in general. Manure increases the activity of soil microorganisms, and at the same time improves the physical condition of the soil which permits more rapid infiltration of water and makes the soil more stable when wet.

USE OF COMMERCIAL FERTILIZERS

THE RECOMMENDATIONS given in this circular are based on field studies of rates, times, and methods of application of fertilizers conducted by the College of Agriculture agronomy department the past several years, as well as field observations made of results obtained by farmers in fertilizer practices. Of necessity these recommendations are general and should not be considered to apply to all situations and conditions.

Fertilizers for Corn

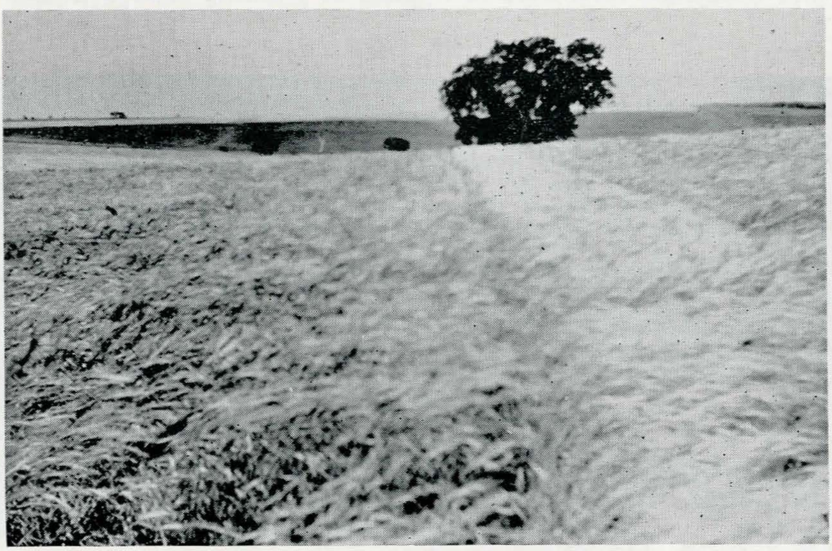
Nitrogen fertilizers. Apply nitrogen fertilizers at the rate of 40 pounds of the element nitrogen [1] per acre in a band six to eight inches from the stalks by means of fertilizer attachments on the cultivator at the second or third cultivation. Unless the field can be irrigated, the soil should be moist to a depth of three or four feet at the time of fertilizer application. Also the field should average approximately one stalk of corn every 20 inches or closer in rows spaced 40 inches apart in order to utilize the fertilizer added. Where adequate moisture is available, as under irrigation, maximum yields are obtained by providing adequate fertility and establishing a close stand, as for example one plant every 10 to 12 inches.

Starter fertilizers. Under some conditions where stimulation of early growth is desired or where an effort is made to improve the stand of corn under adverse weather or infertile soil conditions, it is recommended that approximately 5 to 15 pounds of nitrogen and 20 to 30 pounds of available phosphate (P_2O_5) per acre be applied in a mixed fertilizer. The fertilizer should be applied at the time of planting by placing in bands at least two inches deep and about two inches away from the seed. In most instances nitrogen fertilizer should be applied at the last cultivation in addition to the starter fertilizer.

[1] N and P_2O_5 in this circular refer to pounds of these materials applied per acre. To apply 40 pounds of nitrogen per acre with ammonium nitrate (32% N), for example, one and one-fourth bags or 125 pounds per acre is required.

Fertilizers for Wheat

WHERE PHOSPHORUS is deficient it is recommended that 20 to 40 pounds available phosphate (P_2O_5) per acre be applied along with the seed at planting time. Best results will be obtained if the fertilizer is applied with attachments on the grain drill. However, if no attachments are available the granulated fertilizer may be mixed with the wheat in the field just before adding to the drill. All moving parts of the drill and exposed metal should be thoroughly covered with old crank case oil and kerosene if such a practice is followed. If there are signs of a nitrogen deficiency, 30 to 40 pounds of nitrogen per acre may be drilled in lightly or spread on the surface by means of fertilizer spreader or broadcasting mechanism when the wheat is three to six inches high in the spring. A nitrogen deficiency is indicated by light yellowish-green, slow-growing plants. If the soil is known to be extremely deficient in nitrogen, an application of five to ten pounds of nitrogen per acre in the fall followed by the heavier spring application may be needed. The spring application should be in quickly available form (as ammonium nitrate, urea, or sodium nitrate), and should not be made when the plants are moist from dew or rain as burning of the leaves may result.



