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Thirty-five years ago in Bulletin 111 of the University of Nebraska, Professor F. J. Alway asked the following question, "To what extent has the fertility of the soil of Nebraska been depleted and what will be the result of the continuance of the present methods of farming?"[2] In answering this question, Professor Alway stated, "The problem of maintaining the fertility of the loess soils of eastern Nebraska is, insofar as the chemical composition is concerned, essentially that of maintaining the supply of total organic matter, which includes both humus and nitrogen."

The cropping systems followed in most areas of Nebraska have not changed materially during the last thirty-five years, the crops grown being influenced largely by climatic conditions and the relative prices of crops. During periods of drouth, legumes have not been popular because of their "overstimulating" effect on other crops. During periods of high prices, emphasis has been placed on cash crops, especially corn and wheat. The result of both practices has been a gradual decline in soil organic matter, accompanied by a lower capacity of the soil to produce available nitrogen. Recent failures to obtain high yields on some fields during seasons of plentiful precipitation or on other fields which have been under irrigation only a few years have been attributed to a deficiency of available nitrogen. It has long been recognized that legumes and manure contribute markedly to the maintenance of available nitrogen in the soil. However, it is frequently necessary to supplement the practices of growing legumes and applying manure with the practice of applying commercial nitrogen fertilizers, in order to supply sufficient available nitrogen for maximum yields. Where less use has been made of legumes and manure, it is even more imperative that commercial nitrogen fertilizers be used.

NITROGEN NEEDS OF CROPS

Corn

Corn is the most widely grown crop in Nebraska and is one of the first crops in the rotation to show a deficiency of available nitrogen in the soil. During the early stages of growth, corn requires relatively small amounts of nitrogen. However, the period just ahead of tasseling and through the period of early ear formation is the most critical,

[1] During 1943 and 1944, a deficiency of soil nitrogen was noted on many farms in Nebraska. Excellent responses were obtained from the use of nitrogen fertilizers in tests conducted during 1944. It is the purpose of this circular to guide farmers (many of whom will be using fertilizers for the first time) in the use of commercial fertilizers, and thus aid in increasing food production.

[2] Alway, F. J. Nebr. Agr. Expt. Sta. Bul. 111, 1909.

insofar as nitrogen supply is concerned. In order to furnish the required amount of nitrogen for a good corn crop during this critical period, the soil must have a reserve supply of available nitrogen or the nitrate producing capacity must be high.

During wet cold weather, nitrate production is not only low but any available nitrogen present may be leached to depths below the root zone. These conditions leave the soil more or less impoverished with respect to available nitrogen. The rate of production of available nitrogen may be sufficient to permit a satisfactory growth of corn prior to the tasseling period, but be insufficient to meet the much heavier demands after that time.[3] If nitrogen is deficient at the time of tasseling, the lower leaves of the corn turn yellow near the midrib, particularly near the leaf tip. Later the tip begins to dry and the whole leaf may be affected, causing the corn to have the appearance of "firing." However, leaves of corn suffering from lack of water usually wither, roll, and dry out without turning yellow. Where the capacity of the soil to produce available nitrogen is quite low, the corn may be yellowish-green in color from early stages of growth. Such plants are spindly, stunted, and seldom produce corn. The "firing" appearance may not be present in such plants.

Sugar Beets

It is a common practice for sugar beet farmers to apply much of their barnyard manure on fields to be planted to sugar beets. The manure furnishes a good supply of fertility throughout the growing season. Early in growth, the sugar beets, like corn, respond more to phosphorus than to nitrogen, but as they become larger, more nitrogen is required. Where nitrogen fertilizers are applied for sugar beets, a small amount of the nitrogen may be applied in a mixed fertilizer such as a 6–30–0 at planting time. However, the bulk of the nitrogen should be applied as a side-dressing after the beets have been blocked and thinned. There have been some indications that it might be better to wait until one of the later cultivations to apply the nitrogen fertilizer. Further studies are needed to determine the most desirable time to apply nitrogen fertilizers for sugar beets.

Potatoes

In many potato growing areas in Nebraska it is a common practice to grow potatoes following legumes and thus an adequate supply of nitrogen is available for the crop. In such instances, commercial nitrogen fertilizers are not needed. However, where potatoes follow non-leguminous crops, such as small grains, a mixed fertilizer containing an appreciable quantity of nitrogen, such as a 10–20–0 applied at planting time, has resulted in substantial increases in yields in the tests conducted in Nebraska.

