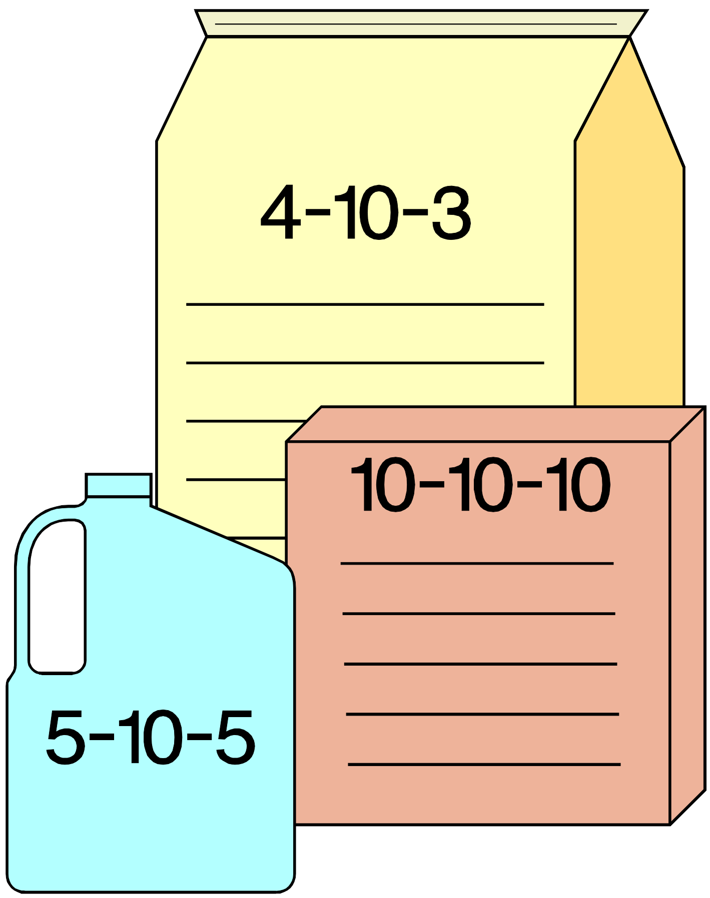
Fertilizer Technology and Use



Soils 447-01

Course Module
Lecture Note Packet

University of Idaho
College of Agricultural and Life Sciences

Outline of Course
Soils 447
Module 1: Fertilizer Technology and Use

Lesson 1: **Background; Chemical Fertilizers; Historical Fertilizer Production**

Lesson 2: **Fertilizer Terminology**

Lesson 3: **Granulation; Bulk Blending; Fluid Fertilizers**

Lesson 4: **Fluid Fertilizers; Addition and Incorporation of Micronutrients; Salt Index**

Lesson 5: **Nitrogen Production Flow Chart; Anhydrous Ammonia**

Lesson 6: **Applying Fertilizers Through Irrigation Water**

Lesson 7: **Applying Solid Fertilizers**

Lesson 8: **Applying Solid Fertilizers**

Lesson 9: **Foliar Fertilization**

Lesson 10: **Physical Properties of Fertilizers; Particle Size; Segregation Properties**

Lesson 11: **Granule Hardness; Bulk Density; Angle of Repose; Critical Relative Humidity; Apparent Specific Gravity**

Lesson 12: **Rate and Effects of Moisture Absorption; Caking of Fertilizers**

Lesson 13: **Chemical Compatibility; Dustiness and Conditioner Adherence; Micronutrients**

Lesson 14: **Slow Release Fertilizers**

Lesson 15: **Alternative Products in Agriculture**

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CIS 757 *Fertilizer Placement*
Download or view from http://info.ag.uidaho.edu/pdf/CIS/CIS0757.pdf

CIS 863 *Fertilizer Primer*
Download or view from http://info.ag.uidaho.edu/pdf/CIS/CIS0863.pdf

LESSON 1
Background
Chemical Fertilizers
Historical Fertilizer Production

I. History of Chemical Fertilizers

A. Background

- **FIRST RECOGNITION OF THE NEED FOR NUTRIENTS IN SOIL WAS IN MESOPOTANIA**
  - **annual flood added silts laden with nutrients to farmland**
  -

Greeks and Romans

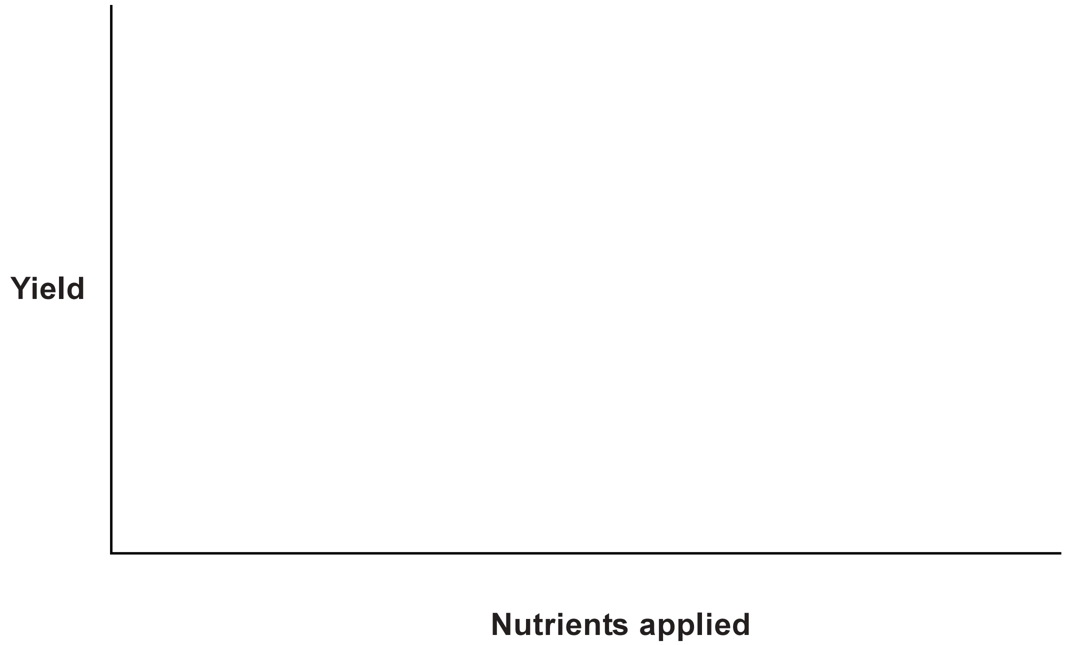
  -
  -
  - **crop rotation with legumes**

No progress from Roman times – Middle Ages

- **Fertilizer industry stared in early 1800s as the foundations for the industry was laid by Liebig**
  -

Liebig's law — called the "Law of the Minimum" is still the basis for the fertilizer chemical industry

Law states — if one of the essential elements is lacking in the soil — plant growth will be poor even when all other elements are abundant



– nutrient balance

concept for idea based in the early 1800s

B. Chemical Fertilizers

1. Phosphate Fertilizers

- First fertilizer was ground bones (1800)

–

–

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- By 1830 the bones were treated with H_2SO_4 to make the P more available

- By 1840 the mining of phosphate rock commenced ⟶ treated with sulfuric acid ⟶ got superphosphate OSP, NSP; still in use

-

- In the 1870s the Germans made TSP by reacting rock phosphate with phosphoric acid — not important until the 1950s

- By the 1960s ammonium phosphates (mixed fertilizer) became important and are chief P sources today

11-5-0	16-48-0
MAP	DAP

  - also nitrophosphates
  -
  - rock phosphate direct — little use; break bonds
  -

2. Nitrogen Fertilizers

- **In ancient times crop rotations with legumes supplied adequate N**
- **Rain water 5 kg/ha/yr**
-
- **First commercial N production was not feasible until the early 1900s**
- **In dark ages (1950s) ⟶ agronomists still advocated crop rotations**

Wheat Yield — History

Palouse	bu/acre	
1930	15	peas/clover adequate rotation
1940	18	
1950	25	
1955	40	
1980	110	

3. Potassium (Potash) Fertilizers

- **Early sources**
  - –
  - –
- **First commercial deposits opened in Germany in 1860**
  - **dominated world market for 75 years**
  - –

4. *Sulfur Fertilizers*

-

- Said to have originated when a German plaster observed that small amounts of plaster spilled from his wheelbarrow made the grass along the pathway grow lush and green

- Gypsum for agricultural use became known as “land plaster”

5. *Ca and Mg Fertilizers*

-

6. *Micronutrient Fertilizers*

- Fe 1844 France
  (but others not recognized until much later)

- Mn 1905

- Cu, B 1920s

- Zn 1930

- Mo 1930

- Cl 1954

- Selenium

- Cobalt

- Nickel

7. *Others*

-

C. Historical Fertilizer Production

-

- Increase is currently faster in less developed than developed countries

Fertilizer Use (NPK)

Year	World	USA
	-----millions of tons-----	
1950	14	
1960	27	
1970	66	
1980	112	
1995	122	

Fertilizer Use Per Person

	Total Use	Per Capita
	x 1,000,000 tons	kg
1950	14	
1960	27	
1970	66	
1980	112	
1990	143	
1995	122	

Source: FAO Yearbooks

Major Fertilizer Users — 1995

Country	Fertilizer Use (x 1,000,000 tons)
China	28.2
USA	19.6
India	13.5
USSR countries	10.6
Rest of world	50.1

Source: World Watch Institute

Fertilizer Response Ratio

Year	Fertilizer Use	Fertilizer Increment	Increase Grain/ Fertilizer Response
1950	14		
1984	126	112	9.1
1989	146	20	1.8
1994	121	-25	—

Source: World Watch Institute

LESSON 2
Fertilizer Terminology

II. Fertilizer Technology and Use

A. Fertilizer Terminology

(Reading Assignment: Current Information Series No. 863, *Fertilizer Primer*)

Fertilizer material — is a fertilizer which either:

1. **Contains important quantities of no more than one of the primary plant nutrients — nitrogen (N), phosphoric acid (P_2O_5), or potash (K_2O), or**
2. **Has 85% or more of its plant nutrient content present in the form of a single chemical compound, or**
3. **Is derived from a plant or animal residue or by-product or natural material deposit which has been reprocessed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration.**

Plant nutrients — there are 17 essential elements required for plant growth

–

–

Soil Derived Nutrients:

- **Macronutrients — 6**

- **Micronutrients — 8**

Macronutrients:

- –
- –
- –
- –
- –
- –

Micronutrients:

- –
- –
- –
- –
- –
- –
- –
- –

<u>Fertilizer</u> — is any substance which is added to the soil (or sprayed on plants) to supply those nutrients required in plant nutrition

Fertilizers can be:

- **Inorganic — chemically manufactured**
- **Organic — dead plant / animal materials**
  - –
  - –
  - –

Every fertilizer has a guaranteed analysis stating:

- **–**
- **–**
- **–**

<u>Fertilizer grade</u> — refers to the minimum guarantee of the plant-nutrient content in terms of total nitrogen, available phosphorus pentoxide, and soluble potassium oxide.