Superphosphate applied at planting time in a strip through this field of winter wheat in Pawnee county resulted in the apparent improved growth. The phosphated strip produced 13.8 bushels more wheat per acre than the non-treated land on either side.

Fertilizers for Spring Small Grains

ON SOILS WHERE phosphorus is needed apply 20 to 40 pounds available phosphate (P_2O_5) per acre with the seed at planting time. (For method, see **Fertilizers for Wheat.**) If the grain is being used as a nurse crop for a legume apply 40 to 80 pounds available phosphate (P_2O_5) (higher quantities on calcareous irrigated soils of western Nebraska); if not, an application of 20 to 30 pounds is sufficient. Nitrogen can be applied at planting time or any time before the plants are six inches in height if a deficiency is observed after the crop has started growth. Nitrogen fertilizers should be applied at the rate of 20 to 40 pounds of nitrogen per acre.

The lighter rate of 20 pounds of nitrogen is recommended for fields where the small grain is used as a nurse crop for a legume. Heavier applications of nitrogen may reduce or eliminate the legume stand because of excessive small grain growth.

Fertilizers for Legumes

Alfalfa. On phosphorus-deficient soils of southeast Nebraska, apply 40 to 80 pounds available phosphate (P_2O_5) per acre. On irrigated calcareous soils of western Nebraska, apply 80 to 120 pounds available phosphate (P_2O_5) per acre. It is recommended that phosphate fertilizers be applied at planting time with new

Liming is necessary for obtaining stands and high production of some leguminous crops on the more acid soils of eastern Nebraska. The sweet clover on the left was limed at the time of seeding, while that on the right was not treated. Agronomy Farm, Lincoln.

seedings, or be broadcast or drilled lightly on established stands. This treatment should be repeated every two or three years.

Clovers. Where phosphorus is deficient, follow the recommendations given for alfalfa except that the rate of application may be reduced.

The application of one ton or more of finely pulverized limestone (100 mesh or finer) per acre will aid in establishing stands and improving yield and quality of legumes, especially sweet clover and alfalfa, on the more acid soils of eastern Nebraska, such as the silty and clayey soils of pH 5.7 or lower and the sandy soils of pH 6.0 or lower. If the limestone is 10 mesh or coarser, it is advisable to apply two tons or more per acre. Waste lime from sugar factories is excellent liming material. These materials should be applied several weeks or months before seeding, and plowed under or disked in. The beneficial effects will last for many years.

A treatment of a few hundred pounds of liming material per acre, if drilled in with the seed, usually insures a good stand of sweet clover or alfalfa, but has less effect on the yield and quality of the crops than the heavier rates of application.

Liming materials should not be applied where not needed, as for example on the neutral and limy soils of central and western Nebraska.

Fertilizers for Grasses

Bromegrass. With bromegrass, where a nitrogen deficiency (sod-bound condition) has been recognized, apply 60 to 80 pounds of nitrogen per acre (175 to 250 pounds of ammonium nitrate, for example). If this supplement is applied early (late March or early April), both seed and forage production will be increased if satisfactory weather conditions prevail. The nitrogen application will also improve the quality of the hay, i.e., increase the protein content on sod-bound fields.

Where phosphorus deficiency has been recognized the application of 30 to 40 pounds available phosphate (P_2O_5) per acre at planting time is recommended.

