Agricultural Marketing Policy Center

B R I E F I N G

Briefing No. 115 **September 2014**

Navigating Fertilizer Terminology

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Objective Analysis For Informed Decision Making

Introduction

Decisions about crop nutrient requirements and fertilizer applications are among the most important made by agricultural producers each year. Those decisions influence crop yields, revenues, costs, and profitability and have short-, medium-, and long-term impacts on soil productivity. The three major plant nutrient decisions center on nitrogen (N), phosphorus (P), and potassium (K). Most common agricultural fertilizers contain one or more of these nutrients and, in many cases, others such as sulfur (S), boron (B), iron (Fe), chloride (Cl), copper (Cu), manganese (Mn) and zinc (Zn).

Soil tests provide important information for agricultural producers' fertilizer application decisions. Such tests quantify available nutrients contained in soils and provide recommendations about the potential effectiveness of fertilizer applications. Fertilizer recommendations are typically based on both soil test information that provide measures of nutrients currently available in soils and crop yield goals. Agricultural producers use these recommendations along with past experience, expected crop prices, fertilizer costs, and expected soil moisture levels for making fertilizer application decisions.

Today, fertilizer is generally purchased based on the units of each nutrient desired per acre.[1] A unit is a measure of nutrient pounds per acre and is different than the amount of a fertilizer product that is applied per acre. This briefing paper provides a pragmatic discussion of soil test reports and fertilizer recommendation terminology.

Soil Test Reports

Soil test reports are produced by both private and public laboratories and usually offer recommendations for nutrient requirements needed to obtain specific crop yields. Soil tests are conducted by trained technicians using specialized equipment. After obtaining a soil sample, plant-available elements such as nitrogen, phosphorus, potassium, and zinc are extracted from the sample and measured. The quantity of available nutrients in the sample is used as the basis for fertilizer recommendations.

Although soil test reports may vary in format, they generally provide similar information. Figure 1 presents a typical soil test report from Montana State University's Department of Land Resources and Environmental Sciences. The report contains:

(A) Producer information, field location, and sample identification.

[1] This briefing paper will refer to units of nutrient applied as "nutrient pounds per acre" to differentiate from "pounds of products" applied per acre.

FIGURE 1. Sample Soil Test Report and Fertilizer Recommendations

Name: Producer
Sample Date: April 1, 2007
Lab Number: 12345
Your Sample Number: 1
Crop to be Grown: Spring Wheat
Previous Crop: Fallow
Sampling Depth: 0 to 24 inches
Yield Goal: 50 bu/acre

A	B Soil Test Results			C Interpretation	D Recommendation
	Nitrate - N	0-6 in [2]	37 lb/acre		
		6-24 in	36 lb/acre		
		0- 24 in	73 lb/acre	Medium	90 lb N/acre
	Olsen Phosphorus	0-6 in	15 ppm	Medium	20 lb P_2O_5/acre
	Potassium	0-6 in	192 ppm	Medium	40 lb K_2O/acre
	Sulfate -S	0-6 in	6 lbs/ acre		
		6 24 in	54 lb/acre		
		0 – 24 in	60 lb/acre	High	----------
	Boron	0-6 in	0.5 ppm	Medium	1 lb B/acre
	Copper	0-6 in	1.7 ppm	Very High	----------
	Iron	0-6 in	47 ppm	Very High	----------
	Manganese	0-6 in	10 ppm	Very High	----------
	Zinc	0-6 in	1.3 ppm	High	----------
	Soluble Salts	0-6 in	0.3	Low	----------
	Organic Matter	0-6 in	3.4%	Medium	----------
	Soil pH	0-6 in	7.7	Medium/High	----------
	CEC	0-6 in	17.8	Medium	
	Soil Texture	0-6 in	Sandy Loam		

Source: http://landresources.montana.edu/soilfertility/PDF/pub/InterpSoilTestMT200702AG.pdf

This includes a list of crops and yield goals for which an agricultural producer requested fertilizer recommendations.

