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Fertilizer Facts

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FS 250

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FS 250

fertilizer facts

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Plant Nutrients

There are at least 16 elements thought to be necessary for proper plant growth. They include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, chlorine, copper, iron, manganese, molybdenum, and zinc.

The first three—carbon, hydrogen, and oxygen—are taken up by the plant from carbon dioxide in the air and from water. Essentially all the remaining nutrients must be obtained from the soil.

Of these, nitrogen, phosphorus, and potassium, known as primary elements, are needed in rather large amounts and are the ones most likely to be deficient in South Dakota soils. Plants can use two forms of nitrogen— ammonium and nitrate salts. Phosphorus and potassium are taken up by plants in the water soluble forms. The supply in South Dakota soils varies from very low to very high for each of these elements.

Calcium, magnesium, and sulfur are called secondary elements. While they are just as important for overall plant growth as the primary elements, you rarely need to apply them to overcome crop nutritional deficiencies. Soils usually contain adequate reserves of these elements.

Boron, chlorine, copper, iron, manganese, molybdenum, and zinc are termed trace or minor elements, since they're required in relatively small quantities for plant growth. With few exceptions, most South Dakota soils contain adequate amounts of these plant food elements.

Nutrient Effects on Plant Growth

All of these essential elements tend to check, balance, support and complement each other in their effects on plant growth. Consequently, all must be available to the plant for optimum growth. When large quantities of some elements are removed, an imbalance between nutrients may develop. Fertilizer applications can correct this; often the addition of only one or two nutrients is necessary.

Nutrient Deficiency Symptoms in Plants

Nitrogen

A nitrogen deficiency results in stunted plants with restricted root systems. Plants become yellow or yellowish green, beginning at the tip and extending down the midrib of lower leaves. Crop yields and quality will be reduced.

Phosphorus

A phosphorus deficiency causes retarded growth and delayed maturity. Lower leaves may become yellow between the veins. In some plants the leaf, stems, or stalks develop a purple color. As leaves die prematurely, the remaining foliage will turn an unusually dark green.

Potassium

A potassium deficiency normally affects the older lower leaves of corn and other common crops first. The lower leaves become mottled, and dead areas develop near the tips and margin of the leaves. A yellowish color begins at the leaf edge and continues toward the center, with affected areas later becoming brown and curved in shape. Older leaves may die and drop off.

Calcium

Young leaves become distorted in shape, fail to enlarge normally, and will appear spotted or contain small light colored areas.

Magnesium

Deficiency symptoms will usually occur in the older lower leaves of affected plants. Symptoms include light striping or chlorosis between veins. Bronze to near red colored vein tissue can occur in severe deficiencies.

Sulfur

Deficiency symptoms resemble those of nitrogen, that is, the unusual light yellow-green color. With nitrogen the older lower leaves exhibit color change first, whereas with sulfur young and old plant tissue appear chlorotic or yellow at the same time.

Boron

Deficiencies vary with the crop. Upper corn leaves develop light striping, along with stunted overall growth and barren stalks. Upper alfalfa leaves become light green, while lower older leaves remain green. Stunted, abnormally small development of new leaf tissue is also typical of boron deficiencies in other crops such as flax, sugar beets, etc.

Chlorine

Deficiencies are not well defined. Wilted leaf tips along with light discoloration are most often mentioned.

Copper

Visual deficiencies are not well defined on common field crops. Corn and small grain crops exhibit light color in the basal and tip areas of upper leaves. Shortened internodes and upper leaf discoloration may appear in alfalfa.

Iron

Iron deficiency, particularly on a temporary basis, has been observed on many common crops. It can be described as a pale yellow leaf color with little or no veinal patterns on the younger leaves of plants. These symptoms are most commonly found on flax, soybeans, sorghum, corn, small fruits, and ornamentals.

Manganese

Visual deficiencies can be described as a pale green color in leaf tissue between the veins, while the veins remain green. In some crops such as potatoes, soybeans, and oats, small gray specks will appear along leaf veins on deficient plants.

