

Lesson C8–2

Determining Fertilizer Formulations

Unit C. Plant and Soil Science

Problem Area 8. Soil Fertility and Moisture Management

Lesson 2. Determining Fertilizer Formulations

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: I: Apply principles of anatomy and physiology to produce and manage plants in both a domesticated and natural environment.

Benchmark: I-A. Analyze and evaluate nutritional requirements and environmental conditions to develop and implement a fertilization plan.

Performance Standard: 5. Apply nutrients to plants for economic growth.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Explain the development of a nutrient management plan.
2. Describe organic and inorganic fertilizers.
3. Explain fertilizer analysis, grade, and ratio.
4. Explain the mixing of fertilizers.
5. Describe the selection of fertilizers.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Lee, Jasper and Biondo, Ron. *Introduction to Plant and Soil Science & Technology*, 2nd Edition. Danville, Illinois: Interstate Publishers, Inc. 2003 (Textbook, Chapter 9)

Soil Fertility Manual. Norcross, Georgia: Potash & Phosphate Institute. 1996 (Manual, Chapters 1 & 2)

Cooper, Elmer L. and Burton, L. DeVere. *Agriscience Fundamentals & Applications*. Albany, New York: Delmar. 2002 (Unit 9)

Plaster, Edward J. *Soil Science and Management*. Albany, New York: Delmar. 1992 (Chapter 13)

Other Resources. The following resources will be useful to students and teachers:

Waldren, Richard P. *Introductory Crop Science*. Edina, Minnesota: Burgess International Group, Inc. 1992

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheets
Examples of fertilizers

Terms. The following terms are presented in this lesson (shown in bold italics):

Bulk blending
Complete fertilizers
Fertilizer
Fertilizer analysis
Fertilizer grade
Fertilizer ratio
Fillers
Inorganic fertilizers
Mixed fertilizers
Nutrient management plan
Organic fertilizer
Single-grade fertilizer

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Display examples of fertilizers of different types. Ask students to identify the differences they observe. Direct the discussion towards the plant nutritional value.

Summary of Content and Teaching Strategies

Objective I: Explain the development of a nutrient management plan.

Anticipated Problem: How is a nutrient management plan developed?

- I. Nutrient management planning is an effort to balance necessary soil fertility levels with environmental protection.
 - A. A **nutrient management plan** identifies the amount, source, time of application, and placement of each nutrient needed to produce the crop grown in a given field each year.
 1. Objectives of a nutrient management plan are to optimize efficient use of all sources of nutrients and to minimize the potential for plant nutrients to degrade water and soil quality. Includes soil reserves, commercial fertilizer, legume crops, and organic sources such as manure, industrial waste, or municipal waste for crop production.
 2. Recognize sensitive areas within fields that require special nutrient management precautions to avoid environmental contaminations. Those areas include sinkholes, wells, drainage ditches, lakes streams, and highly erodible land.
 - B. A four-year plan, with changes being made after new soil tests have been taken, is most effective. The steps involved in developing a nutrient management plan are:
 1. Assess the natural nutrient sources, soil reserves, and legume contributions.
 2. Identify field or areas with fields that require special nutrient management precautions.
 3. Assess nutrient need for each field by crop.
 - C. Determine the quantity of nutrients that will be available from organic sources, such as manure, industrial, or municipal wastes.
 1. Allocate nutrients available from organic sources.
 2. Calculate the amount of commercial fertilizer needed for each field.
 3. Determine the ideal time and method of application.
 4. Select nutrient sources that will be most effective and convenient for the operation.

Use TM: C8–2A, C8–2B, and C8–2C as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts.

Objective 2: Describe organic and inorganic fertilizers.

Anticipated Problem: What are organic and inorganic fertilizers?

