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EC73-197 Fertilizer Know How

D. H. Sander

R. A. Wiese

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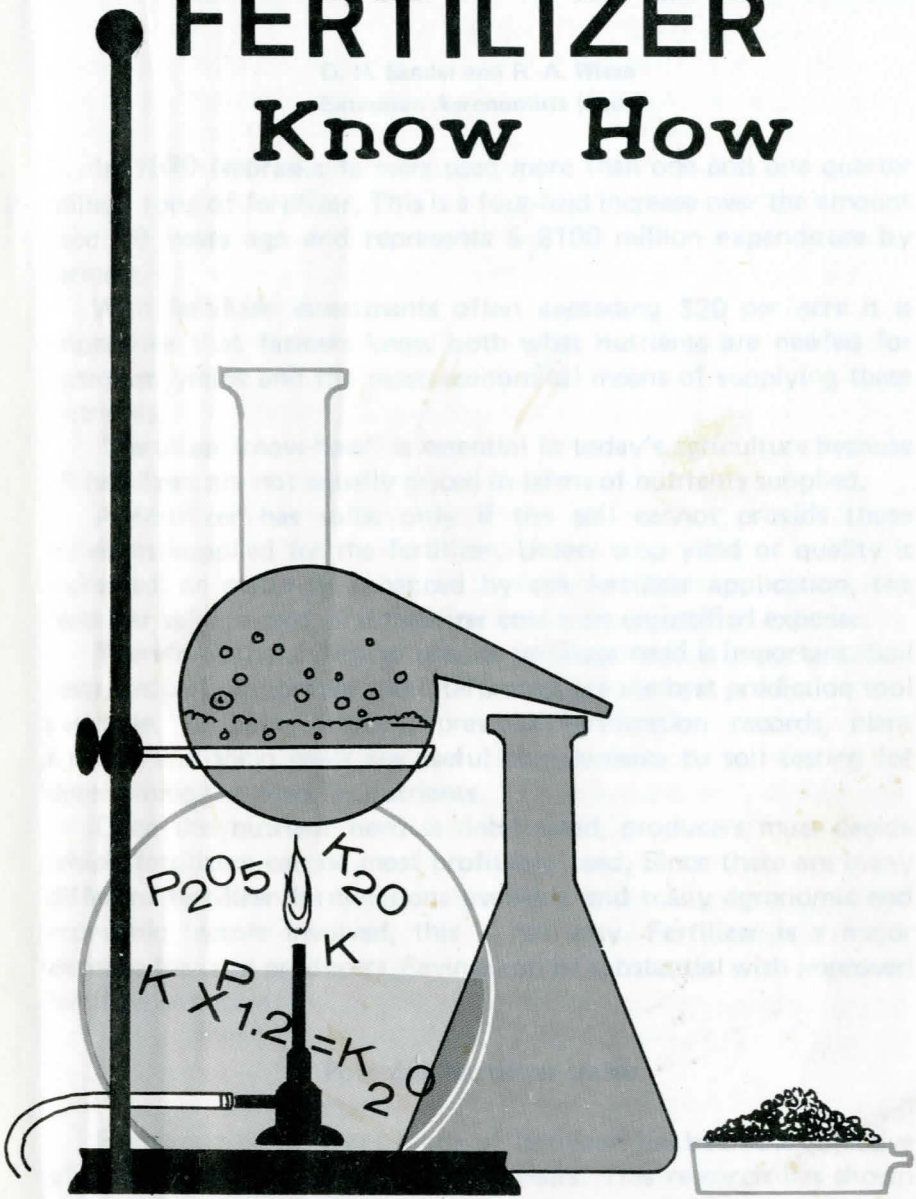
FERTILIZER
Know How



Extension Service, University of Nebraska-Lincoln College of Agriculture Cooperating with the
U. S. Department of Agriculture and the College of Home Economics
E. F. Frolik, Dean J. L. Adams, Director

FERTILIZER know how

D. H. Sander and R. A. Wiese
Extension Agronomists (Soils)

In 1970 Nebraska farmers used more than one and one quarter million tons of fertilizer. This is a four-fold increase over the amount used 10 years ago and represents a $100 million expenditure by farmers.

