UNIT III - SOIL FERTILITY AND MANAGEMENT

Lesson 4: Fertilizing Soils

**Competency/Objective:** Identify fertilizers and the applications needed to obtain optimal crop performance.

**Study Questions**

1. What are the various types of fertilizers?
2. What are the forms of fertilizer?
3. Where can fertilizer formulations be obtained?
4. What are the different application techniques?
5. When should fertilizer be applied?
6. How are fertilizer application rates calculated?

**References**

1. *Advanced Crop Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2000, Unit III.
2. Activity Sheet
   a) AS 4.1: Calculating Fertilizer Needs and Cost
UNIT III - SOIL FERTILITY AND MANAGEMENT

Lesson 4: Fertilizing Soils

TEACHING PROCEDURES

A. **Review**

The previous lessons reviewed the composition of the soil and how important nutrients are to maintaining healthy soil. Nutrients are easily used up or lost due to cultivation, topsoil erosion, and crop harvesting. These nutrients have to be replenished through fertilization. This lesson will review forms of fertilizer and the factors involved with the application of fertilizer.

B. **Motivation**

Present a bag of fertilizer to the class and point out the ingredients found on the bag. Determine if the bag lists application techniques and safety warnings to be observed.

C. **Assignment**

D. **Supervised Study**

E. **Discussion**

1. Discuss the various types of fertilizers including mineral fertilizers, organic fertilizers, and chemical (inorganic) fertilizers that can be applied to soils to supply the nutrient elements needed for optimum plant growth.

What are the various types of fertilizers?

a) Mineral fertilizers - rocks containing nutrients that are ground up and applied to the soil
   1) Limestone
      (a) Used to neutralize soil acidity
      (b) Good source of calcium, magnesium, and sulfur
   2) Phosphorus
      (a) Commonly phosphate rock (PO$_4$)
      (b) Processed into soluble fertilizer sources
      (c) Used only on soils with a definite phosphorus shortage

b) Organic fertilizers - plant or animal tissues that have become waste materials
   1) Plant residue, animal manure, bone, cottonseed, and soybean meal, and biosolids (sewage sludge)
   2) Advantages
      (a) Slow-releasing nutrients are less likely to cause root damage.
      (b) Organic wastes are long lasting.
      (c) Source of live bacteria needed to convert natural soil minerals and chemical fertilizers into useable forms for plants.
   3) Disadvantages
      (a) Low in major nutrients
      (b) Bulky material
      (c) Difficult to measure exact amount of fertilizer to apply

b) Chemical (inorganic) fertilizers - manufactured from a nonliving source
   1) Formulations of nitrogen (N), phosphorus (P), and potassium (K)
   2) Advantages
(a) Higher proportion of useable nutrients than mineral or organic fertilizers
(b) More readily soluble and immediately available for plant use
(c) Easier to measure

3) Disadvantages
(a) They are more costly.
(b) Errors in application can damage crops and the environment.

2. Discuss the various forms in which fertilizers can be purchased and how they are applied. Include in the discussion the placement of the fertilizer, whether they are surface applied or injected into the soil, and how this affects plant growth.

**What are the forms of fertilizer?**

a) Fluid
   1) Nutrients in true liquids are completely dissolved.
      (a) Sprayed or dribbled directly on soil or plant surfaces
      (b) Injected into the soil
      (c) Mixed with irrigation water
   2) Suspension fertilizers are mixtures of liquids and finely divided solids.
      (a) Solids redispersed by easily agitating to give a uniform mixture
      (b) Applied to the soil surface

b) Pressurized liquids
   1) Injected directly into the soil from tanks
   2) Adheres to the moisture in the soil

c) Dry
   1) Applied mechanically or absorbed into soil through rainfall
   2) Available in powders, granules, or prills
   3) Can be mixed with liquid and applied as a fluid fertilizer

b) Pressurized liquids
   1) Injected directly into the soil from tanks
   2) Adheres to the moisture in the soil

d) Slow release
   1) Dissolve into the soil slowly
   2) Available in dry or liquid form
   3) Most commonly used in horticulture or vegetable production

3. Review how the proportions of nitrogen, phosphorus, and potassium are expressed on a fertilizer bag. Include how to figure the total pounds of each active ingredient. This information will help the student understand how bulk fertilizers are mixed. Chemical fertilizer dealers will have trained personnel who will mix and apply the fertilizer, but the producer should understand the product purchased. Complete AS 4.1 to help students understand a fertilizer bill of sale. If more detailed information is needed, obtain the Farmland Soil Fertility Manual available for free loan from MRCCTE.