(B) Results from a soil test typically include salinity (measured as electrical conductivity), pH, organic matter (O.M.), measures of primary nutrients (i.e. N, P, and K), and, sometimes, secondary nutrients such as sulfur, calcium, and magnesium, or micronutrients such as boron and zinc.

For example, in the soil test report from Figure 1, soil sampled between zero and six inches deep was reported to have 37 pounds of available nitrate per acre (lb N/acre). In most cases, nitrogen soil tests measure available nitrate (NO_3^-) rather than available ammonium (NH_4^+) because ammonium levels are typically much lower than nitrate levels. The N tests, therefore, show current nitrogen availability but those levels can change as nitrate is leached as a result of rainfall or irrigation.

(C) A rating system helps producers interpret test results and evaluate the relative benefits of additional fertilizer application.

In the sample report, each soil test level category indicates the relative amount of nutrient in the soil (figure 1). A low soil test level indicates that there is a *high* potential for

[2] This represents the soil depth at which the sample was taken. See the following link for information on how to collect the proper soil samples. http://landresources.montana.edu/soilfertility/PDF/pub/InterpSoilTestMT200702AG.pdf

substantial yield responses from fertilizer applications whereas a high soil test level indicates a *low* potential for substantial yield responses from fertilizer applications.

(D) Fertilizer application recommendations are based on soil sample results, the previous crop produced on the field, the intended crop, yield goals specified by a farmer based on yield history and, sometimes, water availability. Recommendations are provided in terms of the actual amounts of nutrients in pounds per acre rather than a total amount of fertilizer product or materials to be applied.

These recommendations are guidelines, and specific field recommendations can be obtained through consultation with local Extension agents or crop advisors.[3]

Determining the Quantity of Nutrients in Fertilizers

Fertilizer nutrient concentrations are regulated by various Federal and State agencies, including the Environmental Protection Agency and State Departments of Agriculture. The proportions of nitrogen, phosphorus, and potassium in a particular fertilizer are presented as percentages of each primary
nutrient that are available to crops. Phosphorus is referred to as P_2O_5 in fertilizer products.[4] Potassium is often referred to as potash (potassium chloride or KCl) and is listed as K_2O in fertilizer products.[5]

The interpretation of nutrient grades (i.e., 11-52-0) for typical fertilizers purchased by home gardeners and commercial agricultural producers are similar.

Home Gardeners:

Figure 2 presents a typical label for a blended, granulated fertilizer product with a fertilizer grade of 5-10-15 that might be purchased by a home gardener. The grade indicates that the fertilizer product contains 5 percent nitrogen, 10 percent P_2O_5, and 15 percent K_2O. Therefore, a 50 pound bag of 5-10-15 fertilizer contains 2.5 pounds of actual nitrogen (50 lbs x 0.05), 5 pounds of P_2O_5 (50 lbs x 0.10), and 7.5 pounds of K_2O (50 lbs x 0.15).

Figure 2: Fertilizer Labels

Source: Fertilizer 101

Agricultural Producers:[6]

Agricultural producers are likely to purchase fertilizer by the ton. For these producers, nutrient grades provide similar information as bagged fertilizer purchased by home gardeners. For example, MAP (monoammonium phosphate) has a fertilizer grade of 11-52-0. This grade indicates that the fertilizer contains 11 percent nitrogen, 52 percent P_2O_5, and 0 percent K_2O. A ton of MAP contains 220 pounds of nitrogen (2,000 lbs x 0.11) and 1,040 pounds of P_2O_5 (2,000 lbs x 0.52). For fertilizers that contain sulfur (S), a 4th number is often added (e.g. 21-0-0-24S).