- II. Agricultural crops use the nutrients that are held in the soil. As crops are harvested and removed from the land, nutrients are removed with the plant tissues. To maintain high yields, nutrients must be added to the soil.
- A. A **fertilizer** is an organic or inorganic material applied to soils or water, which provide nutrients that increase plant growth, yield, and nutritional quality.
1. An **organic fertilizer** is organic material that releases or supplies useful amounts of a plant nutrient when added to a soil.
 2. Fertilizers can originate as plant or animal tissue and includes animal manures and compost made with plant or animal products. Organic commercial fertilizers include dried and pulverized manures, bone meal, slaughterhouse tankage, blood meal, dried and ground sewage sludge, cottonseed meal and soybean meal.
- B. Characteristics of organic fertilizers:
1. Nitrogen is usually the predominating nutrient with lesser quantities of phosphorus and potassium. One exception is bone meal in which phosphorus predominates and N is a minor ingredient.
 2. Nutrients are only made available to plants as the material decays in the soil, so they are slow acting and long lasting.
 3. Organic materials alone are not balanced sources of plant nutrients, and their analysis in terms of the three major nutrients is generally low. They contribute to the organic matter content in the soil.
 4. The material is bulky and the exact amount of fertilizer applied is difficult to measure.
- C. **Inorganic fertilizers** are those from a non-living source, and included various mineral salts, which contain plant nutrients in combination with other elements.
1. Inorganic fertilizer is manufactured in dry, liquid, or gaseous forms.
 2. Characteristics of inorganic fertilizers that are different from organic fertilizers.
 3. Nutrients are in a soluble form and are quickly available for plant use.
 4. The soluble nutrients make them caustic to growing plants and can cause injury. Care must be used in applying to growing crops so as not to come in contact with the roots or remain on plant foliage for any length of time. Analysis of chemical fertilizer is relatively high in terms of the nutrients they contain.

Use TM: C8–2D as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Unit 9 in *Agriscience Fundamentals and Applications*, Chapter 9 in *Fundamentals of Soil Science*, Chapter 9 in *Introduction to Plant and Soil Science*, and Chapter 13 in *Soil Science and Management* are recommended.

Objective 3: Explain fertilizer analysis, grade, and ratio.

Anticipated Problem: What is fertilizer analysis, grade, ratio, elements, and oxides?

III. It is important to know the nutrient content of a fertilizer in order to apply the recommended amount.

- A. **Fertilizer analysis** lists the fertilizer elements in the bag and their percent content.
1. This list could include any of the 13 mineral elements.
 2. The percentage of the three macronutrients is always listed on the fertilizer label in the same order. They appear as nitrogen, phosphoric acid, and potash.
 3. Additional information may also be found in the analysis, like the percent of nitrogen that is ammoniacal and the percent which is nitrate.
 4. Some fertilizers, especially those blended for turf, may contain nitrogen sources that dissolve slowly. These will be identified as water-insoluble nitrogen (WIN) or slow-release nitrogen (SRN).
- B. All bags of fertilizer should show the **fertilizer grade** which indicates the primary nutrient content of the fertilizer.
1. Grade lists the content as a sequence of three numbers that tell, in order, the percentage of nitrogen (N), phosphate (P_2O_5), which is also called phosphoric acid, and potash (K_2O).
 2. Grade may also identify a secondary nutrient as a fourth number in the traditional N–P–K. For example, calcium nitrate may carry the grade 15–0–0–30Ca, meaning the material is 30 percent calcium. Similarly, one may find sulfur (S) or magnesium (Mg) as a fourth number.
 3. Fertilizer grades never total 100 percent. A 10–10–10 fertilizer is 30 percent nutrient and 70 percent other ingredients. The remainder of the fertilizer is the weight of the other elements that are part of the carrier, such as hydrogen and oxygen.
 4. A small percentage of fertilizer is filler and conditioner. **Fillers** may be sand, clay granules, ground limestone, or ground corn cobs and are used to bring a load of bulk fertilizer to a weight of one ton. Conditioners improve the quality of the fertilizer and make it easier to use.
- C. **Fertilizer ratio** states the relative amounts of nitrogen, phosphate, and potash in fertilizers. Ratios are useful when comparing two fertilizers.

Examples	Grade	Ratio
a	10–10–10	1–1–1
b	20–20–20	1–1–1
c	6–12–12	5–15–30
d	5–15–30	1–3–6

Examples (a) and (b) have the same ratio. This means that one fertilizer can be used in place of the other. Applying one ton of 10–10–10 is the same as applying ½ ton of 20–20–20.