**Where can fertilizer formulations be obtained?**

a) Complete commercial fertilizer mixtures contain nitrogen (N), phosphorus (P), and potassium (K).
   1) Proportions known as fertilizer grade and expressed as percentages
   2) Equation to figure total pounds of each active ingredient
      \[
      \text{total lb. of fertilizer} \times \text{percent of macronutrient} = \text{lb. of macronutrient}
      \]

b) There are several locations where fertilizer can be purchased.
   1) Agriculture supply centers
      (a) Trained personnel mix and apply fertilizers.
      (b) Materials are hazardous and require specialized equipment to maintain safety.
      (c) License is obtained and records are maintained as determined by state law.
   2) Limestone purchased from quarries
3) Barnyards, livestock sewage pits or lagoons, or sewage treatment facility
   (a) Special equipment is required to perform applications.
   (b) License must be obtained to transport and comply with state regulations.

4. Explain the methods of applying dry and liquid fertilizers. Include in the discussion how the application method may affect the penetration rate of the fertilizer and the growth of the plant if placed too closely to the seed or applied too heavily.

**What are the different application techniques?**

a) Broadcasting
   1) Spreading dry fertilizer evenly over soil prior to planting
   2) Uses mechanical equipment or aircraft
   3) Disked or mixed into the soil to increase nutrient breakdown process

b) Soil injection or knifing
   1) Used before and during planting
   2) Anhydrous ammonia injected directly into the soil - evaporates quickly
   3) Preferred option to apply liquid manure to reduce odors

c) Banding
   1) Places dry fertilizers directly into the soil about 2 inches to each side and slightly below the seed
   2) Used extensively for row crops during planting
   3) Starter applications
      (a) Fertilizer applied in a band 1 to 2 inches from one or both sides of the seed, only at planting time
      (b) Commonly used on corn and cotton to stimulate early growth
      (c) Applied as either dry or liquid materials

  d) Side-dressing
      1) Placing fertilizer in bands about 6 to 8 inches from the row of plants
      2) Common in row crops such as corn, cotton, and vegetables
      3) Minimizes leaching during planting and cultivation

  e) Top-dressing
      1) Dry or fluid fertilizer is broadcast lightly over close-growing plants.
      2) It is a common method for applying nitrogen to wheat, small grains, hay fields, pastures, and lawns.
      3) Rainfall dissolves dry fertilizer and soaks into soil.

f) Foliar
   1) Application of liquid fertilizer directly on foliage or leaves
   2) Broadcasted soluble nutrients on plants for rapid utilization
   3) Can cause severe burning of leaves if sprayed too heavily
   4) Not recommended for applications of nitrogen, phosphorus, or potassium

g) Fertigation
   1) Fertilizer is applied in irrigation systems.
   2) Liquid fertilizers are typically used.
   3) Dry fertilizers may be dissolved and dispersed by irrigation.
   4) Type of irrigation system dictates type of fertilizer used.

5. Determining when fertilizer should be applied depends on many factors. The soil temperature, moisture levels, crop to be grown, and the specific nutrients to be applied are all primary factors to consider when planning fertilizer application. Discuss the various factors with the students and how the four seasons affect the appropriate application time.

**When should fertilizer be applied?**
a) Soil temperature
   1) Rate (speed) affects chemical activity.
   2) Nitrification begins just above freezing and continues to increase up to about 85°F.
b) Moisture
   1) The amount between fertilizer application and plant utilization affects efficiency of applied material.
   2) Nitrifying bacteria remain active in very dry conditions.
   3) Saturated soils do not contain enough oxygen for nitrifying bacteria.
c) Crop to be grown
   1) Single application of primary nutrients is satisfactory for most fast-growing annual crops.
   2) Split applications of nitrogen may be desirable for perennials, cool- and warm-season grasses.
d) Nutrients
   1) Mobile nutrients are more susceptible to leaching losses than phosphates or potassium.
   2) Nitrogen applied in ammonia form must be nitrified before leaching or denitrification can occur.
e) Favorable planting season
   1) Fall application
      (a) Soil texture, average temperatures, and nitrogen carrier influence possible losses from leaching.
      (b) Applying nitrogen materials to sandy soils is discouraged.
      (c) Anhydrous ammonia is recommended.
      (d) Phosphorus and potassium are relatively safe in most areas.
   2) Winter application
      (a) Plow-down applications and anhydrous ammonia application can continue until ground freezes.
      (b) In some areas, these methods continue throughout the winter.
   3) Spring application
      (a) Most popular
      (b) Broadcast applications for plow-down or disk-in on row crops
      (c) Preplant applications of anhydrous ammonia for row crops
      (d) Starter applications for spring small grains or row crops
   4) Summer application
      (a) Provide supplemental amounts of plant nutrients not applied previously.
      (b) Side-dressing with nitrogen during irrigation applications is used.