Molybdenum

Clear-cut visual deficiency symptoms are not well understood or well defined for this nutrient. In legumes progressively lighter green color is perhaps the best description.

Zinc

Severe deficiencies of this nutrient will cause pale yellow stripes to develop on each side of the midrib in lower leaves. Such striping begins in basal areas of leaves. The color change approaches bronze to near-red as severity of deficiency increases.

Fertilizer Terms and Definitions

Carrier is another word used to identify nutrient source. A carrier will be selected because of its specific nutrient content, availability, physical characteristics, and the cost of the plant nutrient contained. A material possessing only one plant nutrient is called a single carrier (ammonium nitrate, concentrated superphosphate, etc.) Other carriers may contain two or more essential plant nutrients (diammonium phosphate). Carriers shouldn't be confused with inert or inactive materials that were associated with some fertilizers in the past.

Fertilizer analysis expresses the nutrient content of the fertilizer. It is given as a percentage.

Nitrogen fertilizers are commonly marketed on the basis of total available nitrogen content (N). The forms of nitrogen may include inorganic and organic materials.

Phosphorus fertilizers are usually evaluated on the basis of the quantity that dissolves in successive extractions of the sample with water and a neutral ammonium citrate solution. The soluble phosphorus determined in this manner is readily usable by plants and is commonly designated as available phosphate (P_2O_5). Phosphorus analysis has also been expressed recently as the amount of elemental phosphorus (P). Some companies list both analyses on the bag.

Potassium fertilizers are marketed on the basis of the water soluble potash content (K_2O). Potassium analysis has also been based on the amount of elemental potassium (K). Again, some companies list both analyses on the bag.

Some of the more common primary plant food materials are shown in Table 1, along with the approximate nutrient content of each. South Dakota law requires fertilizer registered for agricul-

Table 1. Primary fertilizer materials

Analyses % N-P_2O_5-K_2O	Common name	Equivalent analyses N-P-K
82.5-0-0	Anhydrous ammonia-gas	82.5-0-0
20-0-0	Aqua ammonia solution	20-0-0
32-0-0	Nitrogen solution	32-0-0
34-0-0	Ammonium nitrate	33.5-0-0
21-0-0	Ammonium sulfate	21-0-0
45-0-0	Urea	45-0-0
0-20-0	Superphosphate	0-8.8-0
0-46-0	Triple superphosphate	0-20.2-0
0-76-0	Super phosphoric acid	0-33.4-0
0-0-60	Muriate of potash	0-0-49.8
0-0-53	Potassium sulfate	0-0-44.0
0-0-22	Potassium magnesium sulfate	0-0-18.3
11-48-0	Monoammonium phosphate	11-21.1-0
18-46-0	Diammonium phosphate	18-20.2-0
10-34-0	Diammonium phosphate	10-15-0
23-23-0	Nitric phosphates	23-10.1-0
25-25-0	Nitric phosphates	25-11.0-0
29-14-0	Ammonium phosphate nitrate	29-6.2-0
13-0-45	Potassium nitrate	13-0-38

tural use contain no less than 18% total available nitrogen plus phosphate plus potash.

Fertilizer grade means essentially the same as analysis. A 11-48-0 grade contains 11% N, 48% available P_2O_5, and 0% water soluble K_2O by weight.

Proposals to list nutrient content on a elemental basis only have been studied by both industry and regulatory agencies. If these changes are instituted, fertilizer grades will be expressed in elemental N, P, and K instead of the present N, P_2O_5, and K_2O. This does not directly affect fertilizer quality or performance, but you would have to understand the conversion rate.

Nitrogen is already reported as elemental N, so it would remain unchanged. Phosphorus has been reported as P_2O_5 which contains 44% elemental (pure) P. To convert P_2O_5 to P, multiply the percent of P_2O_5 by .44. Potassium has been reported as K_2O which contains 83% K. To convert, multiply the percent K_2O by .83. For example, 10-20-10 when converted to an elemental percentage would read 10-8.8-8.3 (20 x .44 = 8.8, 10 x .83 - 8.3). Consequently, the same fertilizer grade may be expressed in two ways: 10-20-10 or 10-8.8-8.3.