[3] The cover page picture is of a cornfield deficient in nitrogen; the youngest leaves are light yellowish-green in color and the lower part of the plants have the appearance of "firing." The plants at the end of the field and those in the outside row show no nitrogen deficiency. These plants are receiving sufficient nitrogen because they do not have so much competition with other plants.

Grasses—Bromegrass

"Sodbinding" in grasses is apparently due, in part at least, to a deficiency of available nitrogen since applications of nitrogen fertilizers aid markedly in overcoming this condition. The effect of the nitrogen fertilizer is noticed during the year of application only and thus it is necessary to apply fertilizer each year. Nitrogen fertilizers are commonly applied to grasses for increasing seed production, although forage production may also be greatly affected. For increasing seed production, the fertilizer should be applied early in the spring when the grass first begins growth. This is usually in late March or early April. Applications in May will increase the protein of the forage but will not greatly increase seed production.

The optimum rate of applying nitrogen fertilizers for bromegrass is 40 to 60 pounds of nitrogen per acre. Increases may be obtained from lighter applications, but the pounds of seed obtained for the second 20 to 30 pounds of nitrogen will likely be as great as for the first 20 to 30 pounds. Applications of more than 60 pounds of nitrogen have not materially increased the yields over a 60 pound application.

Small Grain

Ordinarily, nitrogen fertilizers are not recommended in Nebraska for wheat, oats, and barley since the increase in yields obtained are frequently insufficient to be profitable, especially for oats and barley. There is usually a sufficient supply of available nitrogen for the fall growth of wheat, especially where early fall plowing or summer fallow is practiced. Winter wheat occasionally responds to applications of nitrogen fertilizer made in the spring. This is especially true in cool, wet springs when nitrate production is retarded and when the excessive moisture may leach most of the available nitrogen below the root zone. Nitrate deficiency is indicated in the small grain by a light yellowish-green color. Under such a condition an application of 30 to 40 pounds of nitrogen per acre before the "jointing stage" may result in profitable increases in yield. Ammonium nitrate, uramon, and sodium nitrate are superior to ammonium sulfate for use on small grain.

Vegetable Crops

Nitrogen fertilizers are frequently used by both commercial and home gardeners. Nitrogen, especially in the form of nitrate, promotes rapid growth of lettuce, cabbage, and other leafy vegetables where crisp succulent growth is desired. An early application of a nitrogen fertilizer to large vined varieties of tomatoes may stimulate excessive vine growth and delay flowering and fruit setting. There are some indications that nitrogen fertilizers can be applied to tomatoes about the time the first tomatoes have "set" if soil moisture is not a limiting factor. This is especially true of the smaller determinate varieties. Sweet corn is much like field corn in nitrogen requirements.

METHODS AND TIME OF APPLICATION

Caution

Most soluble nitrogen fertilizers are extremely corrosive. Thus, all equipment should be thoroughly rinsed with clean water immediately after use and all moving parts should be oiled before and after using.

Although ammonium nitrate is used in loading ammunition, that released for agricultural purposes is relatively safe. However, care should be exercised in handling not to mix it with organic materials since the mixture will be a fire hazard when dry.

Planter and Cultivator Attachments

An application of fertilizer at planting time or at one of the cultivations or at both times appears to be most successful for row crops in Nebraska. Fertilizers applied at planting time should be placed in bands about two inches away from and slightly below the seed. Nitrogen fertilizers applied at the last cultivation of corn should be placed in bands two or three inches deep about six or eight inches away from the stalk (on one side only) or behind the shovel closest to the corn when two or three shovels are used on the cultivator. The band of nitrogen fertilizer should be closer to the row for sugar beets than for corn. In irrigation farming, a little more care should be exercised in placing the fertilizer, to prevent excessive leaching of the fertilizer or the carrying of the fertilizer to the surface by side movement of water. Special fertilizer attachments for the planter or the cultivator are necessary for this method of application.