Example:

- **In addition to N-P-K, a 4th number represents percent sulfur (S)**
- **If the 4th number is not S, the elemental symbol will be shown:**

Example:

Fertilizer ratio — the smallest whole number relationship among N, P, and K in a grade

Example:

Mixed fertilizer — a fertilizer that contains 2 or more of the 3 macronutrients — N, P, K

Examples: **10-0-6** **–**

12-12-0 **–**

0-10-20 **–**

Complete fertilizer — a fertilizer that contains N, P, and K

Examples:

Fertilizer formula — is an expression of the quantity and analysis of the materials in a mixed fertilizer.

Filler — is a make-weight material added to a mixed fertilizer or fertilizer material to make up the difference between the weight of the added ingredients required to supply the plant nutrients in a ton of a given analysis and 2000 lb.

Acid-forming fertilizer — is one capable of increasing the acidity of the soil, which is derived principally from the nitrification of ammonium salts by soil bacteria.

<u>Basic fertilizer</u> —

<u>Non acid-forming or neutral fertilizer</u> — is one that is guaranteed to leave neither an acidic nor a basic residue in the soil.

<u>Dry bulk blending</u> —

<u>Bulk fertilizer</u> — is a fertilizer distributed in a non-packaged form. Most fertilizers are sold this way.

<u>Clear liquid fertilizer</u> — is a fertilizer in which the N-P-K and other materials are completely dissolved.

<u>Suspension fertilizer</u> — is one in which some of the fertilizer materials are suspended as fine particles.

<u>Fluid fertilizer</u> —

<u>Compound fertilizer</u> — is a term often used in Europe and has about the same meaning as mixed in the USA.

<u>Specialty fertilizer</u> — is a fertilizer distributed for non-farm use.

Nitrogen Fertilizer Types:

- **Gas form:**

  1. Ammonia (AA)

  –

  –

- **Solid form:**

1. **Ammonium Nitrate (AN)**

   –

   –

   –

2. **Urea (U)**

   –

   –

   –

   –

3. **Ammonium sulfate (AS)**

   –

   –

   –

   –

4. **Slow-release N fertilizers**

   –

   –

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   –

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–

- **Liquid form:**

  Nitrogen Solutions

  –

  –

Phosphorus Fertilizer Types:

1. **Rock phosphate (0-25-0)**

   –

   –

2. **Organics (from 5-40% P_2O_5)**

   –

   –

   –

3. **Triple Superphosphate (TSP)**

   –

   –

   –

4. N—P Combinations

a. Mono Ammonium Phosphate (MAP)

–

–

b. Di Ammonium Phosphate (DAP)

–

–

Potassium Fertilizer Types:

1. Potassium Chloride (KCl)

–

–

–

–

2. Potassium Sulfate (K_2SO_4)

–

–

–

–

Sulfur Fertilizer Types:

Common S Materials:

–

–

–

–

Classes of Fertilizers

◆

◆

◆

◆

USA Fertilizer Consumption by Class

1994:

Bulk –

Fluid / NH_3 –

Bagged –

*** Trend toward fluid fertilizers**

Terms:

<u>Bulk</u> **<u>Fluid</u>**

Problems:

Conversions for P and K:

Apply 20 lbs of N per acre as ammonium nitrate:

Make 2 tons of a 10-10-0-8 fertilizer using TSP, AN, and AS:

LESSON 3
MAJOR FERTILIZER SYSTEMS
Granulation
Bulk Blending
Fluid Fertilizers

B. Major Fertilizer Systems

1. Granulation

- **The process of granulating dry fertilizers was developed to provide a more uniform product for use in labor saving mechanical applicators and to reduce the costs of manufacturing and transport**

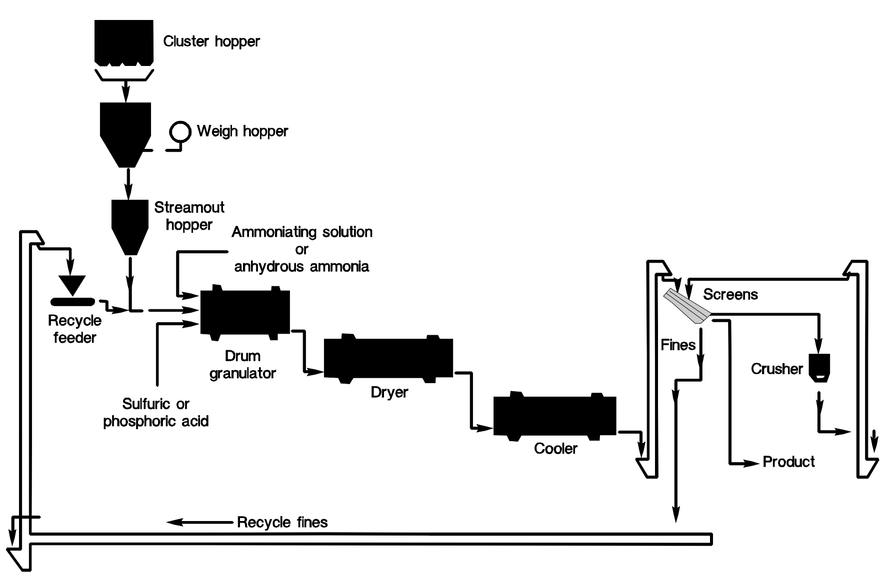
- **Basic Process:**

  –

  – **incoming materials screened to remove lumps; weighed and continuously fed into granulator at controlled rate**

  – **steam discharged under bed, water sprayed on top; amount of water controls granulation**

  – **discharged particles —**



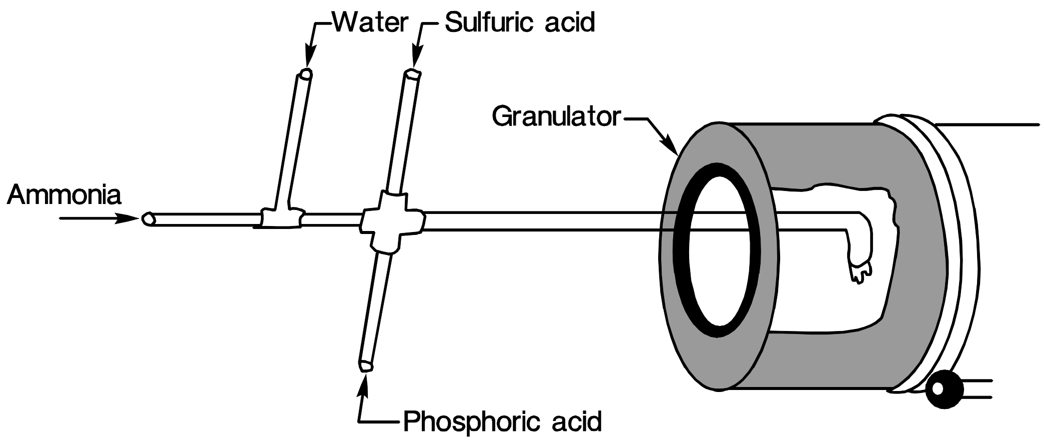
a. **Melt Granulation**

Process:

- –

- – **phosphoric acid + ammonia are reacted in a confined pipe (pipe cross reactor);**

- –



Advantages over regular granulation:

1. **Reduced drying costs**

   –

   –

2. **Easier compliance with environmental regulations because fewer ammonium chloride fumes are produced**

3.

4.

b. Caking and Dustiness

- Between manufacture and application to the soil, dry fertilizers must be stored in bulk or in bags. It is essential that the fertilizer maintain their free flowing character and not cake or form lumps in storage.

Caking — when crystal bonds grow between particles

–

– due to excessive H2O left in fertilizers at time of manufacture

–

Conditioners — are anti-caking agents; diatomaceous earth, kaolin, clay, talc, and chalk

– sometimes after manufacture fertilizer granules are coated with a conditioner

–

Not Treated	Treated

–

– conditioner will lower analysis slightly

Dustiness — undesirable property; caused by poor sizing, which leaves too many fine, soft particles which break up under normal handling

–

–

2. Bulk Blending

- Granulation is used to produce single nutrient carriers as well as complete NPK fertilizers. Bulk blending is the physical mixing of two or more granular materials.