With fertilizer investments often exceeding $20 per acre it is imperative that farmers know both what nutrients are needed for optimum yields and the most economical means of supplying these nutrients.

"Fertilizer know-how" is essential in today's agriculture because all fertilizers are not equally priced in terms of nutrients supplied.

A fertilizer has value only if the soil cannot provide those nutrients supplied by the fertilizer. Unless crop yield or quality is increased or maturity enhanced by the fertilizer application, the fertilizer value is zero, and fertilizer cost is an unjustified expense.

Therefore, the ability to predict fertilizer need is important. Soil tests, properly calibrated and interpreted, are the best prediction tool available. Cropping history, previous fertilization records, plant analysis and yield goals are useful complements to soil testing for determining the need for nutrients.

Once the nutrient need is determined, producers must decide which fertilizers can be most profitably used. Since there are many different fertilizer formulations available and many agronomic and economic factors involved, this is not easy. Fertilizer is a major expense for crop producers. Savings can be substantial with improved fertilizer selection.

Potential Fertilizer Value

Evaluation of different kinds of fertilizers has been the objective of much research over the past 50 years. This research has shown that fertilizer compounds containing the same amount of nutrients do not always perform the same.

Of the major nutrients—nitrogen (N), phosphorus (P) and potassium (K)—only phosphorus compounds vary widely in plant availability. This depends primarily on the degree of water solubility. Phosphorus fertilizers with low water solubility are likely to perform poorly on annual crops.

Most of the phosphorus fertilizers presently sold in Nebraska, however, are of high water solubility and are essentially of equal value as sources of P.

The effectiveness of fertilizer is essentially the same irrespective of its physical form (gas, liquid or dry) as long as the same amount of available nutrient is properly applied.

For example, liquid and dry phosphorus sources have been shown to be of equal value under most situations but liquid polyphosphates can be superior carriers for micronutrients. This superiority is not caused by polyphosphates being liquid. It is due to the chemical characteristics of phosphorus in polyphosphate form.

Common nitrogen fertilizers are essentially of equal value if properly applied. Proper application means soil incorporation or subsurface application of anhydrous ammonia, a gas.

Several factors are involved in the proper application of anhydrous ammonia. Losses may be high under some soil conditions and must be considered in terms of final costs. Performance of liquid and dry nitrogen fertilizers may also vary considerably when applied on the surface. Incorporation will usually increase dependability of their performance.

In spite of the above limitations, **it is generally accepted that it is the N, P and K content which determines the potential value of a fertilizer.** Obviously, this is an oversimplification in view of the above considerations and is not valid for micronutrient fertilizers. Nevertheless, the amount of nutrient received per dollar spent should be the deciding factor governing fertilizer purchase in most cases. Certainly such factors as ease and cost of application and availability of products will influence fertilizer purchase decisions.

Fertilizers and Their Nutrient Content

Fertilizer manufacturers and distributors are required by law to register with the State Department of Agriculture each grade of commercial fertilizer being offered for sale or distributed in the state.

Additionally, manufacturers and distributors must show on the label of bagged fertilizer and on the invoice for bulk blends and liquids the percent of nitrogen, percent available phosphorus (as P_2O_5) and percent available potassium (as K_2O) that fertilizer contains. This is called the "guaranteed analysis."

Additional nutrients must also be guaranteed when such content is claimed. All fertilizers offered for sale in the state are subject to inspection by the State Department of Agriculture.

Since the amount of nutrients in a fertilizer must be guaranteed to comply with law, the major plant nutrients (nitrogen, phosphorus and potassium) are expressed in a fertilizer grade which indicates the nutrient percentage of nitrogen (N), available phosphorus (P_2O_5) and available potassium (K_2O).