Fertilizer ratio refers to the unit percentages of nitrogen, phosphate, and potash in a fertilizer. A 6-24-0 or 8-32-0 grade has a 1-4-0 ratio; 10-20-10 or 15-30-15 both have 1-2-1 ratios. Fertilizer analyses expressed as an elemental percentage will change the expressed ratio.

Unit of plant nutrients is the percent of available plant nutrients on the basis of a ton of fertilizer. The chemical analysis of any fertilizer is a statement of the number of units carried in a ton. One unit equals 20 pounds of actual plant nutrients. For example, urea with 45% available nitrogen has 45 units or 900 pounds of available nitrogen per ton.

Sources and Forms of Common Commercial Fertilizers

Commercial fertilizers are manufactured in essentially three forms—dry or granular, liquid, and gas. Some nitrogen carriers on the market contain relatively small amounts of available nitrogen while others are highly concentrated.

All nitrogen fertilizers do not react the same in a given soil. For example, nitrogen in the ammonium and nitrate form is immediately available for plant use. The nitrogen of organic carriers (manure, crop residue, etc.) must be converted to an available form by soil microorganism activity before it is taken up for plant use.

Nitrogen Fertilizers

With few exceptions, most of today's nitrogen fertilizers are manufactured by combining a hydrogen source such as natural gas with nitrogen from the air to form anhydrous ammonia. It contains the highest analysis possible for any nitrogen fertilizer.

Anhydrous ammonia is a gas containing 82% nitrogen. When compressed under suitable conditions of pressure and temperature, it becomes a liquid which can be stored and shipped in pressure tanks. It is used to make other fertilizers as well as for direct application to the soil.

Soil pH levels in the immediate ammonia band may temporarily reach 8.0 to 9.0. These temporary increased levels will return to previous levels in a few weeks.

The most favorable soil conditions for field application appear to be those soil moisture levels ideal for routine tillage such as plowing, chiseling, etc. Anhydrous ammonia normally should be injected at least 6 inches deep. Increase depth to 7-9 inches where injection spacing reaches 36-40 inches and nitrogen rates reach or exceed 100 lbs of actual N per acre. The deeper injection depth is also recommended for sandy soils.

Maximum nitrogen loss will occur where extremely wet or dry cloddy soils prevent sealing or closure of the openings behind the applicator.

Available research indicates nitrogen loss will usually remain low when the above guidelines are observed. See FS 557, "Anhydrous Ammonia Fertilizer," for more details.

Ammonium sulfate is made by passing ammonia gas through sulfuric acid and evaporating to dryness. This crystalline salt is usually white or grayish and is soluble in water. It contains about 20% nitrogen plus about 24% sulfur. It is an excellent sulfur fertilizer.

When applied to soil most of the ammonium nitrogen is changed into the nitrate form. Ammonium sulfate tends to slowly increase the acidity of soil (particularly very sandy soils) when used in large amounts or over many years.

Ammonium nitrate is also a crystalline salt. The pure salt is white, but it usually appears on the market as an off-white granular material which has been coated to prevent absorption of water from the air and to make it easier to apply uniformly. It contains 34% nitrogen, half of which is in the ammonium form and half in the nitrate form.

This fertilizer is water soluble and tends to slowly increase soil acidity. Its readily available forms of nitrogen are quickly taken up from soil by plant roots.

Urea is a white or gray crystalline product containing approximately 45% nitrogen.

Urea is completely soluble in water. The nitrogen, once applied to a soil, is converted rapidly to the ammonium and finally into the nitrate form. While undergoing chemical change and prior to becoming converted to nitrate nitrogen, some of this nitrogen may actually exist as a gas and thus is free to escape into the air. Urea, like all nitrogen fertilizers, should be incorporated into the soil immediately after application to prevent unnecessary losses.