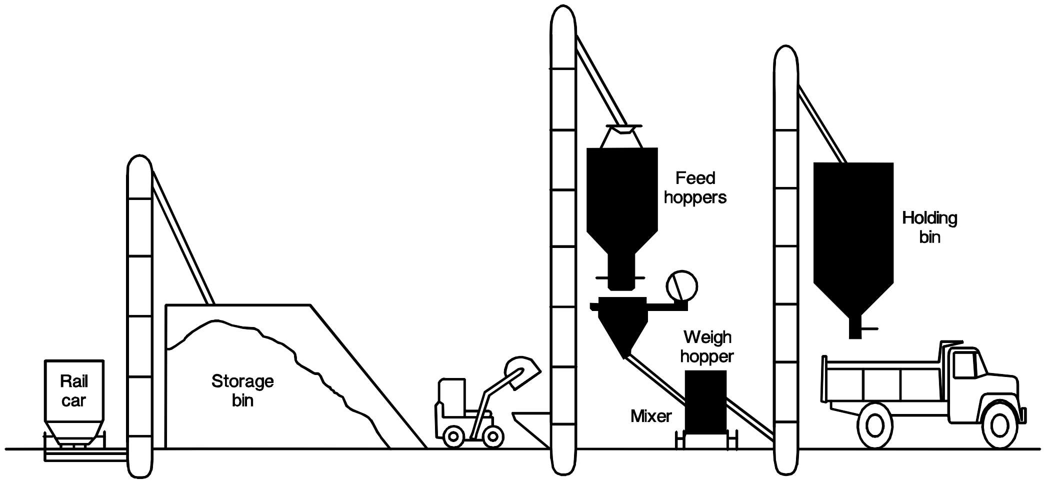
- Bulk blended materials can be bagged or distributed in bulk

- Major advantages:

1.

2. The entire cycle of weighing, mixing, and discharging can be automated

3.



a. **Problems associated with bulk blends**

   i. **Chemical incompatibility of intermediates**

– **may cause mixture to**

   –

   –

   –

   –

U + AN = H_2O CRH

<u>CRH</u> — Critical Relative Humidity

– is the relative humidity above which materials spontaneously absorb water from atmosphere

	Urea	AN	U + AN
CRH			

ii. Segregation

–

–

– Segregation is undesirable because subsequent ununiformity makes it impossible to obtain proper samples of fertilizers to meet analytical guarantees

3 types of segregation:

1.

2.

3.

–

3. Fluid Fertilizers

- **Consists of two materials: liquids and suspensions**
- **Advantages of fluid fertilizers:**

  1. dustless

  2.

  3. uniformity of application

  4.

  5.

  6. fluids added to irrigation water (chemigation, fertigation)

  7.

- **Disadvantages of fluid fertilizers:**

  1.

  2. increased shipping costs

  3.

a. Liquid fertilizers

- **A liquid fertilizer is a clear solution containing plant nutrients**

  Principal intermediates:

  - **For Nitrogen:**

- For Phosphorus

- For Potassium

- **Color:**
  - Solutions are usually clear, blue, brown, or green
  -

LESSON 4
MAJOR FERTILIZER SYSTEMS
Fluid Fertilizers
Addition and Incorporation of Micronutrients
Salt Index

- **Primary P source is ammonium polyphosphate (APP)**
  - **NH_4 + superphosphoric acid**

    ↓

    pipe reactor (NH_4 + SPA)

    ↓

    → **drives off H_2O**

    ↓

    ↓

10-34-0　　11-37-0

- **The polyphosphate has a higher P content and sequesters both the impurities of the acid and any micronutrients that are added**

- **Simple mixing process to make NPK fertilizer:**

- **Major limitation of liquids is generally their lower analysis compared to dry fertilizers**

- For NP fertilizers:

- For NPK liquids:

- KNO_3 has low solubility at low temperatures, and crystals form and settle (salting out)

-

b. Suspension Fertilizers

- The generally low analysis of liquid fertilizers is overcome by the manufacture of suspensions

-

- The suspended particles may be water-soluble in a saturated solution, insoluble, or both

- Suspension advantages:

  1.

  2.

  3.

- **Suspension disadvantages:**

  1.

  2.

- **Manufacture of suspensions:**

  – **highly varied — but parallels liquid manufacture; similar materials are used but they may be lower in quality and cost less**

-

- **Suspensions can be stored weeks or months; if too long large crystals form ⟶**

4. Addition and Incorporation of Micronutrients

- **Recommended amounts of micronutrients are usually less than 10 kg/ha**

-

- **Compatibility and uniform distribution are the major objectives of the successful addition of micronutrients to mixed fertilizers**

a. Addition to granular fertilizers

◆

◆ The micronutrient granule size must match that of the other materials in bulk blends to prevent segregation

◆ Adding micronutrients as a spray or a powder during the manufacturing process prior to ammoniation and granulation, gives presence in every granule.

◆ Major disadvantage ⟶ little flexibility ⟶

◆ Micronutrients can be coated to granular products to achieve a uniform distribution of them throughout a fertilizer

◆ Binders for coating micronutrients on fertilizer granules include:

–

–

–

–

–

◆

◆ A disadvantage of coating, compared to incorporation, is higher cost. Consequently, micronutrients are not widely coated in the USA.

b. **Addition to Fluid Fertilizers**

- **The addition of micronutrients to fluid fertilizers has become very popular because the micronutrients can be added just before the fertilizer is applied in the field**

-

- **The addition of micronutrients to liquid fertilizers, however, is greatly limited by the solubility of intermediates. Only sodium borate and sodium molybdate have sufficient solubility to be effective when the P source is orthophosphate.**

- **Sequestering agents that react with micronutrients to prevent precipitation with P can be used**

- **Micronutrient intermediates are easily added to suspension fertilizers with minimal reaction with other components or other undesirable results**

- **$CuSO_4$, $MnSO_4$, $FeSO_4$, $ZnSO_4$ can be used in suspension; apply soon to prevent crystal growth**

C. Salt Index

- **Fertilizers are composed for the most part of soluble salts that increase the ion concentration of the soil solution**

- **This higher ion concentration increases the osmotic pressure of the soil solution and at the same time decreases water potential**

-

- The salt index is a measure of the extent to which various fertilizers increase the osmotic pressure of the soil solution

SALT INDEX:

N fertilizers
K fertilizers
S fertilizers — High SALT INDEXES

P fertilizers — Low SALT INDEXES

HIGH SI FERTILIZERS

- The salt index is determined by:
  - adding fertilizer to the soil and incubating for 5 days. The osmotic pressure of the displaced soil solution is determined.

- The cultivar, placement of fertilizer, time of application, soil properties, and the water content in particular will have some bearing on what effect a fertilizer with a given salt index has.

-

Salt indices of fertilizer materials (from Follett et al.)

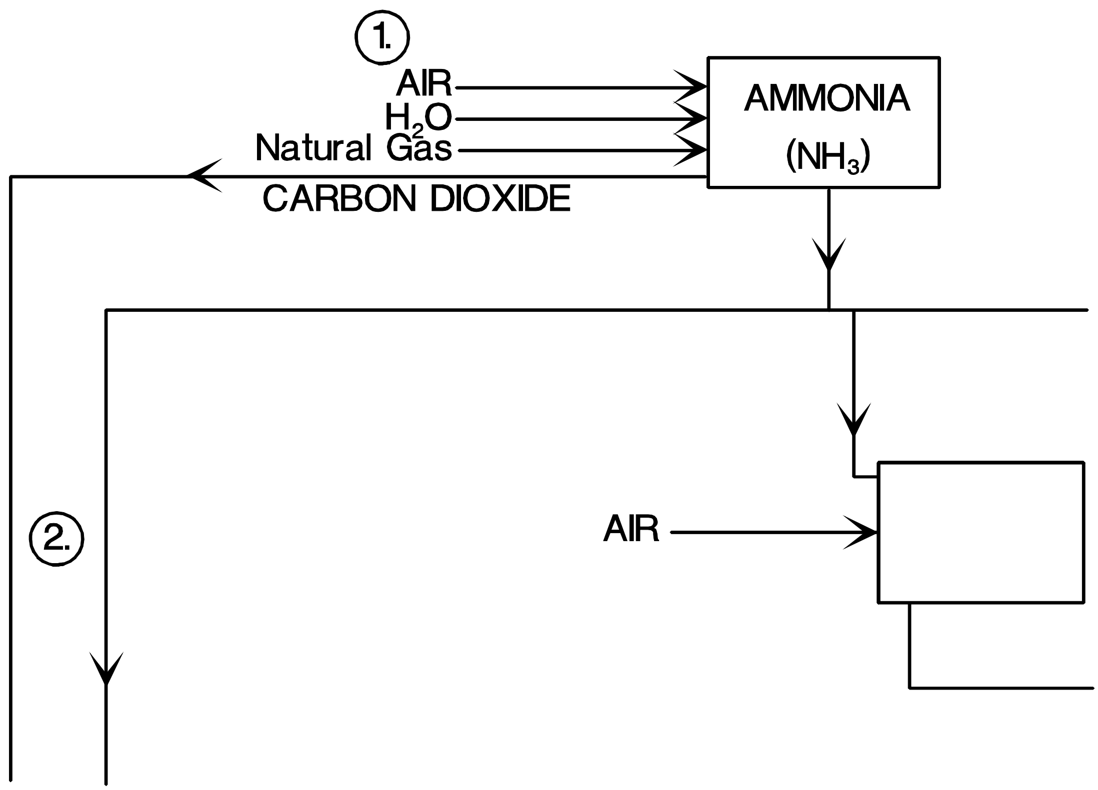
Fertilizer Material	Analysis	Salt Index	SI/20 lb of nutrient
N Fertilizers			
anhydrous ammonia	82-0-0	47.1	0.572
ammonium nitrate	34-0-0	101.7	2.904
ammonium sulfate	21-0-0	69.0	3.253
urea	45-0-0	72.7	1.560
pressure N solution	41-0-0	78.3	1.930
sodium nitrate	16.5-0-0	100.0	6.06
P Fertilizers			
normal superphosphate	0-20-0	7.8	0.390
triple superphosphate	0-45-0	10.1	0.224
MAP	11-55-0	26.9	0.407
DAP	18-46-0	29.0	0.454
K Fertilizers			
potassium chloride	0-0-60	116.3	1.936
potassium sulfate	0-0-50	46.1	0.853
potassium nitrate	14-0-46	73.6	1.219