Being able to obtain fertilizers of different ratios is very useful. The grower simply selects a fertilizer with the ratio recommended by soil test reports. If the test report recommends 100 pounds of nitrogen, 50 pounds of phosphate, and 75 pounds of potash per acre, a single fertilizer with the ratio of 4–2–3 would be ideal.

- D. The way fertilizer grade is listed leads to some confusion. Most people think of fertilizer grade as N–P–K; nitrogen, phosphorus, and potassium. Actually, nitrogen is listed as the element, but the other two nutrients are listed in their oxide forms. The true grade should be listed as N–P₂O₅–K₂O, which is read as nitrogen, phosphoric acid, and potash.
1. Consider the fertilizer 20–10–10, the numbers would seem to mean that there are 200 pounds of phosphorus in a ton of this fertilizer. Actually one ton contains only 88 pounds of phosphorus. The amounts of nutrients in a ton of 20–10–10 can be listed in the elemental and oxide forms:

	Oxide	Elemental
N	400	400
P	200	88
K	200	166

2. When reading soil test reports or other recommendations, always check to see which form is being used. To convert between the amounts of phosphorus/phosphoric acid, and potassium/potash, the following formulas are used:

$$P \times 2.29 = P_2O_5$$

$$P_2O_5 \times 0.44 = P$$

$$K \times 1.2 = K_2O$$

$$K_2O \times 0.83 = K$$

Use TM: C8–2E as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Unit 9 in Agriscience Fundamentals and Applications, Chapter 9 in Fundamentals of Soil Science, Chapter 9 in Introduction to Plant and Soil Science, and Chapter 13 in Soil Science and Management are recommended.

Objective 4: Explain the mixing of fertilizers.

Anticipated Problem: How are fertilizers mixed?

- IV. Growers can apply a fertilizer that contains a single nutrient, which would mean a fertilization operation for each nutrient.
 - A. It would be more convenient to use fertilizers that contain several nutrients.

1. A fertilizer containing only one element is called a **single-grade fertilizer**.
 2. Many fertilizers contain two or three nutrients and are called **mixed fertilizers**.
 3. **Complete fertilizers** have all three of the primary elements but that does not mean that all 13 mineral nutrients are included.
 4. To determine the amount of each nutrient in a complete fertilizer, the percentage of the nutrient is multiplied by the weight of the fertilizer. For example, in a 50 pound bag of 20–10–10:

Nitrogen = 50 pounds \times 20 percent/100 = 10 pounds

Phosphate = 50 pounds \times 10 percent/100 = 5 pounds

Potash = 50 pounds \times 10 percent/100 = 5 pounds
- B. Growers may buy a premixed fertilizer, but a limited number of ratios are available. Fertilizer can be custom blended to mix carriers to obtain the analysis and ratio that best suits the needs of the grower.
1. **Bulk blending** is physically mixing solid fertilizer materials into multinutrient mixtures.
 2. Fertilizer bulk-blending plants provide a convenient and economical means of mixing dry fertilizer materials to produce specified ratios and grades of varying nutrient percentages
 3. A principle asset of blending is the ability of the blender to produce an unlimited number of ratios and grades to suit individual needs. The reasons blending is attractive are economy, versatility, and convenience.
 4. The finished raw materials of nitrogen, phosphate, and potassium fertilizers can be produced in large economic plants in different areas and combined in the market area.
 5. Practically any grade or ratio can be produced.
 6. Bulk-spreader truck can carry freshly blended material directly to field. No bagging or storage of fertilizers or farmer labor is required.
 7. The disadvantages of bulk blending are materials must have approximately the same particle size and be chemically compatible.

Use text material to strengthen student understanding of concepts. Unit 9 in Agriscience Fundamentals and Applications, Chapter 9 in Fundamentals of Soil Science, Chapter 9 in Introduction to Plant and Soil Science and Chapter 13 in Soil Science and Management are recommended.

Objective 5: Describe the selection of fertilizer.

Anticipated Problem: How are fertilizers selected?