Severe nitrogen deficiencies will often be noted with the first crop on land where sod-bound bromegrass has been plowed under. This is due to the fact that the decomposition of the sod takes much of the available nitrogen supply from the soil; the microorganisms use the available nitrogen in the soil during the process of decomposing the grass and its roots. The results from this condition are similar to those observed where heavy residues of straw are plowed under. In succeeding years, as decomposition becomes more complete, the nitrogen contained in the grass and

A replicated fertilizer test plot on three-year-old bromegrass, Lancaster county, May, 1947. The left foreground plot received no fertilizer, while the right foreground was treated with commercial nitrogen fertilizer. In this test there was an increase of slightly over one-half ton of forage per acre from the application of 60 pounds of nitrogen. This quantity of nitrogen also increased seed production from 197 to 320 pounds per acre.

in the bodies of the microorganisms will become available for crop use. Thus, one of the most practical places for the use of a commercial nitrogen fertilizer is on the first crop following the plowing under of an old bromegrass field.

Native Grasses. Increased yields and improved protein and phosphorus content of the hay can be obtained through the application of commercial nitrogen fertilizer on native hay meadows in several parts of Nebraska. On some of the hay meadows in the sand hills, phosphate as well as nitrogen may be needed. The phosphate tends to encourage the growth of clover and alfalfa in the meadow.

Fertilizers for Potatoes

IN WESTERN NEBRASKA, potatoes commonly follow a legume such as alfalfa or sweet clover. Where the legumes have made a satisfactory growth, an adequate supply of available nitrogen is usually present in the soil and thus a nitrogen fertilizer is not generally required for the potato crop. A phosphorus fertilizer supplying 40 to 80 pounds of available phosphate (P_2O_5) per acre may be needed, however, if the soil is deficient in phosphorus. A fertilizer providing 30 to 40 pounds of nitrogen, and if phosphorus

Irrigated potatoes respond to nitrogen fertilizer on nitrogen-deficient soils. The portion of the field in the foreground received no fertilizer, while the area in the background was treated with 40 pounds of nitrogen at planting time.

is needed, 40 to 80 pounds of available phosphate (P_2O_5) per acre applied at planting time is recommended for potatoes following non-leguminous crops or poor stands of legumes.

In central Nebraska some nitrogen is often required even though potatoes follow a legume. A fertilizer application of 20 to 30 pounds of nitrogen and 40 to 80 pounds of available phosphate (P_2O_5) per acre, if phosphorus is deficient, is recommended. The difference in nitrogen needs following legumes in the two areas may be explained by the relatively unfavorable temperature for nitrate production in the soil following the early planting (early April) of potatoes in central Nebraska, compared with the relatively favorable temperature following the late planting (middle of June) of potatoes in western Nebraska.

Fertilizers for Sugar Beets

IN NEBRASKA, barnyard manure is commonly applied on fields to be planted to beets. This supplement provides a supply of available nitrogen and some phosphorus throughout the growing

season, the amounts depending upon the quality and the rate of application. In addition to manure, an application of sufficient superphosphate at planting time to supply 40 to 80 pounds of available phosphate (P_2O_5) per acre is often needed. The response of the sugar beet crop to phosphate applications is generally greatest on the more calcareous bench and bottomland soils.

Where manure has not been used for sugar beets, and in many instances where it has been used, an application of a mixed fertilizer at planting time providing 10 to 15 pounds of nitrogen and four to five times as much P_2O_5 per acre (where phosphorus is deficient) is desirable. The small amount of nitrogen supplied in the mixed fertilizer is helpful for stimulating early growth of sugar beets during the time when only small amounts of nitrogen are needed and the weather is unfavorable for the production of available nitrogen in the soil. Where additional nitrogen is needed, 40 to 60 pounds should be applied as a side dressing following blocking and thinning. There is some evidence to indicate that it is better to make this application at the last cultivation.

SELECTING THE FERTILIZER

THE NUMBER of different commercial fertilizer products offered for sale in Nebraska is rapidly increasing. Some are straight carriers of nitrogen, phosphorus or potassium, while others are mixtures of two of these nutrients and still others are mixtures of all three. It is essential that farmers acquaint themselves with the fertilizer formula so that they will know what they are obtaining in their fertilizer purchases, and will know they are obtaining the **desired** nutrient elements at the most economical price.