For example, a 16-8-12 fertilizer contains 16% N, 8% phosphorus as P_2O_5 and 12% potassium as K_2O. Each 100 lb of 16-8-12 fertilizer contains 16 lb N, 8 lb P_2O_5 and 12 lb K_2O. To determine the amount of nutrients in one ton of 16-8-12 fertilizer multiply each nutrient percentage by 20 (20 X 100 lb = 1 ton).

For example, the 16-8-12 fertilizer has 320 lb N, 160 lb P_2O_5 and 240 lb K_2O in each ton. In any fertilizer guaranteed nutrients other than N, P_2O_5 or K_2O will be shown on the tag or invoice and the percentage given.

For example, a fertilizer guaranteed to have 3% zinc will contain 60 lb of zinc in each ton.

Many plant nutrients are often found in fertilizers for which no guarantee is given or shown. This is because the chemical compounds carrying a specific nutrient such as nitrogen or phosphorus may also carry another of the 13 essential nutrients that plants obtain from the soil.

For example, ammonium sulfate has a guaranteed analysis of 21-0-0 but also contains 24% sulfur. These nutrients occur either as an actual part of the fertilizer compound or result from the method of manufacture. If sulfur is required, these fertilizers may have extra value and be more economical to use than other sources of nitrogen or phosphorus which do not contain sulfur.

The above discussion leads us to the question that we have partially answered: Why doesn't a fertilizer material carry 100% nutrient content? The formula 16-8-12 adds up to 36%. What is the other 64%? Is this 64% simply filler?

The answer is that most nutrients cannot be applied or are not available to the plant in their pure state. Nitrogen, for example, is found in the air around us as an inert gas. About 78% of the air is nitrogen but none of this is available to plants. Certain bacteria in nodules on the roots of legumes have the ability to combine nitrogen from the air into chemical compounds that plants can use. Fertilizer manufacturing plants combine the nitrogen found in air with hydrogen to form ammonia which is either used directly as a nitrogen fertilizer or used to form other nitrogen fertilizers.

Pure phosphorus is a yellow substance which bursts into flame when exposed to the air. Potassium also reacts quickly with oxygen in the air to form oxides which then react with water to form caustic potash or potassium hydroxide. Sulfur, on the other hand, is commonly applied to soils in the elemental form although sulfate sulfur forms are more available to plants. In some soils it may take months for sulfur to become completely available to plants in the sulfate form.

Fertilizer Formulation

Fertilizer manufacturers have many different compounds or materials that they may use in formulating a particular fertilizer. The most common nitrogen sources are ammonium nitrate (33-0-0), urea (45-0-0), ammonium sulfate (21-0-0) and anhydrous ammonia (82-0-0). The first three nitrogen carriers are used as either liquid or dry material. Anhydrous ammonia is stored as a pressurized liquid and is a gas under normal atmospheric pressure.

Fertilizers containing only phosphorus are marketed as superphosphate (0-20-0) and triple superphosphate (0-46-0). Phosphoric acid (0-54-0 or 0-76-0) is sometimes used directly as fertilizers but is more commonly used after neutralization with ammonia to form ammonium phosphates.

Fertilizers containing both nitrogen and phosphorus occur either as so called "chemically combined" fertilizers or as bulk blends. "Chemically combined" nitrogen-phosphorus fertilizers refer primarily to the ammonium phosphates. Common dry grades are 16-20-0, 11-48-0, 16-48-0, 18-46-0 and 21-53-0. Bulk blends are mechanical mixtures of the above fertilizers to achieve a desired grade.

Liquid mixed fertilizers commonly utilize an ammoniated phosphoric acid solution (10-34-0) into which other solid materials may be added. Potassium chloride is the common source of potassium in both liquid mixed and dry bulk blended fertilizers.