- V. Growers can choose from a wide variety of fertilizers.

- A. Factors influencing the selection include the crop to be fed, the time of year, the application method, and the cost. For most crops, the form of the fertilizer is not critical. The form absorbed will depend somewhat on the weather conditions.
1. Plants absorb both the nitrate and ammonium nitrogen. But the preference is the nitrate form. However, under warm moist conditions, ammonium ions will nitrify to nitrate nitrogen in four to six weeks. For that reason, ammonium and nitrate usually have the same effect on crop growth. On the other hand, nitrates are lost more easily from the soil.
 2. Growers need to be concerned with crop sensitivity to certain elements and about a fertilizer's affect on soil pH or salinity. The selection of fertilizers commonly depends upon the price, the least costly fertilizer per pound of plant food is the one commonly selected.

Use text material to strengthen student understanding of concepts. Unit 9 in Agriscience Fundamentals and Applications, Chapter 9 in Fundamentals of Soil Science, Chapter 9 in Introduction to Plant and Soil Science, and Chapter 13 in Soil Science and Management are recommended.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used to determine which objectives need to be reviewed or taught over with a different approach. Questions provided in the recommended textbooks may also be used to help in the review.

Application. Application can involve student activity with the provided labs.

Evaluation. Evaluation should focus on student achievement of the objectives for each lesson. Various techniques can be used, such as performance on the application activities. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1 = d, 2 = a, 3 = c, 4 = g, 5 = b, 6 = f, 7 = e

Part Two: Completion

1. Fertilizer
2. Fertilizer analysis
3. Nutrient management plan
4. Organic fertilizer
5. ratios, grades

Part Three: Short Answer

1. Factors influencing fertilizer selection include the crop to be fed, the time of year, the application method, and the cost.
2. Materials must have approximately the same particle size and be chemically compatible.

Test

Lesson C8–2: Determining Fertilizer Formulations

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- | | |
|------------------------|----------------------------|
| a. Bulk blending | e. Fertilizer ratio |
| b. Complete fertilizer | f. Inorganic |
| c. Conditioners | g. Single-grade fertilizer |
| d. Fertilizer grade | |

- _____ 1. Indicates the primary nutrient content of the fertilizer.
- _____ 2. Physically mixing solid fertilizer materials into multinutrient mixtures.
- _____ 3. Improve the quality of the fertilizer and make it easier to use.
- _____ 4. A fertilizer containing only one element.
- _____ 5. Contain all three of the primary elements but not necessarily all 13 mineral nutrients.
- _____ 6. Fertilizer from a non-living source.
- _____ 7. States the relative amounts of nitrogen, phosphate and potash in fertilizers.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. _____ is an organic or inorganic material applied to soils or water, which provide nutrients that increase plant growth, yield, and nutritional quality.
2. _____ lists the fertilizer elements in the bag and their percent content.
3. _____ identifies the amount, source, time of application, and placement of each nutrient needed to produce the crop grown in a given field each year.
4. _____ is organic material that releases or supplies useful amounts of a plant nutrient when added to a soil.
5. A principle asset of blending is the ability of the blender to produce an unlimited number of _____ and _____ to suit individual needs.

NUTRIENT AVAILABILITY AND REQUIREMENTS FOR INDIVIDUAL FIELDS

Farm name: _____ Year: _____

	Units	A	B	C	D	E
Field size	Acres	160	80	160	160	320
Soil type		Drummer	Flanagan	Drummer	Drummer	Flanagan
Special nutrient precautions		Yes No				
Crop		Corn/Soybean	Soybean/Corn	Corn/Soybean	Soybean/Corn	Corn/Soybean
Yield	bu/a	135/46	62/170	155/54	51/148	168/58
Previous crop		Soybean	Corn	Soybean	Corn	Soybean
Lime	ton/a		4		5	3
Phosphate (P₂O₅)						
Buildup	lb/a	0	50	16	72	40
Maintenance	lb/a	58/39	53/73	67/46	43/64	72/49
Total	lb/a	97	226	145	251	201
Potassium (K₂O)						
Buildup	lb/a	0	50	0	65	40
Maintenance	lb/a	38/60	80/48	0/0	66/41	47/75
Total	lb/a	98	228	0	237	202
N requirement						
Corn	lb/a	162	204	186	178	202
Wheat	lb/a					
Forage crop	lb/a					
Legume N contribution						
Alfalfa	lb/a					
Clover	lb/a					
Soybean	lb/a	40		40		40