State Fertilizer Law

ACCORDING TO THE Nebraska fertilizer law, any material offered for sale as a fertilizer at a price exceeding three dollars per ton shall be registered with the State Department of Agriculture and Inspection before May 1 each year, with the payment of a 20-dollar fee. Each package sold must be plainly labeled with certain items of information, including the guaranteed chemical analysis and the list of ingredients. The guaranteed analysis consists of the percentage of nitrogen, available phosphoric acid (phosphorus pentoxide), and water-soluble potash (potassium oxide). These percentages together make up the fertilizer formula and are always in the above order, i.e., nitrogen—phosphoric acid—potash (N-P-K). Thus, a commercial fertilizer described by a formula of 6-10-6 contains 6 per cent nitrogen, 10 per cent available phosphoric acid, and 6 per cent potash. A formula of 32-0-0

indicates a straight nitrogen fertilizer containing 32 per cent nitrogen, **or 32 pounds of nitrogen in a 100 pound bag.**

Factors Affecting Fertilizer Need

HIGH ANALYSIS materials containing only nitrogen and phosphorus are the fertilizers recommended generally for Nebraska crops at the present time. In many cases only one of these nutrient elements is required for the crop, in which case a fertilizer containing only the one element should be applied. In other instances the type to be used and the time of application are influenced by the fact that the demands for nutrient elements by crops vary throughout the growing season. In these instances, timeliness of application of the correct element or elements will result in the maximum efficiency in the use of the fertilizer and in largest economic returns. In obtaining maximum yields, an adequate phosphorus supply is required throughout the entire life of most plants. Thus, planting time applications are essential with this nutrient. However, relatively small quantities of nitrogen are needed by most crops during the early stages of growth, and delayed application of this nutrient is usually most efficient. For example, experimental work on corn has shown that most efficient results from the application of nitrogen fertilizer are obtained when the fertilizer is applied as a side dressing when the plants are two or three feet tall. Earlier applications may result in losses of the nitrogen to the plant through leaching or from the action of microorganisms. The late application does not increase the size of the plant materially, which is important in relation to moisture utilization. Timeliness of application of nitrogen fertilizers is important with grasses, small grains, and other crops as well.

In contrast to nitrogen, phosphorus moves but little in the soil. However, some of the phosphorus added to the soil may become fixed and unavailable to plants. In soils that are high in lime (calcareous) much phosphorus is fixed because the lime reacts with the phosphorus to form a compound that is only slightly soluble in the soil solution. For this reason, various crops growing on soils high in lime such as many of the first bottomland soils along the Platte, North Platte, South Platte, and Republican rivers respond to application of superphosphate. Usually heavier applications of superphosphate are needed on limy soils than on non-limy soils because of fixation. Granulated superphosphate is more effective than powdered superphosphate on such soils.

Profitable responses from application of superphosphate to some crops are being obtained also on upland soils of southeastern Nebraska, particularly on soils developed from glacial material

such as the Carrington, Shelby, Steinauer, Burchard, and Pawnee soil series, and the more acid upland loessial soils. Legumes and small grains are the crops most likely to respond to superphosphate in this area. Usually superphosphate applied to these crops will carry over for other crops in the rotation such as corn. Other soils where a response is likely to be obtained from application of phosphorus include most of the sandy soils of the state (where moisture is adequate) and the limy (calcareous) upland soils in the northern part of the state.

In many instances maximum returns from fertilizer application result from a combination of both nitrogen and phosphorus. This is especially true where fertilizers are being used to stimulate early growth, or as a starter. In certain adverse conditions such as a wet, cold spring, a starter fertilizer may be very helpful in establishing stands by getting the young plants off to a good start. Also, a combination of nitrogen and phosphorus may be very helpful in establishing a legume or a grass seeding even though phosphorus supplement seldom increases yields of established stands of grass in Nebraska, and though legumes will utilize atmospheric nitrogen after the plant is established and nodules have formed on the roots. The seeding of waterways is an example of a situation where use of a starter fertilizer will usually prove beneficial.