Note that the percentages do not add to 100, and the pounds of primary nutrients in one ton do not add up to 2,000 pounds. This is because fertilizer products contain additional compounds (e.g., oxygen and carbon), secondary nutrients (e.g., calcium), micronutrients and, to a small degree, filler materials that are used to form granules or prills that prevent deterioration during transport and application. For example, urea ($CO(NH_2)_2$) consists of 46 percent nitrogen; the remaining 54 percent consists of carbon oxygen and hydrogen. Table 1 presents nutrient concentrations for several widely used fertilizer products.[7]

[3] Recommendations may need to be adjusted based on specific locations due to the high degree of variability throughout the state of Montana and between labs. Please see the link below and contact your local Extension agent or crop adviser for specific recommendations.
[4] P_2O_5 is historically referred to as the amount of available phosphate in the fertilizer abbreviated in figure 2 as simply "P".
[5] Although the convention is to call potash "K_2O", potash fertilizer actually contains potassium chloride or KCl.
[6] For liquid fertilizers, solution densities determine nutrient concentrations by weight rather than volume.
[7] Note that the analysis can be slightly varied for different manufacturing processes.

Nutrient recommendations and subsequent producer decisions about the agronomic and financial benefits of applying crop nutrients must be converted into fertilizer application rates. The conversion requires: (1) a content analysis of the selected granular fertilizer product, or (2) information on the density of liquid fertilizer products. In both cases, however, the amount of fertilizer *material* applied per acre differs from the amount of fertilizer *nutrients* being applied per acre because fertilizer products contain additional chemical compounds, secondary nutrients, and additives. For example, a decision to apply 100 pounds of actual nitrogen per acre is referred to as the application of 100 *units* of nitrogen. The total material weight used to deliver 100 units of nitrogen will be much larger and is referred to as "pounds."

For example, suppose a producer wants to apply 100 units of nitrogen per acre (that is, 100 pounds of actual nitrogen nutrient). If the nitrogen is to be applied using a granulated urea product (which contains 46 percent nitrogen), then the calculation of the total pounds of the urea product or material that is required per acre becomes:

$$\begin{aligned} Total\ pounds\ of\ Material &= \frac{required\ units\ of\ nitrogen}{fraction\ of\ nutrients\ in\ product} \\ &= \frac{100\ units\ per\ acre}{0.46} \\ &= 217\ pounds\ of\ urea\ \ product\ per\ acre \end{aligned}$$

Similarly, suppose a producer wants to apply 25 units of nitrogen per acre using a liquid fertilizer such as UAN. The exact percentage of nitrogen in UAN products varies between 28 and 32 percent. Assume that the selected UAN product contains 30 percent nitrogen, which means that each pound of liquid fertilizer contains 0.30 pounds of actual nitrogen. In addition, each gallon of UAN weighs 10.86 pounds.

The UAN liquid product, therefore, contains 3.26 pounds of nitrogen in every gallon of product (10.86 pounds/gallon x 0.30 pounds of nitrogen). Using the above formula, 7.7 gallons per acre (25 units/3.26 units per gallon) of the UAN product would be needed to deliver 25 units of nitrogen per acre.

Summary

Soil tests are important tools for making fertilizer application decisions. Agricultural producers use these tests along with expert recommendations, personal experience, expected crop yield responses, yield goals, expected crop prices, fertilizer prices, and current and expected moisture conditions when making such decisions. Fertilizer application decisions are often made in the form of nutrient units (i.e., pounds of nutrients) to be applied per acre. Fertilizer dealers convert those orders into the amount of material that must be applied per acre to meet the nutrient requirements. Since fertilizer products contain different percentages of those nutrients, conversion rates vary depending on the fertilizer product being purchased.

Table 1. An Analysis of Common Fertilizers

Material	Analysis	N (%)	P_2O_5 (%)	K_2O (%)
Ammonium nitrate	34-0-0	34	0	0
Ammonium sulfate*	21-0-0-24S[8]	21	0	0
Diammonium phosphate	18-46-0	18	46	0
Potassium chloride (muriate of potash)	0-0-60	0	0	60
Potassium sulfate**	0-0-50-16S	0	0	50
Potassium magnesium sulfate***	0-0-22-23S-11Mg	0	0	22
Triple super phosphate	0-46-0	0	46	0
Urea	46-0-0	46	0	0

[8] When present, levels of micronutrients such as boron or sulfur will also be listed on fertilizer labels.

References

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