Plow Under

Commercial fertilizers, including nitrogen in the form of ammonium compounds, can be applied in bands at the bottom of the plow furrow at the time of plowing. The purpose of this method of application is to place the fertilizer in the soil below the zone of evaporation where more moisture will be present. Also the cooler temperature will retard the speed with which the ammonium compounds are changed to nitrate compounds by the organisms present in the soil. There is little loss of nitrogen through leaching, as long as it remains in the ammonium form. Thus, the nitrogen remains in the root zone of the plant longer by this method. Special fertilizer attachments for the plow are necessary for this method of application.

Attachments on Grain Drills and Broadcasting Equipment

For applying nitrogen fertilizers on small grain or grasses, it is desirable to have equipment that covers considerable area in a relatively short time. Fertilizer attachments on grain drills appear to be best for this purpose. The discs on the grain drill should be set to run very shallow at the time the fertilizer is applied. Special machines for broadcasting nitrogen fertilizers are also on the market. The same machines may be used for spreading chemicals on noxious weeds.

Application in Irrigation Water

The practice of applying water soluble fertilizers in the irrigation water has merit, but there are many problems involved. It is difficult to distribute water uniformly over a field during an irrigation, making it doubly hard to distribute fertilizers uniformly when dissolved in the water. Best results are obtained when the fertilizer is applied during the last part of the irrigation. This avoids leaching of the nitrate which would take place if the fertilizer were applied early or during the entire irrigation. In the furrow method of irrigation, it is difficult to distribute the fertilizer uniformly over the field unless the solution is thoroughly mixed with the water in the ditch. To facilitate mixing of the fertilizer solution with the water in the ditch, there should be considerable turbulence. Drops in a ditch or a division box near a pump may have sufficient turbulence for this purpose. However, unless these structures are near the field where the fertilizer is wanted, considerable loss of fertilizer may take place in the lateral and it will be difficult to gauge the time when the fertilizer should be added.

A box suitable for mixing the fertilizer solution with the water in the lateral near the field is shown in Figures 1 and 2.

The box is made of 1 x 12 and 2 x 4 inch lumber. It is ten feet long, three feet wide, and two feet deep. A V shaped divider is placed near the entrance to the box to constrict the opening and increase the rate of water flow. Three vertical baffles are placed in the box at 45° angles to the side. A 50 gallon barrel with a faucet near

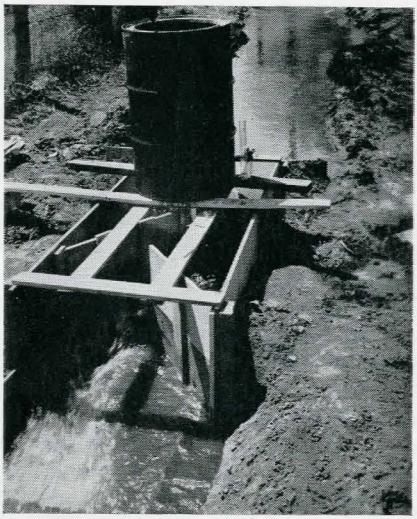

FIGURE 1.—Application of ammonium nitrate in irrigation water.