Low pressure solutions can vary in nitrogen content from approximately 37 to 41%. Much of that nitrogen is anhydrous ammonia dissolved in water, which explains why a low vapor pressure of up to 15 psi exists and an ammonia smell can be detected. The remaining nitrogen is dissolved ammonium nitrate or urea. These materials, though seldom used today, should be injected 2-3 inches into the soil.

Aqua ammonia solutions might also be categorized as low pressure psi solutions, although vapor pressures at warm temperatures can reach 15 psi. Aqua ammonia solutions should be injected 2-3 inches into the soil. Field results are similar to anhydrous ammonia from which aqua ammonia is made. The nitrogen content will be approximately 20%.

Non-pressure nitrogen solutions contain 28-32% nitrogen. About one-fourth of the nitrogen is in the nitrate form, one-fourth in ammonium, and half in urea nitrogen. Frequently these solutions will also contain phosphorus and potash.

Solutions having no pressure can be applied on the surface of the soil by dribbling or spraying without rapid loss of nitrogen. However, loss will increase if incorporation is not completed in 24-48 hours.

Organic sources release nitrogen slowly. Such sources include dried sewage sludge, dried manure, and dried blood. These nitrogen materials must be converted into available ammonium and nitrate salts by soil microorganisms before plant uptake can occur.

Slow release fertilizers are marketed in limited quantities. They are most extensively used in turf management for golf courses, park or recreation areas, and lawns. One common chemical form is urea-formaldehyde. It contains about 38% nitrogen.

Sulfur coated urea is also a form of slow release nitrogen fertilizer. The manufacturing process involves coating regular urea nitrogen fertilizer with a sulfur-wax compound. The final analysis will be about 35% N; however, the analysis can vary both above and below that value. Limited SDSU research indicates there is little or no yield advantage from use of such fertilizer compared to common nitrogen fertilizers under normal farming conditions. Under some conditions the nitrogen release rate is too slow and yields are reduced.

Phosphorus Fertilizers

Superphosphate is produced by treating raw rock phosphate with a strong acid. This breaks the strong chemical fluorapatite bond and releases the phosphorus into a form that can be utilized by plants. The analysis of normal superphosphate will usually be 20% P_2O_5. It also contains 12% sulfur.

Triple superphosphate is produced by treating rock phosphate with phosphoric acid. This process purifies and increases the phosphorus concentration by removing impurities such as calcium and sulfur contained in normal superphosphate. Triple is marketed almost entirely as a dry straight fertilizer that contains up to 46% P_2O_5 (20.2% elemental P).

Phosphoric acid is also one of the basic sources of phosphorus used for making phosphate fertilizers, particularly the liquid forms. It is also produced from rock phosphate.

To date both electric furnace and wet-process production methods have been used in manufacturing. While the electric furnace method results in perhaps a clearer and more desirable product with a higher analysis, cost of production and energy demands have forced industry to use the wet-process method.

While this type of phosphoric acid may not be quite as appealing because of lower analysis and higher impurities, it appears to have the same agronomic value, pound for pound of P_2O_5 applied, but at a more reasonable cost. The phosphate content of common electric furnace phosphoric acid will usually range from 54-62% P_2O_5 whereas wet-process acid when concentrated seldom reaches 54%.

Superphosphoric acid is made by evaporating water from wet-process phosphoric acid or by using less water in the electric furnace process of manufacturing. Wet-process super acid may contain up to 72% P_2O_5, and electric furnace P_2O_5 content may reach 83%.

Polyphosphate is a popular term used to identify types of today's higher analysis phosphorus fertilizers. Polyphosphate refers to one of several chemical forms of phosphorus found in both liquid and dry fertilizers. Fertilizers high in polyphosphate have not been shown conclusively to be a better source of phosphorus for crops. High polyphosphate fertilizers do exhibit greater effectiveness as a carrier for trace nutrients.