6. Discuss fertilizer application (spread) rates. The rate will be listed on the bill of sale if the fertilizer is purchased from a service center or dealer. The spread rate is necessary to calibrate application equipment.

**How are fertilizer application rates calculated?**

a) Dry chemical fertilizers
   1) Pounds per acre (also called spread ratio)
   2) Formula - spread rate = total lb. of fertilizer / total acres
   3) Listed on side of bill from local supply center or dealer
   4) Spread ratio needed to calibrate application equipment

b) Lime
   1) Measuring based on rating system
      (a) ENM is the ability to reduce soil acidity and is determined by material purity and fineness.
      (b) Local quarry can provide ENM per ton.
2) Always applied - pounds of ENM per acre
   (a) Found on soil test recommendations
   (b) Formula - ENM recommendation / ENM rate or guarantee of material = amount of lime needed per acre
3) ENM sources
   (a) Sources are not equal in rating or price.
   (b) Use least expensive source per pound of ENM.

F. Other Activity

Visit a local fertilizer supply center and ask the staff to explain the procedure of mixing bulk fertilizer from a soil test report. Use the soil test report from Lesson 3 as an example for the supply center to work from.

G. Conclusion

Determining fertilizer needs for a specific crop or soil is highly technical. Many factors and variables need to be considered when choosing the most appropriate fertilizer and application process. Consultation with trained professionals is important to achieve the most productive and profitable crop.

H. Answers to Activity Sheet

1. a. 2250 lb.
   b. 5250 lb.
   c. 3750 lb.
2. 18,037 lb.
3. 240.5 lb. per acre
4. $2,351.35
   (Note: Complete fertilizer bill of sale on next page.)

I. Answers to Evaluation

1. Mineral, organic, chemical (inorganic)
2. Fluids, pressurized liquids, dry, slow-release
3. Nitrogen, phosphorus, potassium
4. Agriculture supply centers
5. Any or all of the following: quarries, barnyards, livestock waste pits or lagoons, sewage treatment facility
6. Temperature, moisture, crop to be grown, nutrient being applied
7. Fall
8. Total pounds of fertilizer material divided by the total acres to be fertilized
9. Lime
10. b
11. f
12. d
13. c
14. a
15. h
16. g
17. e
**Agriculture Supply Center**
Anyplace, Missouri 000-555-9999

<table>
<thead>
<tr>
<th>Name</th>
<th>Delivered by</th>
<th>Address</th>
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**Nitrogen Phosphorus Potassium**

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<th>Soil Test Recommendation (lb./ac.)</th>
<th>30</th>
<th>70</th>
<th>50</th>
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<tr>
<td>Total Acres to Spread</td>
<td>75</td>
<td>75</td>
<td>75</td>
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<tr>
<td><strong>Total Pounds of Fertilizer Needed</strong></td>
<td>2250</td>
<td>5250</td>
<td>3750</td>
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**MANUFACTURING INSTRUCTIONS**

*Use the Following:*

<table>
<thead>
<tr>
<th>Fertilizer Source</th>
<th>Lb. N</th>
<th>P</th>
<th>K</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
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<td>18</td>
<td>46</td>
<td>0</td>
<td>2054</td>
<td>5250</td>
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<tr>
<td>Ammonium Nitrate 34-0-0</td>
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<tr>
<td>Potassium Chloride 0-0-60</td>
<td>6048</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>3750</td>
</tr>
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</table>

**Total Lb.** 18,037  **Total Lb. Supplied** 2250 5250 3750

\[
\frac{18,037}{75} = 240.5 \text{ Spreading Rate (lb. per acre)}
\]