Is a chemically combined fertilizer superior to a bulk blend of similar grade? Every particle of a chemically combined fertilizer contains the exact fertilizer grade. A bulk blend fertilizer of similar grade depends on the mixing of different kinds of particles to achieve an overall grade. Therefore, uniform mixing of bulk blends is critical for good nutrient distribution.

Studies have shown that if particles of the proper size and density are mixed, segregation is limited and not a serious problem. Therefore, a properly mixed and distributed bulk blend fertilizer should be equal in value to a chemically combined fertilizer of the same grade.

Oxide vs Elemental

As previously discussed, fertilizer content of phosphorus (P) is guaranteed in terms of phosphorus pentoxide (P_2O_5) and potassium (K) in terms of potassium oxide (K_2O). Actually there isn't any P_2O_5 or K_2O in fertilizer materials. These are simply traditional chemical expressions which have been used for many years. Nitrogen was reported as percent ammonia (NH_3) until 1916 at which time most states changed to reporting it as the element nitrogen (N).

The two methods of reporting as oxide or as elemental form has caused a great amount of confusion. Phosphorus pentoxide (P_2O_5) actually contains only 44% phosphorus (P). In attempting to avoid this complex name several other incorrect names are often used. The terms phosphoric acid, phosphate and even phosphorus are often used incorrectly for phosphorus pentoxide.

To eliminate the confusion, the Soil Science Society of America adopted the policy in 1963 of reporting on an elemental basis. Reporting on an elemental basis for phosphorus and potassium is a significant change from the old oxide system. However, the nutrient contents are unchanged. The new terminology does not change the form of the nutrients in the fertilizer. The amount of phosphorus and potassium available to the plant remains the same.

An example best illustrates the change from the oxide to the elemental system of reporting phosphorus and potassium in fertilizers. Concentrated superphosphate is a 0-46-0 fertilizer on the oxide basis. This fertilizer becomes 0-20-0 on the elemental basis.

In applying 100 lb of concentrated superphosphate the nutrient content is the same whether expressed as 46 lb of phosphorus pentoxide (P_2O_5) or 20 lb of phosphorus (P). The difference in the two values is the weight of oxygen in P_2O_5. Similarly potassium chloride, a 0-0-60 fertilizer on the oxide basis, becomes a 0-0-50 when calculated on the elemental basis.

Conversion from oxide to elemental or vice versa is easily done by using Table 1 or by using conversion factors as follows:

$$P \times 2.3 = P_2O_5$$
$$P_2O_5/2.3 = P$$

$$K \times 1.2 = K_2O$$
$$K_2O/1.2 = K$$

No conversion is necessary for nitrogen and all secondary and trace nutrients, because they are already expressed on the elemental basis.

Fertilizer Arithmetic

The cost of plant nutrients can vary for a number of reasons. Manufacturing, storage, distribution or freight charges may differ at different locations. Transportation or freight costs are directly associated with the distance and kind of transportation required to distribute fertilizer materials to retail outlets. Retail dealer services for delivery, storage, renting application equipment and application affect the final cost of fertilizer nutrients. Dealer services have different values to each individual farm operator and must be appropriately considered.

The cost per pound of a nutrient can be calculated from the *price for a given weight* and the *percent of nutrient* in the fertilizer. Below are examples of procedures for calculating nutrient costs starting with price per ton or per 100 pounds or per gallon. **The prices used are assumed retail prices only and are not intended to reflect what retail prices are or should be.**

Fertilizers Containing One Nutrient

Single nutrient applications in Nebraska are mostly confined to nitrogen and phosphorus. This method can be used to compare nitrogen sources for topdressing wheat or forage crops or preplant and sidedress applications of nitrogen on corn and sorghum. Fertilizers containing only phosphorus are used primarily on legumes such as alfalfa. However, the method for calculating the cost of one nutrient is basic to other calculations for mixed fertilizers. Examples:

Example (A) Anhydrous ammonia (82-0-0) @ $82 per ton.