Potassium Fertilizers

Potassium chloride (muriate of potash) is a high analysis fertilizer material varying from 48-62% water soluble K_2O or 39.8-51.5% K. It is a white, crystalline, naturally occurring salt that is readily available to plants. Mineral impurities frequently give it a pink color.

Potassium sulfate (sulfate of potash) is a high grade fertilizer material varying from 48-51% water soluble K_2O or 40.2%-42.7% K. It is a white crystalline, naturally occurring salt, readily available to plants. This material also contains 18% sulfur.

Potassium nitrate (saltpeter) is still another suitable potash fertilizer, containing up to 45% available K_2O or 38% K. This fertilizer also contains 13% available nitrogen. It is a white, crystalline material in its pure form.

Mixed Fertilizers

Mixed fertilizers contain two or more essential plant nutrients. They are available both in the dry and liquid forms.

For example, ammoniated phosphates are manufactured by combining nitrogen carriers such as anhydrous ammonia with normal and superphosphate. Treatment of phosphoric acid with anhydrous ammonia produces ammonium phosphate.

The degree or amount of ammoniation determines whether the final product is a mono-ammonium phosphate such as 11-48-0 or a diammonium phosphate such as 18-46-0. Similar processes involving superphosphoric acids are used to manufacture ammonium polyphosphates.

Mechanically mixed or "blended" fertilizers are usually prepared by the local dealer in specially designed equipment. Since fertilizer materials used in blending vary in particle size, shape, and specific gravity, segregation in the final product during handling and delivery can take place no matter how thoroughly mixed. Extreme segregation will result in non-uniform field application and poor crop results.

The final analysis of blended fertilizers can never exceed the highest combined percentages of the elements in any one of the materials used. For practical purposes, it cannot exceed 77% since the highest analysis ingredient currently available for mixing is a 15-62-0 or a total of 77%.

A wide variety of liquid mixed fertilizer grades can be manufactured and are well suited for use in this region. Solubility and salting-out characteristics limit production and use of some of the higher analysis grades. In general, the upper limit is about 50% total primary plant nutrients.

Organic Fertilizers

The term organic is often used to denote naturally occurring plant food sources not chemically altered by man. Livestock and municipal wastes, rock phosphate, and gypsum would be examples. Organic fertilizers are very satisfactory forms of fertilizer elements, providing adequate rates are applied to supply the necessary amounts of available nutrients needed. Some materials sold as organic fertilizer contain very little if any available plant food; most of the contents are inert or nonavailable forms. Research shows farmers who substitute use of such organic fertilizers for conventional fertilizers will eventually experience serious yield reductions.

Secondary Element Fertilizers

Research to date shows most soils in the state contain adequate supplies of the secondary elements calcium, magnesium, and sulfur. Commercial sources of these fertilizers are available, should deficiencies occur. Some secondary nutrient fertilizers are less effective than others because of their low water solubility; granular elemental sulfur is a good example. Finely grinding such forms will improve availability to plants; but, better yet, choose products with high solubility.

Trace Element Fertilizers

Most South Dakota soils appear to contain adequate amounts of iron, manganese, boron, zinc, copper, chlorine and molybdenum. Nevertheless, continued and intensified farming may create deficiencies and a need to make periodic applications. Soil tests and research show a limited number of fields may now need application of zinc for corn, sorghum and edible beans.

Many commercial sources of trace elements are available. These product sources, with the exception of boron, fall into one of two general categories: metallic salts such as sulfates (i.e. zinc sulfate) etc.; and chelates (i.e. chelated zinc). Only small amounts of these elements are needed, therefore, care should be exercised to assure uniform accurate application. Excessive application of some trace elements such as boron can be toxic to commonly grown field crops. Table 2 contains some of the commercial forms of trace element fertilizer materials sold today. Other liquid, wettable powder, granular, or frit forms may also be equally effective pound for pound of actual guaranteed available plant food element used.

Products of Questionable Value

Some soil conditioners and seed treatment products have been marketed with the claim that they improve soil structure and organic matter levels. Such soil properties as structure and organic matter are indeed important in attaining high yields of top quality crops. However, research has shown that serious yield reductions can occur when low analysis products are used in place of conventional fertilizers.