It is difficult for any one (especially the layman) to diagnose deficiency symptoms by appearance of the plant alone. Many factors other than nutrition, such as insect damage or disease, affect the plant's appearance and often the appearance is due to a combination of factors. Nitrogen deficiency, however, is usually characterized by a slow-growing spindly plant that is light yellowish-green in color. Many fields of corn become deficient in nitrogen during the tasseling period. Then the lower leaves of the corn turn yellow near the midrib, particularly near the leaf tip. Later the tip begins to dry out and the whole leaf may be affected, causing the corn to have the appearance of firing.

Plants deficient in phosphorus seldom show any symptoms which are easily recognized, but the plants generally are stunted and slow in growth. Corn plants may show a reddish purple coloring of the leaves when the plants are one or two feet tall in cases where extreme phosphorus deficiency exists. Usually corn does not respond as much to phosphate fertilizers as some other crops such as legumes, sugar beets, potatoes, or small grains.

It should be remembered that use of commercial fertilizers is only one of the methods by which fertility is added to the soil. A sound fertility program should be built around legumes and barnyard manure supplemented by commercial fertilizers where

feasible. In some instances legumes and manure applications in the rotation may increase the response obtained from commercial fertilizers by improving the physical condition of the soil.

Commercial fertilizer use will not ruin soils for future generations, provided good cropping and farming practices are followed which will maintain a good state of soil tilth and a supply of organic matter in the soil.

Care of Machinery

SPECIAL CARE should be given to farm machinery used for spreading commercial fertilizers, as these materials usually are corrosive. It is recommended that those parts of fertilizer attachments which are in contact with the fertilizer be washed with water and rinsed with waste oil or tractor fuel after each day's use.

Comparative Values of Fertilizers

IN SELECTING the fertilizer, the **unit cost of the nutrient elements** should be considered rather than the **cost per ton** of fertilizer. Examples are shown in Table 1.

TABLE 1.—*Cost per unit of nutrient elements contained in straight fertilizer carriers.*

Fertilizer formula	Pounds of N in 1 ton of fertilizer	If the cost per ton is:	Cost of 1 pound of N
33-0-0	33x20 = 660	$66.00	$\frac{\$66}{660} = \$0.10$
20-0-0	20x20 = 400	50.00	$\frac{50}{400} = 0.125$
	Pounds of available phosphorus (P_2O_5) in 1 ton of fertilizer		Cost of 1 pound available phosphorus (P_2O_5)
0–43–0	43x20 = 860	$55.00	$\frac{\$55}{860} = \$0.064$
0-18-0	18x20 = 360	35.00	$\frac{35}{360} = 0.097$

The value of mixed fertilizers can be determined on a comparative basis whereby the fertilizer constituents are evaluated according to what they would cost in high-analysis straight carriers. At the present time, among carriers available in appreciable quantities, ammonium nitrate at a cost of $60-70 per ton is the cheapest source of nitrogen chemical fertilizer for Nebraska farmers. At this price, the nitrogen costs approximately 10 cents

TABLE 2.—*Calculating the comparable values of fertilizers.*

4-12-4 *	Pounds nutrient/ton	Nutrient value/ton	Total ** value/ton
Nitrogen	4x20 = 80	80x\$0.10 = \$ 8.00	
Phosphorus (P_2O_5)	12x20 = 240	240x\$0.07 = 16.80	
		\$24.80	\$24.80
		\$3-5 per ton for mixing	4.00
			\$28.80
11-48-0			
Nitrogen	11x20 = 220	220x\$0.10 = \$22.00	
Phosphorus (P_2O_5)	48x20 = 960	960x\$0.07 = 67.20	
		\$89.20	\$89.20
		\$3-5 per ton for mixing	4.00
			\$93.20

* Assuming no potash requirement in Nebraska soils.

** Mixed fertilizers are justifiably somewhat more expensive than straight fertilizers per unit of nutrient material due to the additional handling involved in mixing and conditioning the product for simplified use.