1. Multiply percent of nutrient (N) in fertilizer by 20.
   82 X 20 = 1640 lb of N per ton.

2. Divide cost per ton by pounds of nutrient (N) per ton.
   $82 ÷ 1640 = $0.05 or 5¢ per lb of N.

Example (B) Urea - Ammonium nitrate solution (28-0-0) @ $56 per ton.

1. Multiply percent of nutrient (N) in fertilizer by 20.
   28 X 20 = 560 lb of N per ton.
2. Divide cost per ton by pounds of nutrient (N) per ton.
   $56 ÷ 560 = $0.10 or 10¢ per lb of N.

Example (C) Superphosphate (0-46-0) @ $82.80 per ton.

1. Multiply percent of nutrient (P_2O_5) in fertilizer by 20.
   46 X 20 = 920 lb of P_2O_5 per ton.
2. Divide cost per ton by pounds of nutrient (P_2O_5) per ton.
   $82.80 ÷ 920 = $0.09 or 9¢ per lb of P_2O_5.

From these examples, similar procedures can be used for ammonium nitrate (34-0-0), urea (45-0-0), potash (0-0-60) or any fertilizer containing one nutrient.

Mixed Fertilizers

Fertilizers containing more than one nutrient are called "mixed fertilizers." These fertilizers may be liquid or dry and commonly contain two or more nutrients of nitrogen, phosphorus, potassium and zinc, although other nutrients may also be present. These fertilizers are applied as starters in the row or broadcast and

incorporated before planting for small grains and row crops. They may also be broadcast as topdressings on forage crops.

"Fertilizer arithmetic" for a mixed fertilizer requires that an indirect method be used. One common practice is to assume a reasonable cost for one or more nutrients and then calculate the cost of the residual or remaining nutrients.

Another method is to compare the cost of a mixed fertilizer with the cost of individual nutrients purchased separately. In the following examples of the "Residual Cost Method" and the "Cost Comparison Method," the cost of N is assumed at 10¢ per lb, P_2O_5 at 9¢ per lb and K_2O at 5¢ per lb to demonstrate methods of calculation. Assumed costs could be derived from calculations based on cost of a single nutrient fertilizer.

The "Residual Cost Method":

Example (D) 18-46-0 @ $108 per ton.

1. Multiply each percent of nutrient in fertilizer by 20.
   18 X 20 = 360 lb of N per ton.
   46 X 20 = 920 lb of P_2O_5 per ton.
2. Assume 9¢ per lb for P_2O_5.
   Then 920 X $0.09 = $82.80 per ton for the value of phosphate in the fertilizer.
   Then $108.00 minus $82.80 = $25.20 which is the cost allocated to the nitrogen.
3. Figure cost of nitrogen using $25.20 for 360 lb of N in each ton. Divide $25.20 by 360.
   $25.20 ÷ 360 = $0.07 or 7¢ per pound of N.

In an alternative method for example (D) one could assume a cost of N at 10¢ per lb in step (2) and proceed to figure the cost of the phosphate as follows:

1. Same as above in Example (D).
2. Assume 10¢ per lb for N.
   Then 360 X $0.10 = $36 per ton for value of nitrogen in the fertilizer.
   Then $108.00 minus $36 = $72.00 which is the cost allocated to the phosphate.

3. Figure the cost of the phosphate (P_2O_5) for 920 lb of P_2O_5 in each ton. Divide \$72.00 by 920.
   \$72 ÷ 920 = \$0.078 or 7.8¢ per lb of P_2O_5.

A similar procedure may be applied to other fertilizer materials containing nitrogen and phosphorus, zinc and sulfur, iron and sulfur, etc.

Cost Comparison Method:

Example (E) Liquid 7-21-7 @ \$75 per ton.