Caution, knowledge, and sales resistance are the best tools available to help farmers avoid investment in products of questionable value. Consult your county Extension agent if in doubt about such materials.

Nutrient Loss

Nutrient loss may be both temporary and permanent.

Nitrogen requires the greatest attention. It can be temporarily tied up in crop residue decay as well as lost permanently through leaching or volatilization from soil. Losses of the latter types often occur in very wet, fine textured soils. Some management practices, however, can minimize such losses.

1. Increase N rates in years following the return of large amounts of crop residue or where entire crop is removed for silage.
2. Incorporate N fertilizer into soil wherever possible.
3. Avoid gaseous N fertilizer application into both unusually wet and cloddy soil conditions.
4. Make N applications on sandy and very low, wet soil as near the time of crop uptake as possible.
5. Split N fertilizer application.

Phosphorus and potash are not lost in the same way as nitrogen. They may be easily tied up when extensively mixed with soil; however, they are not subject to gaseous loss. They remain essentially where they are placed in the soil.

Calculating Fertilizer Rates

Soil fertility levels and crop nutrient needs vary widely. The ability to calculate required plant food quantities, using various available fertilizer ratios is extremely important.

The plant food analysis of any liquid or dry fertilizer is expressed in percent. For example, a 20-10-5 fertilizer contains 20% N, 10% P_2O_5, and 5% K_2O by weight. To determine actual plant food content, simply multiply the quantity in pounds by the indicated percent as a decimal. In the case of liquid, it is first necessary to convert gallons of fertilizer into pounds and then multiply by the decimal percent. An application rate of 250 lbs of 20-10-5 per acre means the farmer would be applying (250 x .20) 50 lbs actual N, (250 x .10) 25 lbs actual P_2O_5, and (250 x .05) 12.5 lbs actual K_2O.

If you need to determine the lbs of 20-10-5 fertilizer needed for a soil test recommendation of 50 lbs N, 25 lbs P_2O_5, and 12.5 lbs K_2O reverse the process. In other words, divide 50 by .20, 25 by .10 and 12.5 by .05 which in this example turns out to be 250 lbs of total fertilizer material.

Final fertilizer nutrient levels are more easily understood and meaningful if expressed in pounds of actual plant food rather than units, such as gallons, tons, etc.

Calculating Fertilizer Costs

Most of today's fertilizers are equally effective, pound for pound of actual available plant food, when properly applied. The actual available plant food content is by law required to be shown on the container or invoice. Thus, calculating plant food costs is the most effective way to determine or compare the value of any particular fertilizer.

Figuring the actual available plant food content and fetilizer rates is the first step in calculating fertilizer cost or value. Once the pounds of actual available plant food per unit (i.e. 100 lbs, tons, etc.) of fertilizer are known, then simply divide the unit price by the pounds of actual available plant food in that unit. For example if 32-0-0 is priced at $128 per ton, the cost per pound of actual available nitrogen is $128.00 divided by 2000 lbs x .32 or 20 cents.

Computing value of mixed fertilizers involves the same basic methods with some slight differences. For example if you want to calculate the cost of nitrogen in a mixed fertilizer, you would first deduct the value of any phosphate and potash, based on an assumed current price, and then proceed with nitrogen as above.

Table 2. Secondary and trace element fertilizer materials

Common name	Approximate analysis-%
Borax	11.3 boron
Solubor	20.0 boron
Tronabor	14.3 boron
Manganese oxide	50.0 manganese
Manganese chelate	12.0 manganese
Iron chelate	10.0 iron
Copper oxide	75.0 copper
Copper sulfate	29.4 copper plus 12.8 sulfur
Manganese sulfate	20.0 manganese plus 14.5 sulfur
Iron sulfate	20.0 iron plus 17.0 sulfur
Gypsum	23.0 calcium plus 18.6 sulfur
Sulfur	99.0 sulfur
Zinc sulfate	27.8 zinc plus 13.6 sulfur
Zinc oxide	77.2 zinc
Ammonium thio-sulfate	12.0 nitrogen plus 26.0 sulfur
Zinc chelate	14.0 zinc
Copper chelate	13.0 copper
Polyflavinoids	*
Lignosulfonates	*

* Commercial products containing only iron, copper, manganese, or zinc of unknown analyses.