TABLE 3.—*Rates of application of various fertilizers required to provide different amounts of the element nitrogen or available phosphorus (P_2O_5) per acre.*

Fertilizer formula	Pounds of fertilizer required to provide following amounts of nitrogen per acre			Pounds of fertilizer required to provide following amounts of available phosphorus (P_2O_5) per acre		
	25 lbs.	*40 lbs.*	*60 lbs.*	*30 lbs.*	*50 lbs.*	*80 lbs.*
32-0-0	78	125	188	......	......	......
20-0-0	125	200	300	......	......	......
16-0-0	156	250	375	......	......	......
0-43-0	......	......	......	70	116	186
0-16-0	......	......	......	188	313	500
0-3-0	......	......	......	1000	1667	2667
11-48-0	227	......	......	63	104	167
6-30-0	416	......	......	100	167	267
10-20-0	250	400	......	150	250	400
5-10-5	500	800	......	300	500	800
3-10-6	834	1334	......	300	500	800

per pound. Similarly, concentrated superphosphate is the cheapest source of available chemical phosphate, and at a price of $55-60 per ton, a pound of available phosphorus (P_2O_5) costs approximately seven cents.

Assuming nitrogen worth 10 cents per pound and a pound of available phosphorus (P_2O_5) worth seven cents, the ton value of mixed materials may be determined as indicated in Table 2.

High-analysis fertilizers, either straight or mixed, are usually cheaper in unit nutrient cost than their low-analysis counterparts. This can generally be traced to the lower overhead in mixing, conditioning, bagging, shipping, and storing with the more concentrated products.

CHARACTERISTICS OF FERTILIZER CARRIERS

Nitrogen Carriers

Ammonium nitrate, NH_4NO_3, is a white crystalline salt, containing 32 to 34 per cent nitrogen, which is prepared synthetically. It is highly soluble in water, and it readily absorbs atmospheric moisture. The latter characteristic prevents the use and storage of ammonium nitrate as a fertilizer material in its pure state. To alleviate this condition, the salt is granulated and a conditioner (clay or wax product) is added which coats the granules and prevents them from absorbing moisture. This treatment may change the color of the salt.

Due to its quick action, its high nitrogen content, and the presence of both ammonia and nitrate forms of nitrogen, this compound is considered an excellent nitrogen fertilizer. It is recommended for Nebraska soils where nitrogen supplement is needed.

Ammonium sulfate, $(NH_4)_2SO_4$, is a light tan or gray crystalline salt, containing about 20.5 per cent nitrogen, and is very soluble in water. It is prepared from the reaction of ammonia gas with sulfuric acid. Continued heavy applications of ammonium sulfate over a period of years increases the acidity of the soil. However, with most Nebraska soils this does not present a problem.

Under warm soil conditions, ammonium sulfate is about as quick acting as ammonium nitrate, and it is recommended for Nebraska summer crops where nitrogen is needed. To be approximately equal in value to ammonium nitrate, however, it should cost no more than two-thirds as much per ton as ammonium nitrate due to its lower nitrogen content.

Sodium nitrate, $NaNO_3$, is a white crystalline, water soluble salt containing 16 per cent nitrogen. It is mined in a relatively pure state in Chile and is produced synthetically in the United

States. Sodium nitrate provides nitrogen immediately available for plant use. However, the product's cost in Nebraska is usually excessive in comparison to other nitrogen carriers. To compare favorably with ammonium nitrate in fertilizer value, it should cost no more than half as much per ton since it contains only half as much nitrogen.

Urea, CON_2H_4, is a white crystalline, water soluble organic compound containing about 46 per cent nitrogen. It is prepared synthetically, and is rapidly becoming an important nitrogen fertilizer. It must be conditioned for simplified use which reduces the nitrogen content to about 42 per cent. Much of the urea fertilizer now on the market is sold under the trade name of "Uramon."

Ammonia, NH_3, is a colorless gas containing 82 per cent nitrogen. It is the basic constituent of many nitrogenous fertilizer materials and is obtained as a by-product of the coke industry or is synthesized from atmospheric nitrogen. Anhydrous ammonia is used to some extent in irrigated sections as nitrogen fertilizer, by dissolving in the irrigation water. Experiments are being conducted at the present time with its use on non-irrigated lands. If the anhydrous product proves practical as fertilizer material, Nebraska farmers may benefit appreciably in reduced nitrogen costs.