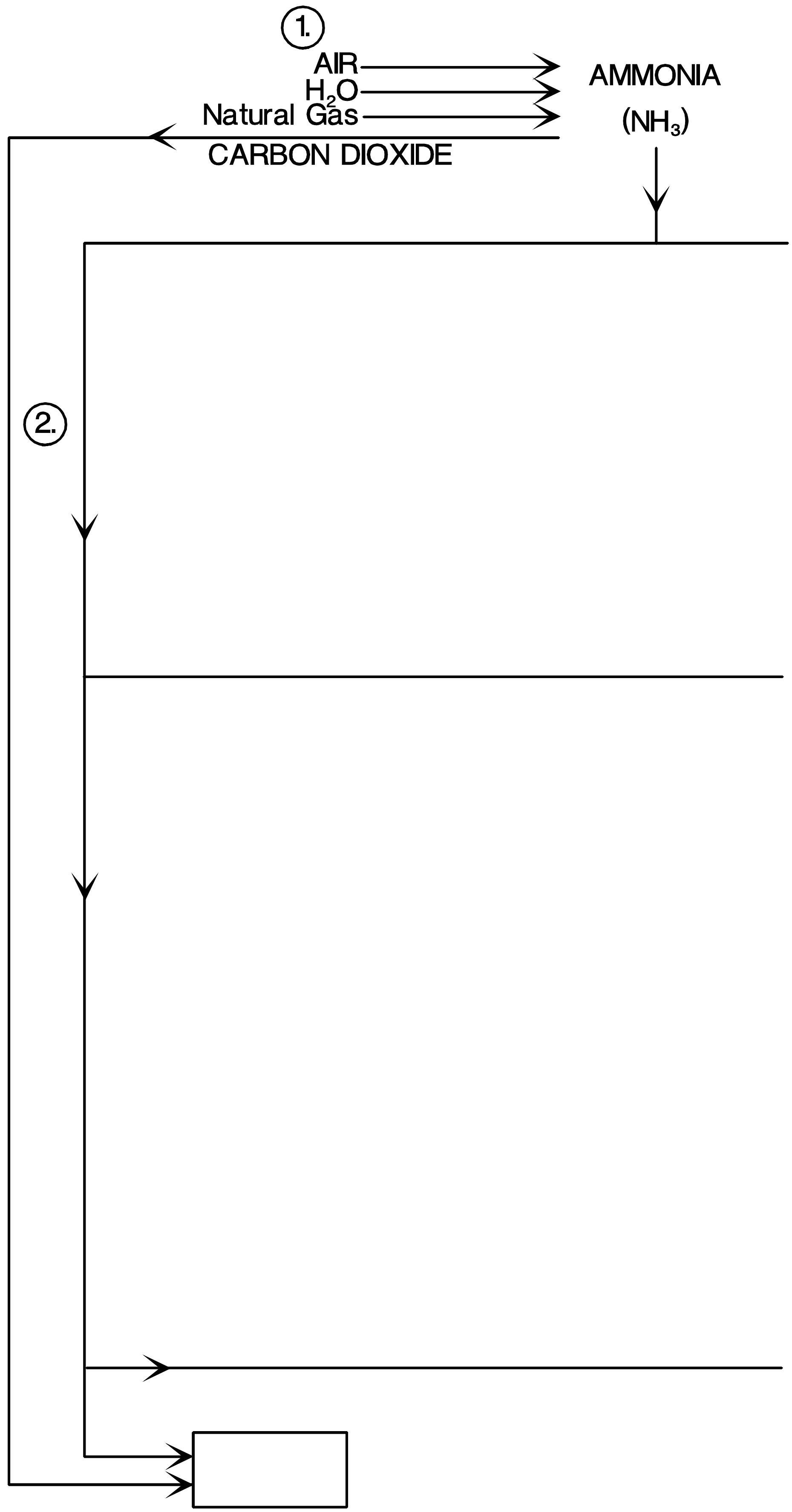
For 20 lb of nutrient:

Fertilizer	SI
AA	.57
AN	2.9
AS	
U	
OSP	
TSP	
KCl	

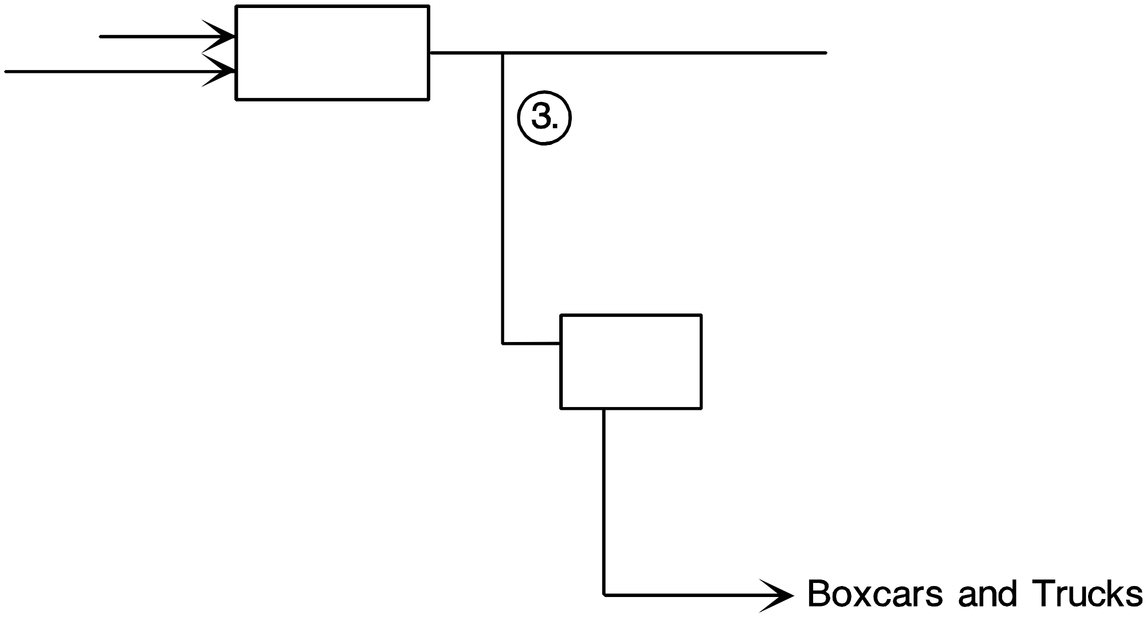
LESSON 5
Nitrogen Fertilizer Production Flow Chart
Anhydrous Ammonia

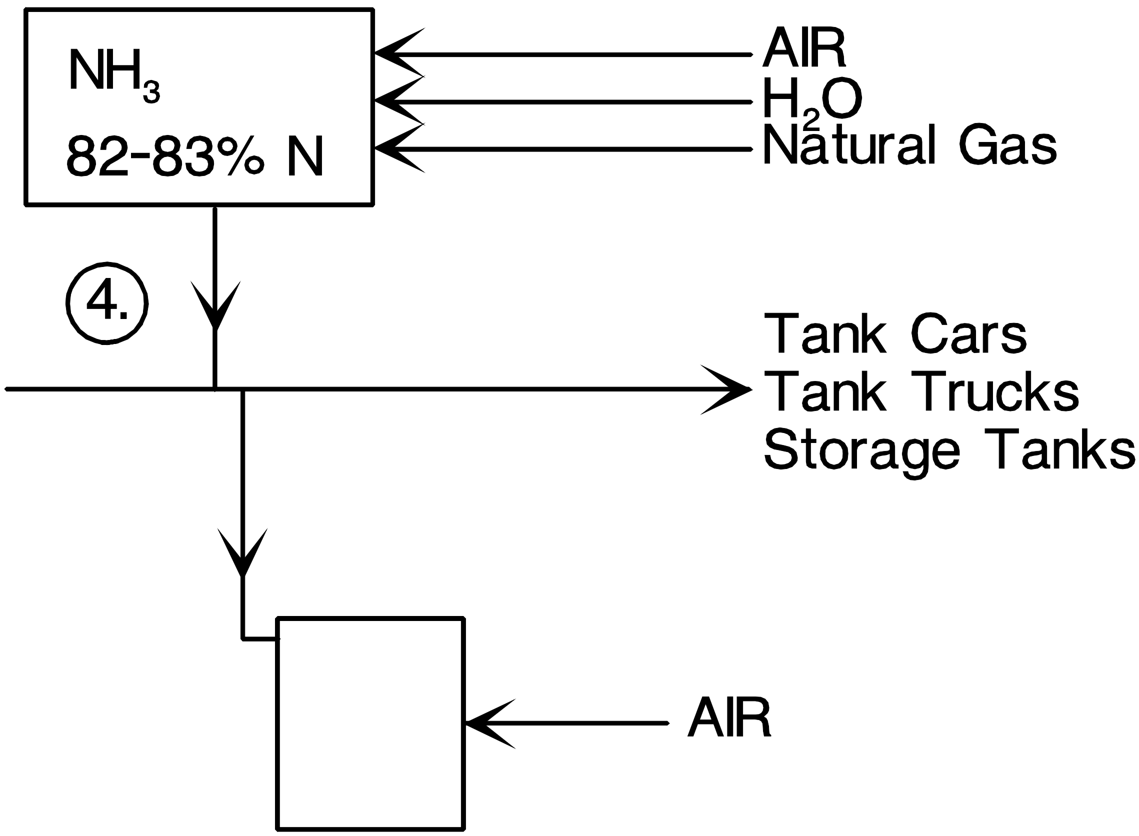
D. Nitrogen Fertilizer Production Flow Chart