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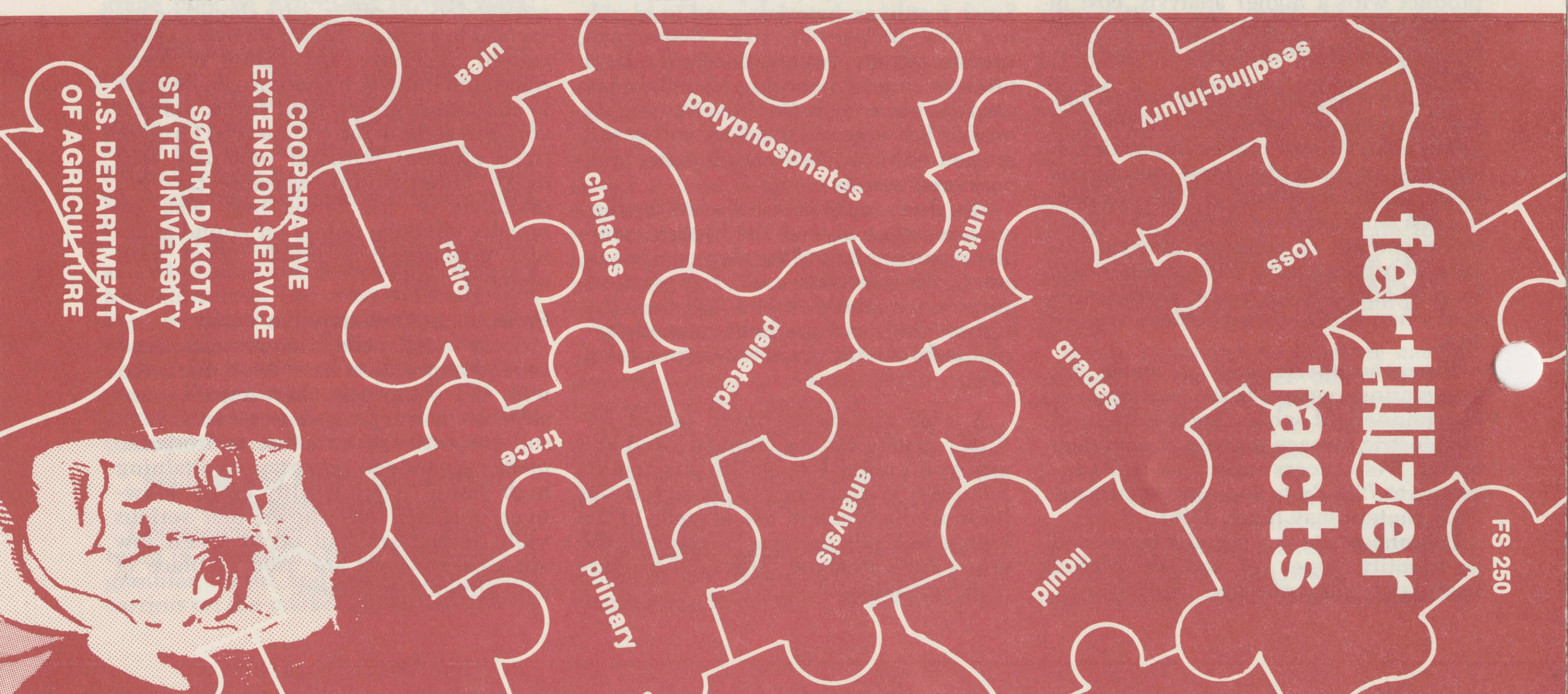

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