Calcium cyanamide, $CaCN_2$, as found in fertilizers, is a grayish-black powdered product containing 21 to 22 per cent nitrogen. The dark color is due to carbon. Pure calcium cyanamide is white and is made up of 35 per cent nitrogen. This material contains considerable lime, making it particularly valuable for use on acid soils. Calcium cyanamide is one of the best driers known and for this reason 20 pounds or more is added to each ton of many mixed fertilizers as a conditioner. The product appears to be a satisfactory fertilizer for many crops when application is made before planting time, but it is not as generally adapted as most other nitrogen fertilizers. Best results are obtained on soils slightly acid in reaction. On soils neutral to alkaline in reaction, calcium cyanamide is not recommended. Because of its toxic effect on growing plants (it is extensively used as a weed killer) cyanamide should not be placed in contact with growing crops, nor should it be used as a side dressing.

Phosphorus Carriers

Rock phosphate is mined commercially in several parts of the United States. It may contain 30 per cent or more total phosphate

but **only two to four per cent is in a form readily available** for plant use. The product has been found practical for use on soils highly acid in reaction and with high organic matter content, but **rock phosphate is not recommended for use in Nebraska** where most soils are neutral to alkaline in reaction. Most of the phosphate rock mined for fertilizer purposes is treated to make other products containing higher percentages of available phosphate.

Superphosphate is prepared by treating ground rock phosphate with sulfuric acid. The reaction converts the insoluble tricalcium phosphate to monocalcium phosphate and dicalcium phosphate which are available to plants. Most superphosphates on the market at the present time contain 16 to 20 per cent available phosphate expressed as P_2O_5.

Concentrated superphosphate is a product prepared from treating rock phosphate with phosphoric acid. It contains 43 to 50 per cent available phosphate, expressed as P_2O_5, and is a high grade material useful in preparing high-analysis mixed fertilizers, and is an excellent straight phosphorus fertilizer. This material is often called double superphosphate, treble superphosphate, or triple superphosphate. Both superphosphate and concentrated superphosphate are recommended for use on Nebraska soils where phosphorus is needed.

Others. There are numerous other chemical nitrogen carriers as calcium nitrate (17% N), potassium nitrate (14% N) and ammonium chloride (26% N), and phosphorus carriers as basic slag, calcium metaphosphate, fused phosphate, bone meal, and phosphoric acid, none of which are used to any appreciable extent as yet in Nebraska. In addition there are several organic materials containing moderate quantities of nitrogen such as cottonseed meal (6-7% N), dried blood meal (9-14% N), linseed meal (5.5% N), tankage (5-10% N), distillers' solubles (by-product of alcohol industry, containing 4-6% N), and others. Few if any of these are practical for use as nitrogen fertilizers, however, because of their value for stock-feeding purposes. This demand results in prices much higher per unit of nitrogen than with the inorganic nitrogen compounds. Another common organic fertilizer is sewage sludge, sold under various trade names, which contains two to six per cent nitrogen and one to three and one-half per cent P_2O_5.

WILL FERTILIZER IMPROVE ALKALI SOILS?

ALKALI SOILS of various types are found in many of the valleys of Nebraska, and the question is often raised, "Will fertilizers correct or improve this condition?" Generally speaking, these

areas are often low in fertility, but the problem is primarily one of inadequate drainage, excessive quantities of soluble salts, poor soil physical condition, or a combination of these. If the alkali conditions were corrected, the restoration of fertility would not prove difficult. The complete reclamation of alkali soil involves considerable time and expense, and it is not the purpose of this circular to outline the required procedures. It may be generally stated, however, that temporary improvement can be achieved by applications of rather large quantities of barnyard manure. The organic materials thus incorporated tend to improve the soil's physical structure and at the same time enhance its productive capacity. Phosphate supplement in addition will often increase yields.

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