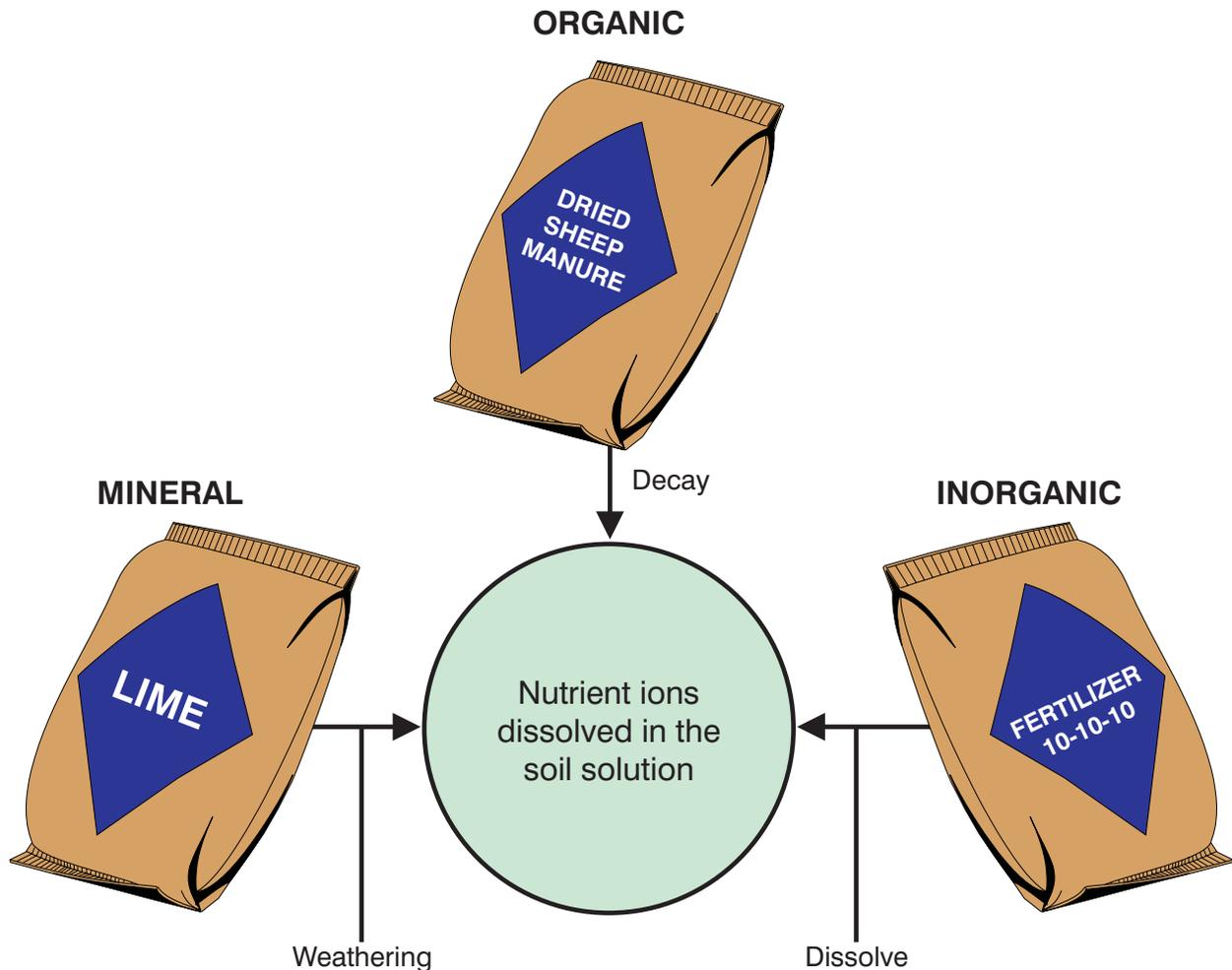
NUTRIENT AVAILABILITY FROM ORGANIC SOURCES

Product	Quantity	Nutrient Analysis, lb/l,000 gal., or lb/ton			First Year Availability Coefficient, %			Available Nutrient Quantity, lb		
		N	P ₂ O ₅	K ₂ O	P ₂ O ₅	N	K ₂ O	P ₂ O ₅	N	K ₂ O
Manure	2,650,000	36	25	22	50	80	85	47,700	53,000	49,555
Manure										
Manure										
Sewage sludge										
Industrial by-product										