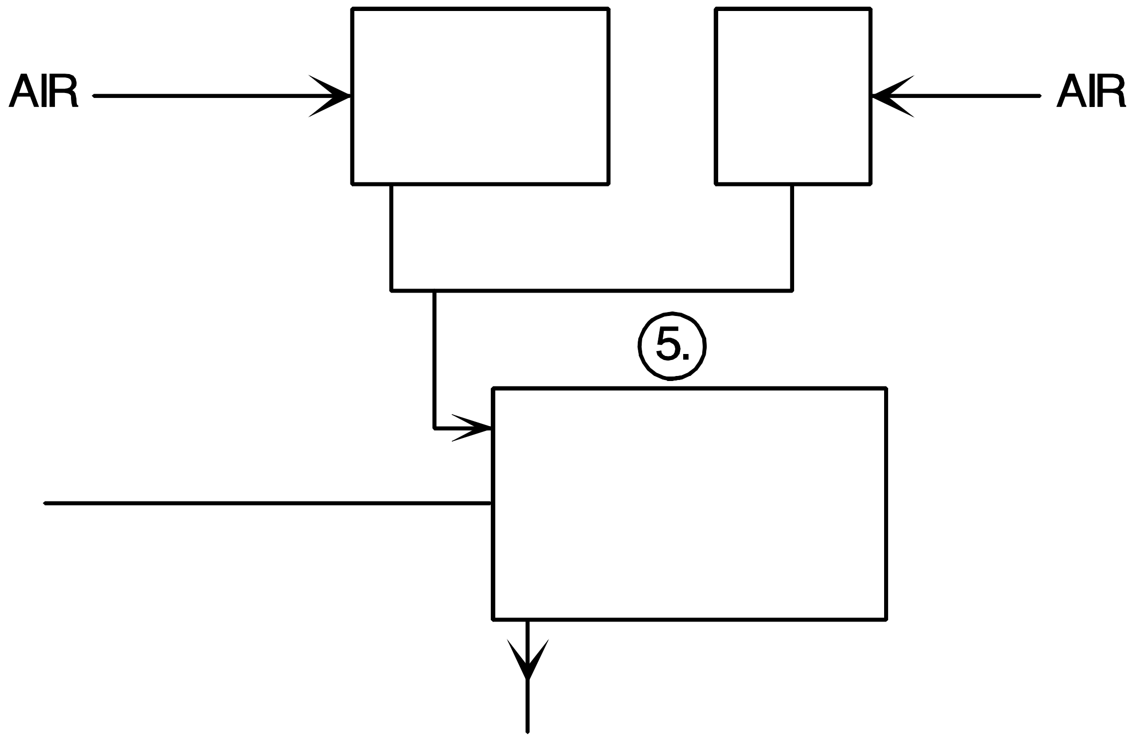


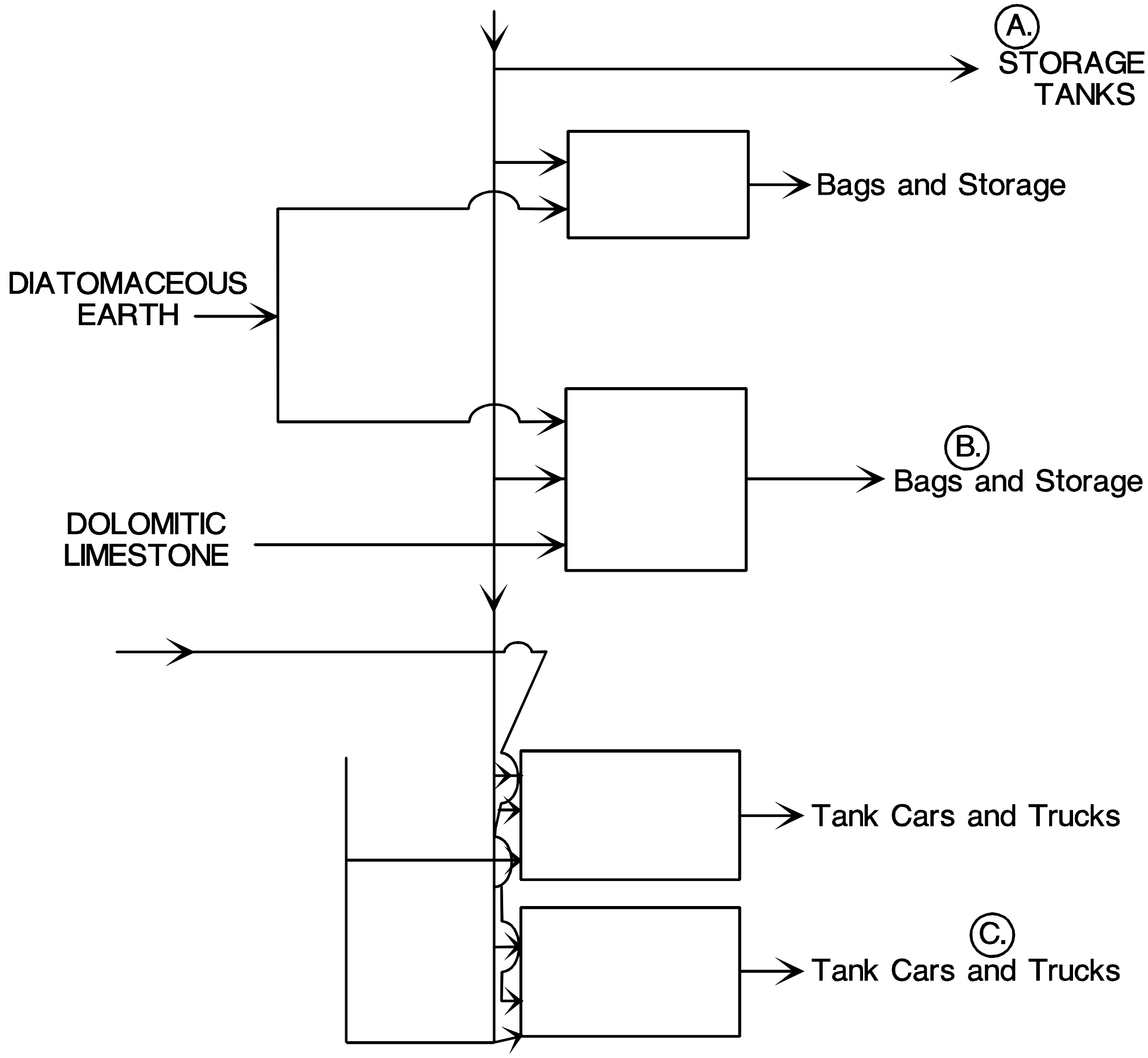
1.
AIR
H_2O
Natural Gas
AMMONIA
(NH_3)
CARBON DIOXIDE
2.


3.
Boxcars and Trucks



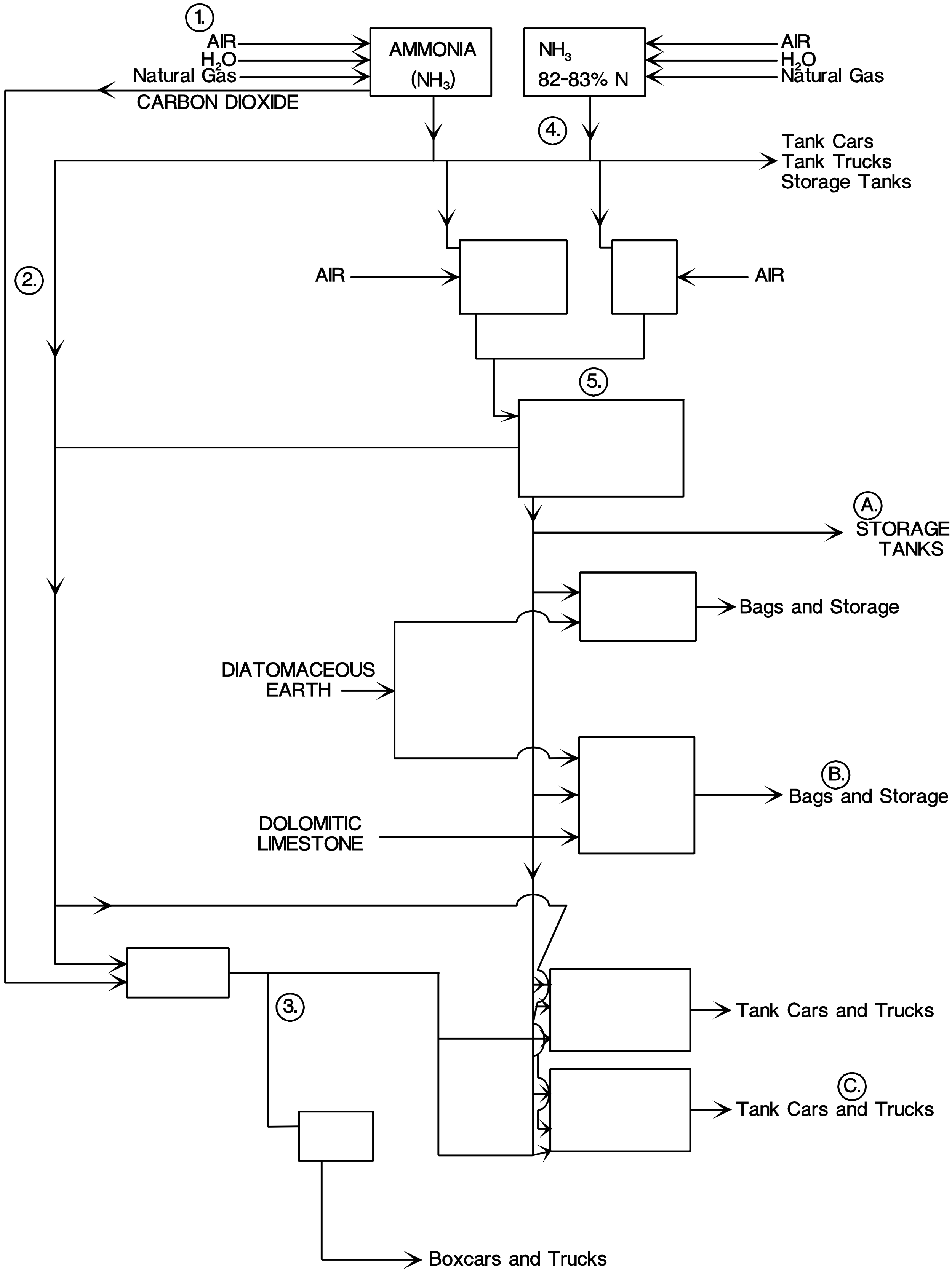
NH3
82-83% N
AIR
H2O
Natural Gas
4.
Tank Cars
Tank Trucks
Storage Tanks
AIR