1. Multiply each percent of nutrient in fertilizer by 20.
   N 7 X 20 = 140 lb of N per ton
   P_2O_5 21 X 20 = 420 lb of P_2O_5 per ton
   K_2O 7 X 20 = 140 lb of K_2O per ton
2. From assumed costs of 10¢ for each pound of N, 9¢ for each pound of P_2O_5 and 5¢ for each pound of K_2O, one can calculate a tonnage cost with which to compare the actual price.

N	140 X \$0.10 =	\$14.00
P_2O_5	420 X 0.09 =	\$37.80
K_2O	140 X \$0.05 =	\$ 7.00
	Total	\$58.80

The calculated cost of \$58.80 per ton is less than the price per ton of \$75 used in example (E). From the calculations it appears the nutrient cost of 7-21-7 is actually greater than assumed costs by approximately 25%.

Example (F) Liquid 10-20-10 @ \$2.35 per gal.

Weight per gal is 11.8 or assumed to be 12 lb for purposes of simple calculation.

1. Multiply 12 lb by percent of nutrient content in fertilizer.
   12 X 0.10 = 1.2 lb of N per gal.
   12 X 0.20 = 2.4 lb of P_2O_5 per gal.
   12 X 0.10 = 1.2 lb of K_2O per gal.

2. From assumed cost of 10¢ for each pound of N, 9¢ for each pound of P_2O_5 and 5¢ for each pound of K_2O, one can calculate a gallon cost with which to compare the actual price of one gal of the fertilizer.

N	1.2 X \$0.10 =	\$0.12
P_2O_5	2.4 X \$0.09 =	\$0.216
K_2O	1.2 X \$0.05 =	\$0.06
	Total	\$0.396 or 40¢ per gal.

From the calculation in Example (F) it appears the cost of nutrients in the gallon of 10-20-10 liquid fertilizer is about six times the assumed costs of the individual nutrients.

Farmers who calculate fertilizer nutrient costs may conclude that it is more economical to purchase high analysis single nutrient fertilizers. It should be remembered that combining fertilizer nutrients together is often essential for row applied nutrients. Fertilizer nutrient availability or crop utilization of a nutrient under certain conditions is improved by combining two or more nutrients.

Micronutrient Fertilizers

While calculation based on the cost of a pound of nutrient received is an excellent method of comparing various nitrogen, phosphorus and potassium fertilizers, it may have little value in determining the most economical micronutrient source. A pound of nutrient in an unavailable form may be cheap on a per pound basis but very expensive in terms of supplying crop needs.

Micronutrient availability is related to water solubility, particle size and reactions that occur between the fertilizer and the soil minerals. The method of application, broadcast vs row applied, may greatly influence results.

Calculations for zinc fertilizers are similar to those used for fertilizers containing one nutrient and would be as follows:

Example (G) Zinc chelate @ \$2.75 per gal.

Other label information: (a.) Material weighs 11.2 lb per gal.

(b.) 6.0% of zinc.

1. Multiply weight per gal of material by percent of nutrient (Zn).
   11.2 X 6.0 = 0.67 lb of Zn per gal.
2. Divide $2.75 by 0.67 lb of Zn per gal.
   $2.75 ÷ 0.67 = $4.10 per lb of zinc.

Example (H) Zinc sulfate @ $12.50 per 100 lb.
Other label information: 36% Zn.

1. From information
   36 lb of zinc costs $12.50
2. Divide cost per 100 lb of fertilizer by pounds of nutrient. (Zn) per 100 lb
   $12.50 ÷ 36 = $ .347 or 34.7¢ per lb of zinc.

The above calculation indicates the zinc chelate costs $4.10 per lb of zinc compared to only $0.35 for zinc as zinc sulfate. This comparison is not justified because chelates are often more effective per unit weight of zinc than inorganic sources such as zinc sulfate.

The problem is that the increased effectiveness of chelates over inorganic sources is not a uniform ratio but depends on many factors such as degree of deficiency, crop or variety, climatic and soil conditions, method of application and stage of plant growth.