**Guaranteed Analysis**

\[
\frac{12.5}{29} = 20.8 \%
\]

<table>
<thead>
<tr>
<th>Fertilizer Source Used</th>
<th>Cost per Lb.</th>
<th>Lb. Used</th>
<th>Cost per Source</th>
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<td>Diammonium Phosphate 18-46-0</td>
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<td>11,413</td>
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<td>Ammonium Nitrate 34-0-0</td>
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<td>Potassium Chloride 0-0-60</td>
<td>0.083093</td>
<td>6048</td>
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<td>Description</td>
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<tr>
<td>Total Fertilizer Cost</td>
<td>$2,126.35</td>
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<tr>
<td>($3.00 per acre) Spreading Charge</td>
<td>$225.00</td>
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<tr>
<td><strong>TOTAL BILL</strong></td>
<td><strong>$2,351.35</strong></td>
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Complete the following questions.

1. What are the three types of fertilizer?
   a. 
   b. 
   c. 

2. In what four forms can mineral and chemical fertilizers be purchased?
   a. 
   b. 
   c. 
   d. 

3. What are the primary soil nutrient deficiencies that most often need to be corrected?
   a. 
   b. 
   c. 

4. What is the primary source for purchasing fertilizer products?

5. What are alternative sources for purchasing fertilizer products?
   a. 
   b. 

6. What four factors affect when fertilizers are applied?
   a. 
   b. 
   c. 
   d.
7. What time of the year is best for applying anhydrous ammonia?

8. How is the application rate determined?

9. What is the only fertilizer that requires measuring on a rating system?

Match the definition on the left to the term on the right.

10. ____ Application technique for anhydrous ammonia.  a. Broadcasting
11. ____ Method used to fertilize pastures.  b. Soil injection
12. ____ Used when planting to stimulate seed germination.  c. Banding
13. ____ Dry fertilizer placed to each side and below seed.  d. Starter applications
14. ____ Spreading dry fertilizer over soil prior to planting.  e. Side-dressing
15. ____ Application of fertilizer in irrigation systems.  f. Top-dressing
16. ____ Fertilizer applied directly to leaves of plants.  g. Foliar
17. ____ Fertilizer applied 6 to 8 inches from the plant row.  h. Fertigation
Calculating Fertilizer Needs and Cost

Objective: Students will be able to identify components of a fertilizer bill of sale and calculate fertilizer needs, spreading rate, guaranteed analysis, and costs.

Directions: Using Table 4.2 from the Student Reference and the following information, complete the fertilizer bill of sale on the back of this page and answer the questions below.

Soil Test Recommendations:
- N = 30
- P = 70
- K = 50

Total acres to spread is 75.

Fertilizer Sources and Costs per pound:
- Ammonium Nitrate 18-46-0 $ 0.073614
- Diammonium Phosphate 34-0-0 $ 0.1385607
- Potassium Chloride 0-0-60 $ 0.083093

Spreading charge is $3.00 per acre.

Key Questions:
1. What are the total pounds needed of each of the following:
   a. Nitrogen -
   b. Phosphorus -
   c. Potassium -
2. How many total pounds of source fertilizer are to be used?
3. What is the spreading rate?
4. What is the amount of the total bill?
**Agriculture Supply Center**  
Anyplace, Missouri  000-555-9999

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| Soil Test Recommendation (lb./ac.) |          |          | |
|-----------------------------------|----------|----------|
| Total Acres to Spread             |          |          | |
| Total Pounds of Fertilizer Needed |          |          | |

**MANUFACTURING INSTRUCTIONS**

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<th>Total Lb. Supplied</th>
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\[
\frac{(\text{Total Lb.)}}{(\text{Acres})} = \text{Spreading Rate (lb. per acre)}
\]

**Guaranteed Analysis** 
\[
\% \% \% (\text{lb. of nutrient/acre ÷ spread rate})
\]

**Fertilizer Source Used**  

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<th>Fertilizer Source Used</th>
<th>Cost per Lb.</th>
<th>Lb. Used</th>
<th>Cost per Source</th>
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| Total Fertilizer Cost  | $ |
| ($______ per acre) |

| Spreading Charge | $ |

**TOTAL BILL**

*Advanced Crop Science, III-66*