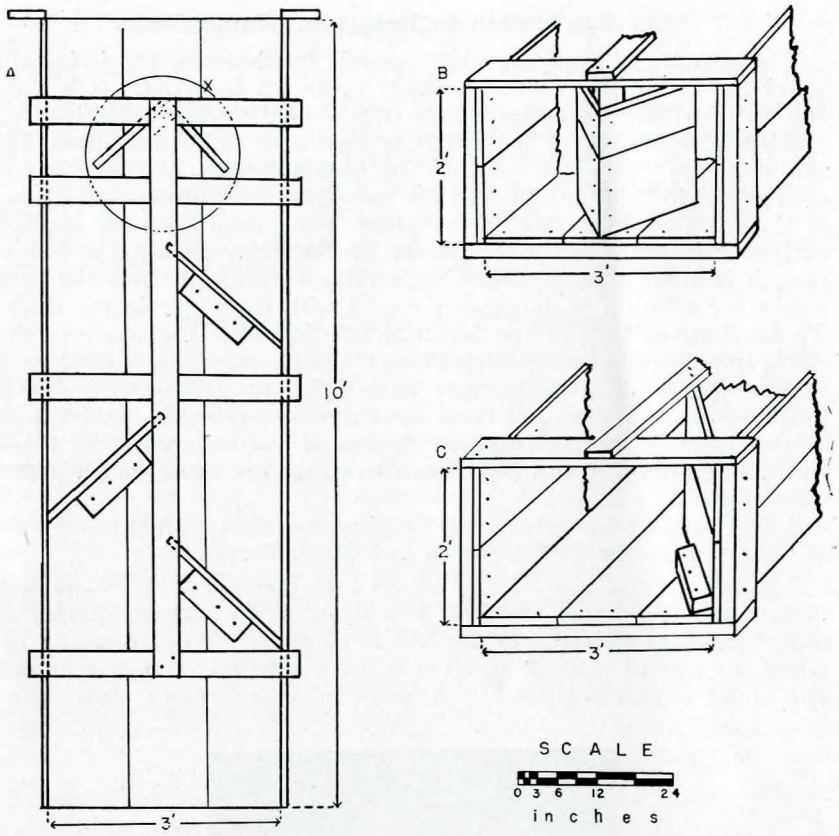

FIGURE 2.—Diagram of box for mixing fertilizers with irrigation water.

the bottom and containing the concentrated ammonium nitrate solution is placed on top of the box and the solution permitted to flow into the water at the V shaped constriction near the entrance. The concentrated solution is prepared by dissolving 200 to 250 pounds of ammonium nitrate in water to make a total volume of about 50 gallons (use 40 gallons of water). The amount of ammonium nitrate added to the irrigation water may be regulated by varying either the time or the rate of flow of the solution from the barrel. The total amount of nitrogen added during a given "set" will depend upon the area to be covered and the rate to be applied. If it is assumed that the rate of application is to be 40 pounds of nitrogen per acre, then the amount of ammonium nitrate in the 50-gallon barrel (250 pounds) will be sufficient for two acres of land. Thus, if two acres of land are to be irrigated at one time, a rate of two gallons per minute during the last 25 minutes of irrigation will empty the barrel and supply the desired amount. However, if only one acre of land is to be irrigated

at one time, a rate of either one gallon in 25 minutes or two gallons in 12½ minutes will be required. If a larger area than two acres is to be irrigated during one "set," it would be desirable to have either a larger container or to have an additional 50-gallon barrel so that the flow of ammonium nitrate solution may be continued without interruption after the first barrel is emptied.

Ammonium nitrate is one of the best fertilizers to use for an application in the irrigation water. It is readily soluble and one pound or more of ammonium nitrate will dissolve in one pound of water. The nitrogen present in the form of nitrate will be carried into the soil by the water whereas the nitrogen present in the form of ammonia is held in the upper few inches of soil. Later the ammonia will be changed to nitrate by soil organisms. Both an early and sustained effect will be obtained by the use of ammonium nitrate. Other nitrogen materials that can be used for application in the irrigation water are ammonium sulfate, liquid ammonia, and sodium nitrate.

NITROGEN IN GREEN MANURE AND BARNYARD MANURE

Although most of the emphasis in this circular has been upon commercial fertilizers, green manures and barnyard manure should not be overlooked as sources of nitrogen. Ordinarily barnyard manure contains about 10 pounds of nitrogen, 5 pounds of phosphate (as P_2O_5) and 10 pounds of potash (as 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. Green manure crops high in protein are excellent sources of nitrogen. Legumes such as sweet clover and alfalfa are good green manure crops since they obtain about two-thirds of their nitrogen from the air through the bacteria living in the nodules on their roots. In the spring of the second year growth of a good stand of sweet clover, about 100 to 150 pounds of nitrogen per acre will be returned to the soil if the sweet clover is plowed under when 10 to 24 inches tall.

Although soybeans are a legume, they are not regarded as a soil building crop where the beans are permitted to mature and are harvested. Most of the nitrogen within the plant passes into the seed and is removed from the field. However, the beans do not remove as much nitrogen from the soil as do crops such as corn or small grain, and as a result there may be a greater quantity of available nitrogen in the soil following a crop of soybeans than following non-legume crops. In addition, the soil following a crop of soybeans is usually in a better state of tilth, although it may be in a condition to erode readily.