AIR
AIR
5.



A.
STORAGE TANKS
Bags and Storage
DIATOMACEOUS EARTH
B.
Bags and Storage
DOLOMITIC LIMESTONE
Tank Cars and Trucks
C.
Tank Cars and Trucks

D. Nitrogen Fertilizer Production Flow Chart



III. Fertilizer Application Methods

A. Anhydrous Ammonia

- Direct application of AA to soils is the most common N material used for direct application in the USA

- 1979

  1988

  1989

  1990

- 82-0-0 is a dry ammonia gas compressed into a liquid which must be stored under pressure in suitable containers

-

-

Factors important in AA application include:

1. Proper Placement Depth

- AA needs to be trapped by the CEC on clays in the soil

-

- After placement, the soil should not be distributed for several days

Proper placement depth:

Soil Texture	Recommended depth	Minimum depth
Clay loam	3-5 inches	
Sandy loam	4-6 inches	
Sand	8-10 inches	

2. *Soil Moisture*

-

- Want optimum soil moisture conditions — optimum conditions for plant growth

-

- If the soil is too wet:
  - slits which shanks/knives create will not close $\longrightarrow$ NH_3 lost to atmosphere
  -

- If the soil is too dry:
  - not enough water to trap the N in the soil — so the fertilizer N is lost to the atmosphere
  -

– on loams and/or clay soils one can not inject anhydrous ammonia to the proper depth because the soil may be too hard

3. *Application Equipment*

- **Knives/shanks to inject anhydrous ammonia into the soil — either rigid or flexible**

- **Knive spacing depends on the type of crop to be grown:**

  –

  –

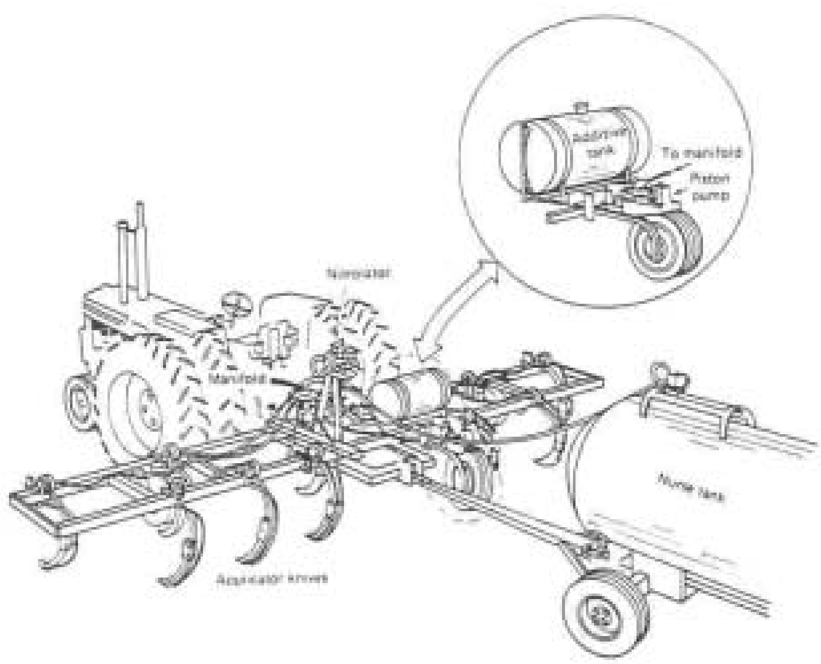
- **More than one nutrient can be added to the soil:**

  –

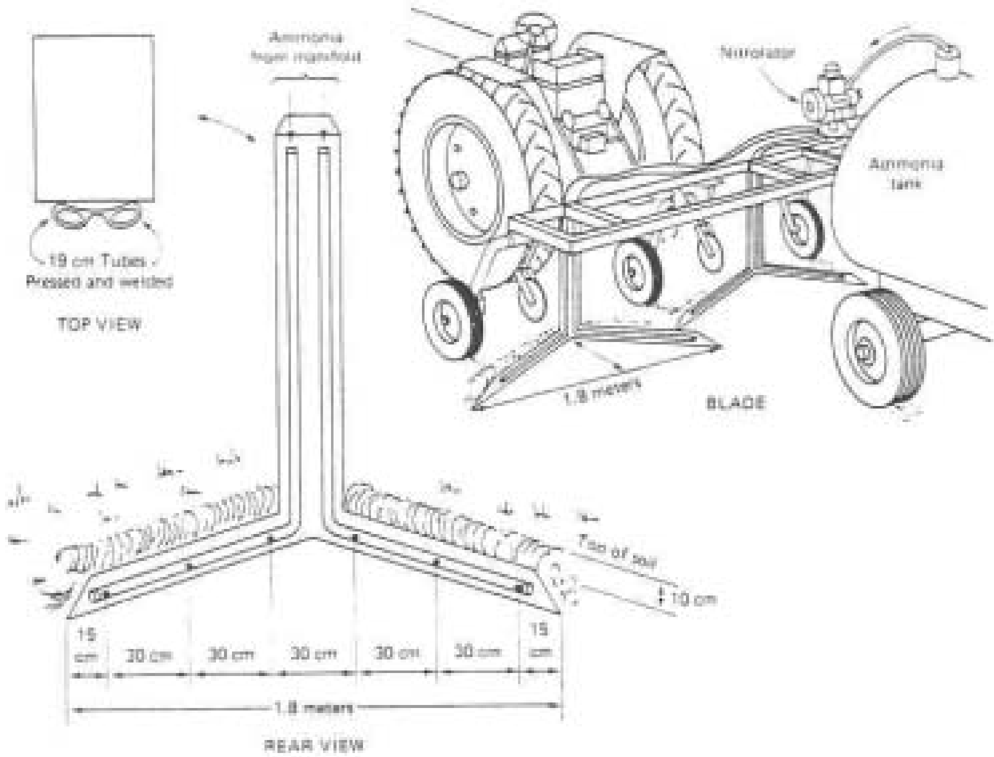
  –

- **Application equipment:**

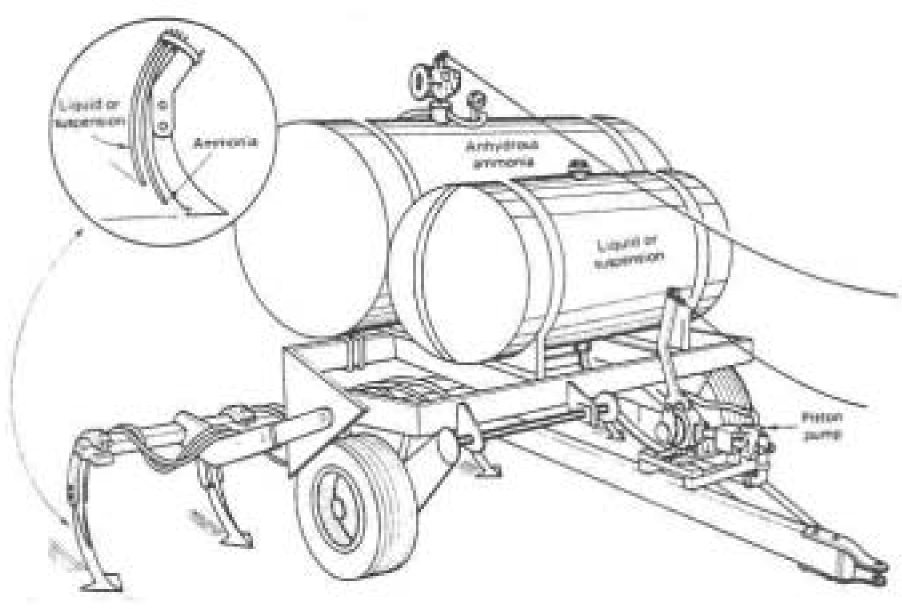
  i. Typical outfit —



ii. Undercutting blade



iii. Double shooting outfit:



4. *Safety Equipment*

Basic safety equipment:

- –
- –
- –

Should also have on hand:

- –
- –
- –
- –
- –

- ◆

- ◆ **AA irritates the lungs, eyes, and mucous membranes of humans and animals**

LESSON 6
Applying Fertilizers Through Irrigation Water

B. Applying Fertilizers Through Irrigation Water

-

- This word is a combination of FERTilization and irriGATION

-

- It is also common to apply: P, S, K, Zn and Fe this way

1. Nitrogen Application

a. Applying NH_3 in irrigation water

  – First use of anhydrous ammonia for direct application involved injection into irrigation water

  –

  –

- When NH_3 is added to water:

  – The OH- increases the pH of the water and causes the solubility of salts to decline (esp. Ca and Mg salts)

- **These salts precipitate and**
  - –
  - –
  - –
- **NH_3 injected into a siphon tube or ditch is less troublesome; however, encrusted siphon tubes are hard to clean**
- **When applying NH_3 into "hard water" you can add an inhibitor such as sodium hexametaphosphate that tends to sequester the Ca — with a resulting decrease in precipitation**
- **Another major problem with NH_3 injection into water is:**
  - **volatilization losses occur from the time that the NH_3-H_2O mixture leaves the sprinkler until it reaches the soil surface**
  - –
- –
- **NH_3 applied in irrigation water is distributed in about the same manner in both furrow and sprinkler systems**
  - **However, in furrow irrigation the water tends to percolate more at the head of a run than at the tail. So the N distribution is often different.**
- **To offset this problem NH_3 is withheld from water during the first part of the irrigation —**

– The major problem involving NH_3 in irrigation water is high pH; the higher the pH of the water the greater the potential volatilization losses

  – counter with adding sulfuric acid to water of equivalent acidity

N Applied (mg/ml)	Acid applied	Water pH	% N loss
48	0	9.0	
49	Equiv	7.4	
179	0	9.6	
178	Equiv	7.1	

b. Applications of N Solutions in Irrigation Water

–

–

– Most popular in sandy soils where PP fertilizers leach over growing season

–

Application Method (Rec. Rate)	Corn Yield (kg/ha)
Broadcast	7275 (110 bu/ac)
50% Broadcast, 50% Irrigation	7526
Irrigation	7777
Irrigation / Split Application	7840
Broadcast + 20 extra by irrigation	8216 (124 bu/ac)

- The larger the irrigation system the better the mixing
- Furrow Run Time:
  -
  -

Maximum Run Time for Good N Distribution:

Soil texture	Max. length of time to reach end of furrow (hours)
Loamy sand	
Sandy loam	
Fine sandy loam	
Silt loam	
Silty clay loam	

- Use of NITROGEN SOLUTIONS in irrigation systems should include:

  Reuse system for TAIL water to:

  1.

  2.

- Non-pressure N solutions are popular in fertigation because:

  1.

  2.

- Pressure N solutions — most compatible with ditch siphon tube irrigation systems — like anhydrous ammonia

c. Application of Solid N Sources in Irrigation Water

- Any soluble N fertilizer can be applied in irrigation water by converting the solid to a liquid

- Techniques exist to put solids such as urea in irrigation water, allow ample distance to the first turnout in the pipe or ditch for good mixing

–

–

2. *Phosphorus Application*

-

- As long as P remains in the system totally dissolved — no major problems should occur

-

Problems in application of P in irrigation water:

i. Precipitation when ammonium polyphosphate liquids injected into water high in Ca and/or Mg

ii.

iii. P applied in water remains near the soil surface — if not incorporated will be much less effective than a PPI treatment (uneven soil distribution)

3. *Potassium and Sulfur Application*

-

- K applications in irrigation water are only popular on corn, grain sorghum, soybeans, and potatoes

-

- Sulfur injection is very easy and common

-

- **Irrigation waters often already contain adequate S levels**

-

4. Micronutrients

- **Sprinkler application of Zn and Fe are the most common uses of micros in irrigation water**

LESSON 7
Applying Solid Fertilizers

Reading Assignment — UI Current Information Series No. 757,
Fertilizer Placement

A. Background

3 Basic Methods of Solid Fertilizer Application:

1.

2.

3.

1. Broadcast Methods

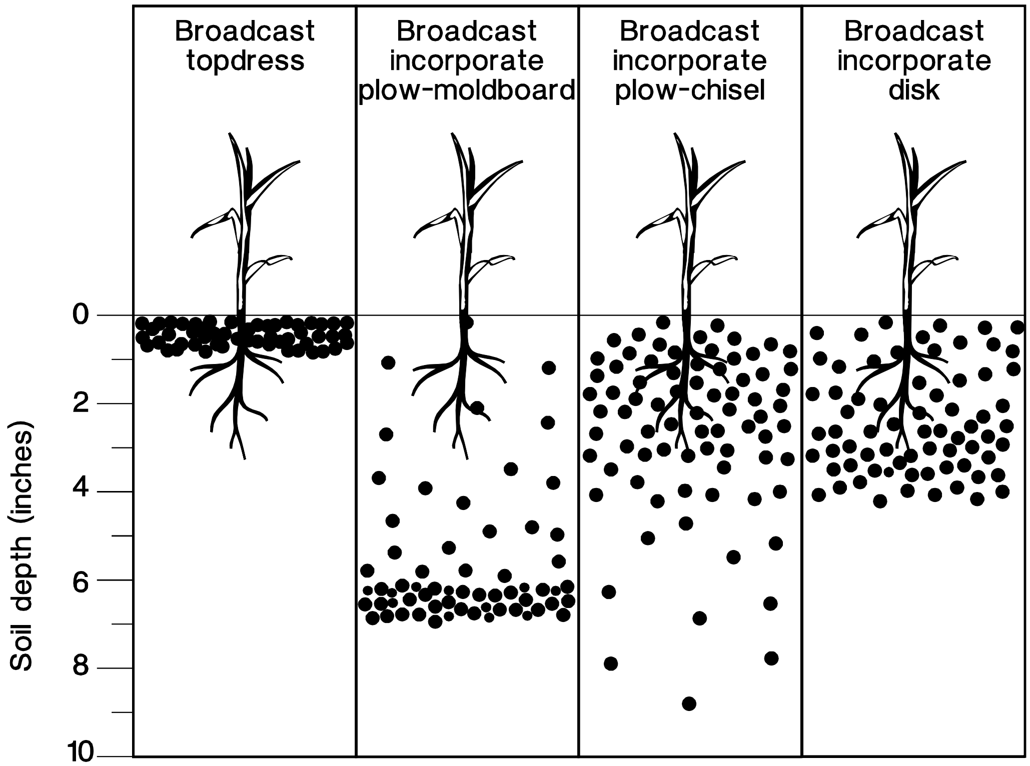
a.

b.

c.

d.

BROADCAST FERTILIZER



- Each method of broadcast is an adequate one for the application of some nutrients

-

- A majority of fertilizer applied in the United States is put on as broadcast applications

- Broadcast, preplant applications of solid fertilizers has become very popular in recent years due to:

1. The desire to lessen the time involved in handling fertilizers

2.

3.

4. Development of bulk blends to put a lot of material on at a time

However, problems also exist with broadcast applications, some of these include:

1.

2.

The following plant nutrients are usually applied as broadcast applications:

1.

2.

3.

4.

5.

6.

7.

8. Zinc

Separate Cases:

9. **Potassium — generally applied either way (broadcast vs band)**

   –

   – **Banding — preferred in soils containing a lot of vermiculite and/or illite — where K fixation occurs**

   –

10. **Phosphorus — generally broadcast only when you have moderate to high P levels already in the soil — at soil pHs 5.5 to 6.5**

    – **pHs greater than 6.5 — too much Ca in soils**
    P $\longrightarrow$ Ca•P unavailable

    –

    – **If soil P is very low it is generally recommended to:**

      –

    – **In Idaho, broadcasting is not nearly as efficient as banding; when P is limiting yields — you do not get comparable results**

11. Iron — generally not broadcast

   –

   – Fe reacts rapidly with the soil and becomes unavailable to plant growth

   –

12. Molybdenum — generally not applied as a broadcast treatment due to extremely low rates required

   –

   –

13. Chlorine — not applied as a fertilizer; used for plant disease control; — does not matter if banded or broadcast

14. Nickel — don’t apply

15. Oxygen — not needed as a fertilizer — Oxygen + (plus) products — no need to apply

16.

17.

18.

- There is a movement toward higher rates of fertilizer application in an attempt to improve the nutrient supplying power of the soil

- Higher rates of nutrient application tend to cause equity between banding and broadcast treatment applications

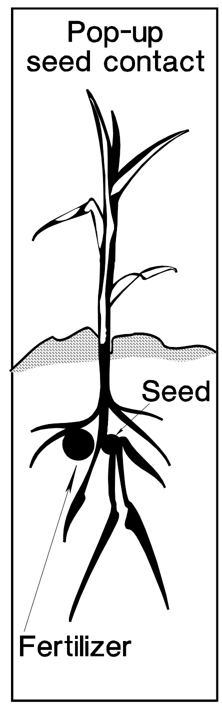
- Most researchers still maintain that fertilizers are used most efficiently when:

1.

2.

2. *Pop-up Fertilizer Application*

Pop-up — refers to the placement of small amounts of nutrients in direct seed contact



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In COLD soils:

1.

2. additional nutrients close to the seed can aid in absorption and result in better plant growth

Desirable characteristics of pop-up fertilizers include:

1. **Contain N, P, and K with high P content**
2.
3.
4. **Have a minimal content of compounds that liberate NH_3 (DAP, Urea)**
5.
6.

- **The most critical aspect however is:**

SALT INDEX — is a measure of the salt concentration that the fertilizer induces in the soil solution. The osmotic pressure of the soil solution is determined to measure the salt index.

SALT INDEX — is expressed as the ratio of the increase in osmotic pressure of the soil solution produced by the material to the osmotic pressure of the same weight of sodium nitrate, based on the relative value of 100.