Under some conditions of acute zinc deficiencies chelates might be 10 times more effective than zinc sulfate in increasing crop yield, while under conditions of near normal plant growth the effectiveness of the two carriers of zinc may be more nearly equal.

In the above examples the zinc chelate would have to be nearly 12 times more effective than zinc sulfate to warrant the increased cost. Similar comparisons could be made where zinc sulfate is much more effective than some zinc sources of very low water solubility.

Since determining the value of micronutrient carriers depends on many factors, producers should contact their county agent for more specific information concerning local conditions.

Selecting The Most Economical Fertilizer Program

1. Obtain representative soil samples by proper sampling procedures.

2. Have your soil tested by a reputable laboratory that provides interpretation and recommendations based on calibrated soil tests

together with suitable crop and fertilizer histories and yield goals.

a. The only soil tests in Nebraska offering some degree of calibration with yield response are lime requirement, nitrogen, phosphorus, potassium and zinc. Much research needs to be done before soil tests for other nutrients can be recommended.

b. Plant analyses are helpful in identifying some nutrient deficiencies but are usually inadequate by themselves to make fertilizer recommendations.

3. Select the fertilizer formulation and method of application that provides the most nutrients for the least cost per acre consistent with recommendations. The cheapest is not always the best—but very nearly so.

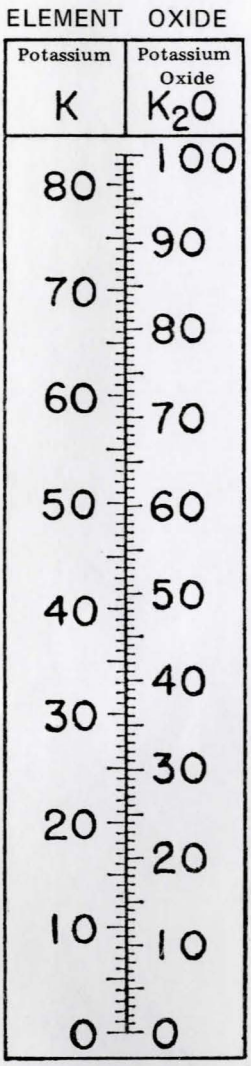
4. Constantly observe results. Always leave a small strip without fertilizer to see what responses can be observed.

5. When you don't know—**find out.** See your county agent or contact your University for more information. Many considerations must be taken into account when making a decision for purchasing fertilizer.

Cost of application is an important factor which can be a very sizable portion of the total cost. The time of application, kinds of nutrients, amount to be applied, how it is to be applied and availability of labor and equipment are influencing factors.

FERTILIZER CONVERSION SCALE

(POUNDS OR PER CENT)



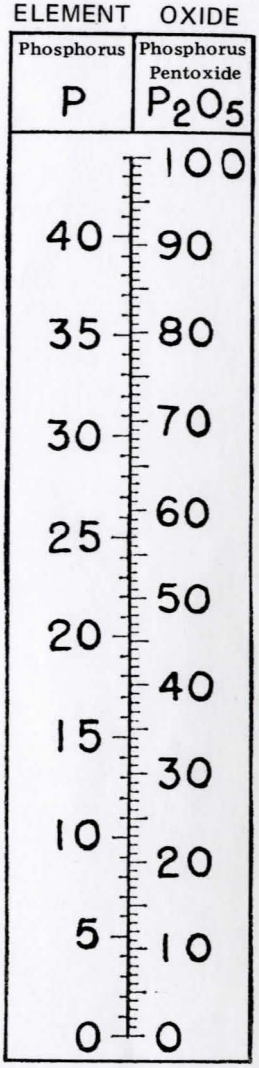


Table 1. Fertilizer conversion scale (pounds or percent).[1/]

[1/] J. A. Stritzel. 1963. Better Names For "Phosphate" And "Potash." Iowa Farm Science, Vol. 18, No. 2. Pages 22-24. Iowa State University, Ames, Iowa.