It is dfficult to compare the value of nitrogen in manures with that in commercial fertilizers. Most of the nitrogen in the manures must be made available to plants through decay by soil organisms. Thus the total amount of nitrogen present in the manure is not made available at once but is released by the soil organisms over a period of one or two seasons. In addition to distributing the available nitrogen throughout the growing season, manures improve the physical condi-

tion of the soil which permits more rapid infiltration of water and makes the soil more stable when wet. In comparison, nitrogen applied to the soil in a commercial fertilizer is either available immediately or becomes available within a short period of time following the application. This permits a quick response in plants during "critical nitrogen" periods.

COMPARABLE VALUE OF NITROGEN FERTILIZERS

Commercial fertilizers vary in the amount and kind of nutrient elements they contain. Each package or bag of fertilizer should be labeled (Nebraska state law) to show the ingredients and the percentages of available nutrient elements present. Frequently, the analysis is shown by the fertilizer formula such as 4–12–4 or 6–30–0. The first figure in the formula refers to the per cent of nitrogen, the second figure to the per cent of available phosphate (P_2O_5), and the third figure to the per cent of available potash (K_2O). Some fertilizers contain only one of the nutrient elements.

When a commercial fertilizer is purchased, attention should be given to the selection of the proper proportion of nutrient elements for the particular soil condition and crop to be grown. Where only nitrogen and phosphorus are required, it would be desirable to select a fertilizer containing only nitrogen and phosphorus such as a 6–30–0 or 10–20–0, the choice depending upon the proportion of the two nutrient elements needed. If, however, only one nutrient element is required, for example nitrogen, it would be better to select a fertilizer containing only nitrogen such as uramon, ammonium sulfate, ammonium nitrate, or sodium nitrate. The following comparison of the nitrogen contents, pounds of nitrogen in one ton, and the rates of application required to apply 40 pounds of nitrogen per acre of several nitrogen carriers and mixed fertilizers illustrate the undesirability of selecting fertilizers containing more than one nutrient element where only nitrogen is needed.

Commercial fertilizer	Nitrogen per cent	Pounds nitrogen in one ton	Rate of application required to apply 40 pounds nitrogen per acre
Nitrogen carriers:			
Uramon (urea)	42	840	95
Ammonium nitrate	32	640	125
Ammonium sulfate	20	400	200
Sodium nitrate	16	320	250
Mixed fertilizers:			
10–20–0	10	200	400
6–30–0	6	120	666
4–12–4	4	80	1000
2–12–6	2	40	2000

RECOMMENDATIONS OF RATES AND METHODS OF APPLYING NITROGEN FERTILIZERS

No fertilizer containing inorganic nitrogen is recommended where crops follow immediately after alfalfa or sweet clover such as potatoes following alfalfa, where 10 to 15 tons of barnyard manure is plowed under, or *where moisture may be expected to be a limiting factor.*

Crop	Pounds per acre[1] nitrogen	Suggested method of application[2]			
		1st	2nd	3rd	4th
Corn	40	A	B	C	D
Sugar beets[4]	40 to 60	A	B	C	D
Potatoes[3]	30 to 40	D	B		
Small grain[4]	30 to 40	D			
Grass	40 to 60	D			

[1] The rate of application is based upon actual nitrogen. Consult table on page 10 for rate per acre of fertilizer to apply.

[2] Suggested methods are listed in order of preference. The methods are as follows:

A Application with fertilizer attachments on cultivator. For corn, it should be at the last cultivation, and for beets after blocking and thinning.

B Application in irrigation water, preferably at first irrigation.

C Application in bands at bottom of plow furrow.

D Application with attachments on planter or drill. For small grain, nitrogen fertilizers should be applied in the spring before the grain reaches the jointing stage. Nitrogen fertilizer should be applied early in spring on grass when plants first begin growth.

[3] Best results in fertilizer tests in Nebraska have been with mixed fertilizers such as a 10–20–0, instead of straight nitrogen. If a mixed fertilizer such as a 10–20–0 is used, the rate of nitrogen application should be 20 to 30 pounds per acre (200 to 300 pounds of 10–20–0 per acre).

[4] In areas where the soil is deficient in phosphorus, superphosphate should be applied at planting time.

The tall dark green bunches of winter wheat are areas where sufficient nitrogen is available to the wheat. The remainder of the field shows nitrogen deficiency.

The sod-bound brome grass on left of the picture received 20 pounds of nitrogen per acre, the center was not treated, and that on the right received 40 pounds of nitrogen per acre.

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