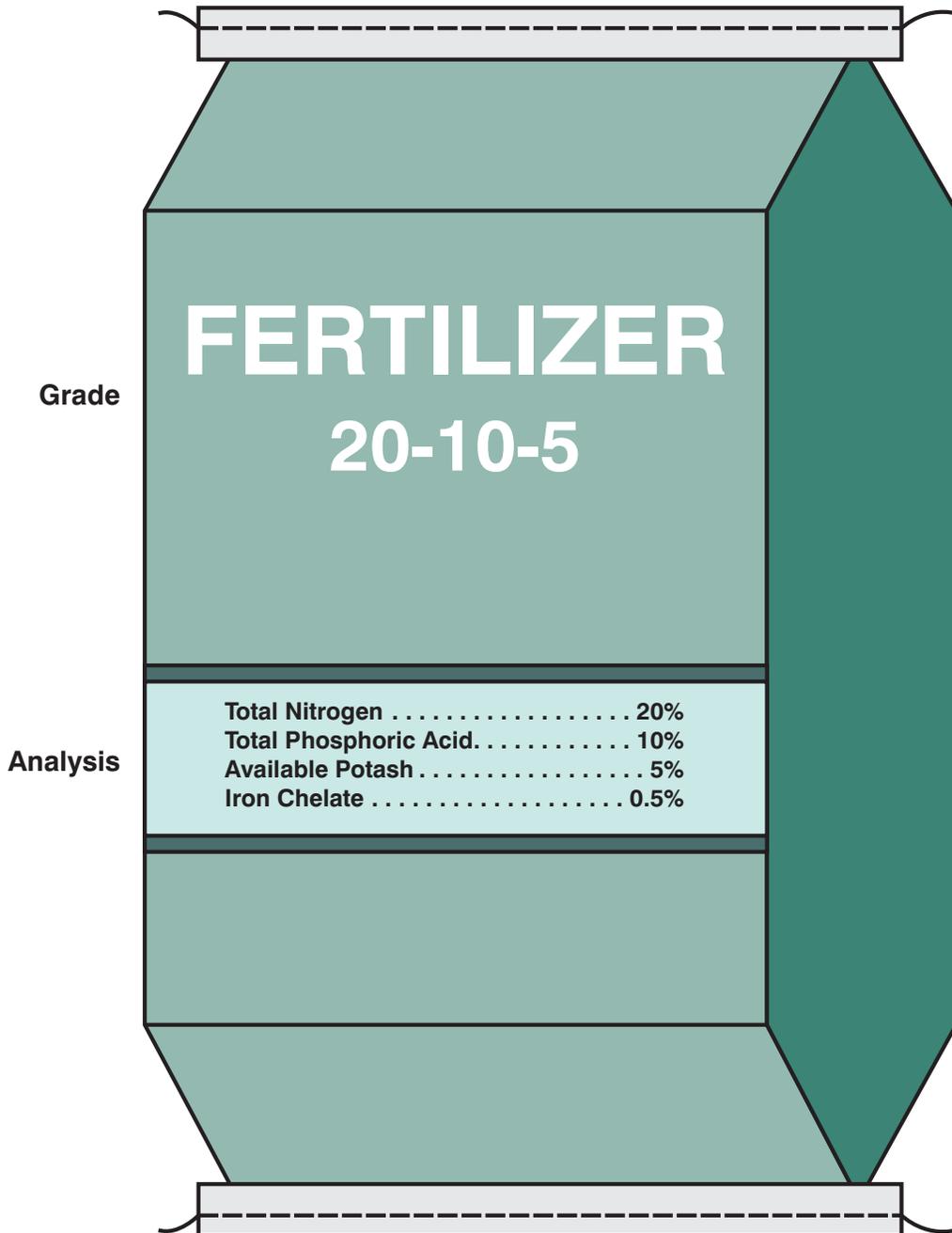
NUTRIENT APPLICATION PLAN FOR SAMPLE FARM

Field	A		B		C		D		E	
Source	Fall	Spr/SD	Fall	Spr/SD	Fall	Spr/SD	Fall	Spr/SD	Fall	Spr/SD
	lb/acre									
N requirement	162				186				202	
Manure									149 (8,300 gal./acre)	
DAP										
Starter										
Previous crop	40								40	
Ammonia	122									
UAN						186				13
Urea										
AS										
Total N	162				186		251		202	
P requirement	97		226		145				201	
Manure									165	
DAP										
CSP			60				90			
Starter										
Total (P ₂ O ₅)	0/-97		60/-166		0/-145		90/-161		165/-36	
K requirement	98		228		0		237		202	
Manure									155	
Starter										
KCl			120				90			
Total K ₂ O	0/-98		120/-108		0/0		90/-147		155/-47	
Lime (ton/acre)										

DISSOLUTION OF FERTILIZERS RELEASES NUTRIENT IONS FOR PLANTS



GRADE AND ANALYSIS ARE LISTED ON FERTILIZER BAGS



Lab Sheet

Determining the Amounts of Nutrients in a Fertilizer

Directions:

Given the following information, answer the problems that follow.

$$\text{Amount of nutrient} = \text{weight of fertilizer} \times \text{percentage}/100$$

1. How much potash is in a 50-pound bag of 0-0-45? _____ pounds of potash.
2. How much phosphate is in a one-ton mix of 0-60-0? _____ pounds of phosphate.
3. Determine the amount of each nutrient in a 50-pound bag of complete fertilizer with a grade of 10-34-12?
_____ pounds of nitrogen.
_____ pounds of phosphate.
_____ pounds of potash.
4. Do the pounds of individual nutrients added together equal the total pounds of the bag?
_____ Explain why this is so.
5. Use the following information to convert between the amounts of elements or oxides:
 - a. $P \times 2.29 = P_2O_5$
 - b. $P_2O_5 \times 0.44 = P$
 - c. $K \times 1.2 = K_2O$
 - d. $K_2O \times 0.83 = K$Pound = Weight of fertilizer \times percentage/100 \times conversion factor.
6. Determine how much actual potassium is contained in one ton of 0-0-60?

Lab Sheet

Determining the Calculations for Mixing Fertilizers

Directions:

Given the following information, answer the problems that follow it.

To blend fertilizers, it is necessary to determine how much of each carrier is needed to produce the final mixed fertilizer. The following formula can be applied to each of the carriers:

$$Z = A \times B/C$$

Where:

Z = pounds of carrier for each element

A = pounds of mixed fertilizer needed

B = percentage of the element needed

C = percentage of the element in the carrier

Determine how a ton of 10-10-20 can be blended from the following carriers:

Ammonium nitrate 33-0-0

Treble superphosphate 0-46-0

Muriate of potash 0-0-60

1. _____ = pounds of Ammonium nitrate.
2. _____ = pounds of Treble superphosphate.
3. _____ = pounds of Muriate of potash.
4. _____ = total pounds of carrier.
5. _____ = pounds of filler.

Lab Sheet

Selecting Fertilizers

Directions:

Given the following information, answer the problems that follow it.

The cost of a fertilizer can be calculated as follows:

$$\text{Price per pound} = \text{Price of fertilizer} / \text{weight of fertilizer} \times \text{percentage} \times 100$$

1. Determine the price for nitrogen in a ton of ammonium nitrate (33–0–0) that costs \$200.

2. Determine the price for phosphorus in a 50 pound bag of treble superphosphate (0–46–0) that costs \$12.