SALT INDICES OF MATERIALS:

Material	Grade	SI	SI/20 lb of nutrient
Anhydrous ammonia	82-0-0	47.1	
Ammonium nitrate	34-0-0	101.7	
Ammonium sulfate	21-0-0	69.0	
Urea	45-0-0	72.7	
Sodium nitrate	16.5-0-0	100	
OSP	0-20-0	7.8	
TSP	0-45-0	10.1	
MAP	11-55-0	26.9	
DAP	18-46-0	29	
Potassium chloride	0-0-60	116.3	
Potassium sulfate	0-0-50	46.1	
Potassium nitrate	13.8-0-46.6	73.6	

LESSON 8
Applying Solid Fertilizers

- Crop tolerance to Salt Index (SI) also varies widely

  Tolerance:

So recommended maximum rate of fertilizer applied with seed varies with:

1.

2.

3.

- General rules for row crops in dry soils:

Corn & Sorghum:

–

– Keep total fertilizer applied for pop-up to a max of 50 lbs/acre

– Row spacing modifies:

  –

  –

Wheat:

- No more than 18-35 lbs N + K per acre in direct seed contact
-
- Row spacing modifies:
  -
  -

3. Band Fertilizers

- Terminology for methods of fertilizer placement vary somewhat depending on region or country
- Band placement of nutrients here is intended to mean:
  -

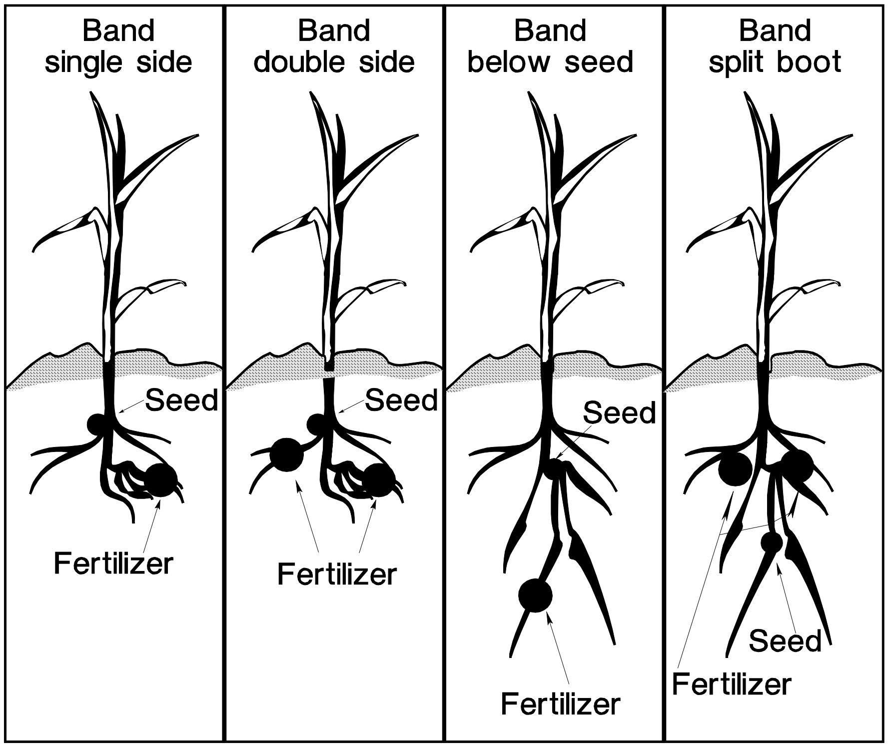
    a.

    b.

    c.

    d.
-

BAND FERTILIZER



- Usually, or at least frequently, the fertilizer material is placed at a depth greater than that of the seed in order to separate the fertilizer from:

1.

2.

-

- **Band placement of nutrients is popular for the following nutrients:**

–

__Topdressed__ — applications of nutrients usually implies post-emergence applications. Usually for N; usually a broadcast treatment.

__Sidedressed__ — refers to post-emergence fertilizer applications for row crops — usually for N.

◆ Phosphorus is the most commonly banded nutrient. Reasons for this include:

1.

2. High P concentration in limited soil zone promotes vigor conductive to early contact by plant roots particularly those growing in cold, wet soils

3.

4. Reduced rate of P fixation with soil due to high concentrations in a limited amount of soil

5.

◆ Environmental and cultural conditions that tend to favor band applications of P include:

1.

2.

3. Large amounts of soluble Al+++ and/or Fe++ in the soil

4.

5.

6.

7. Use of a very small amount of fertilizer (usually goes hand-in-hand with short term lease arrangements)

8.

- The rooting habit and activity strongly influence the responsiveness of a certain crop to band applications of nutrients; especially P

-

Crop	---------- 130 lbs P_2O_5 ---------- Broadcast	Banded
	% P from fertilizer	
Soybeans	30.8	42.4
Alfalfa	52.6	62.1
Red clover	56.6	67.7
Sweet clover	54.2	73.0
Corn	46.6	48.0
Wheat	38.9	56.7
Oats	43.3	60.4
Bromegrass	52.4	53.1
Grain sorghum	44.8	63.1

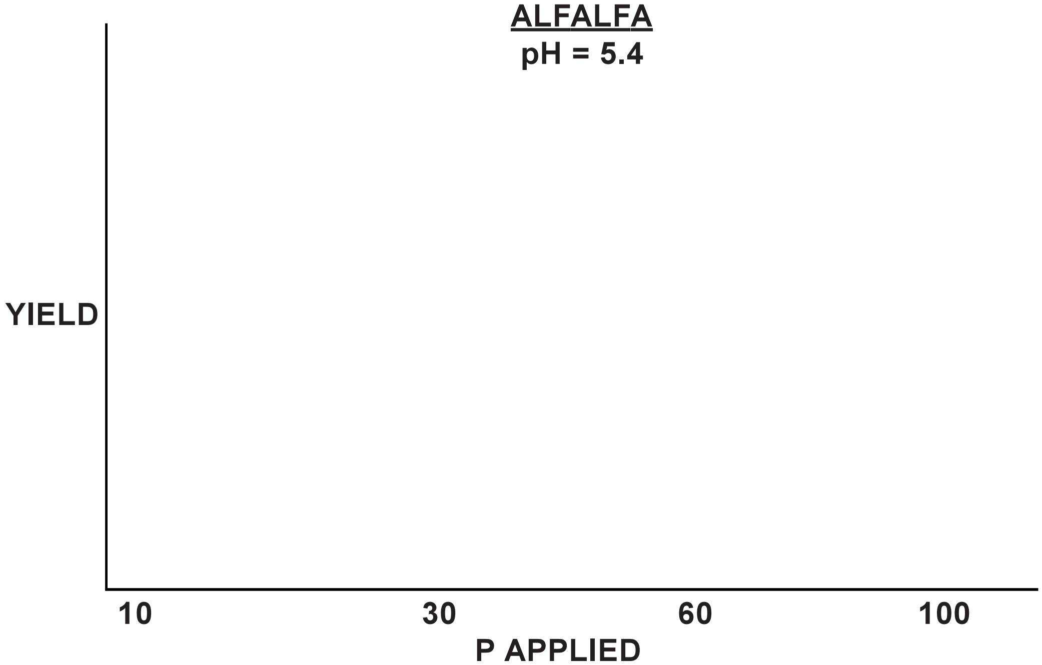
- The response of a crop to banded or broadcast P will also be influenced by:

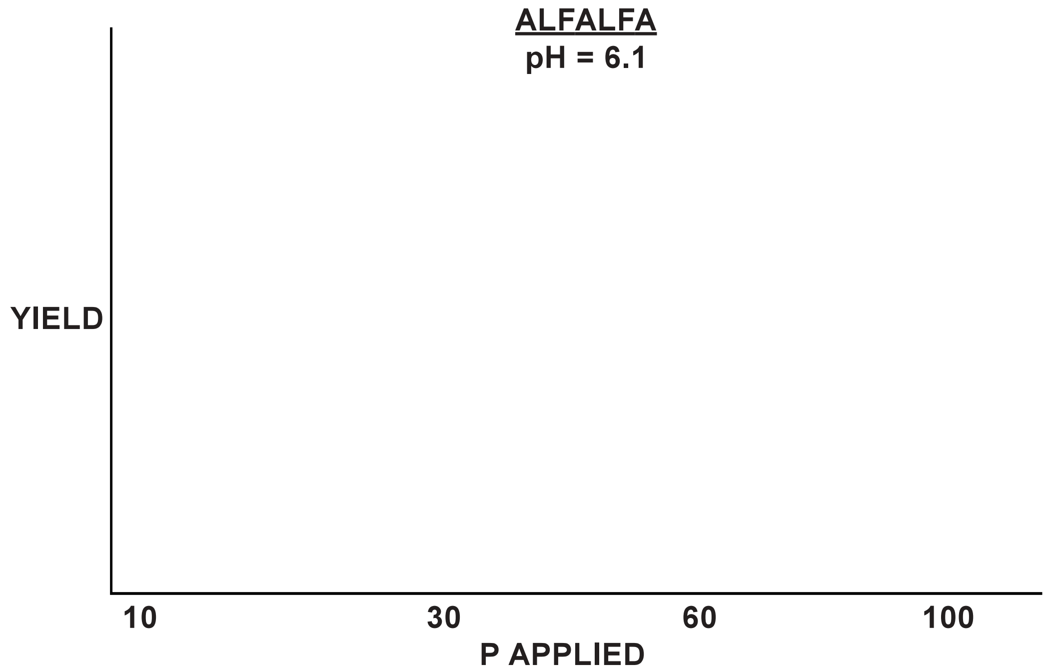
1.

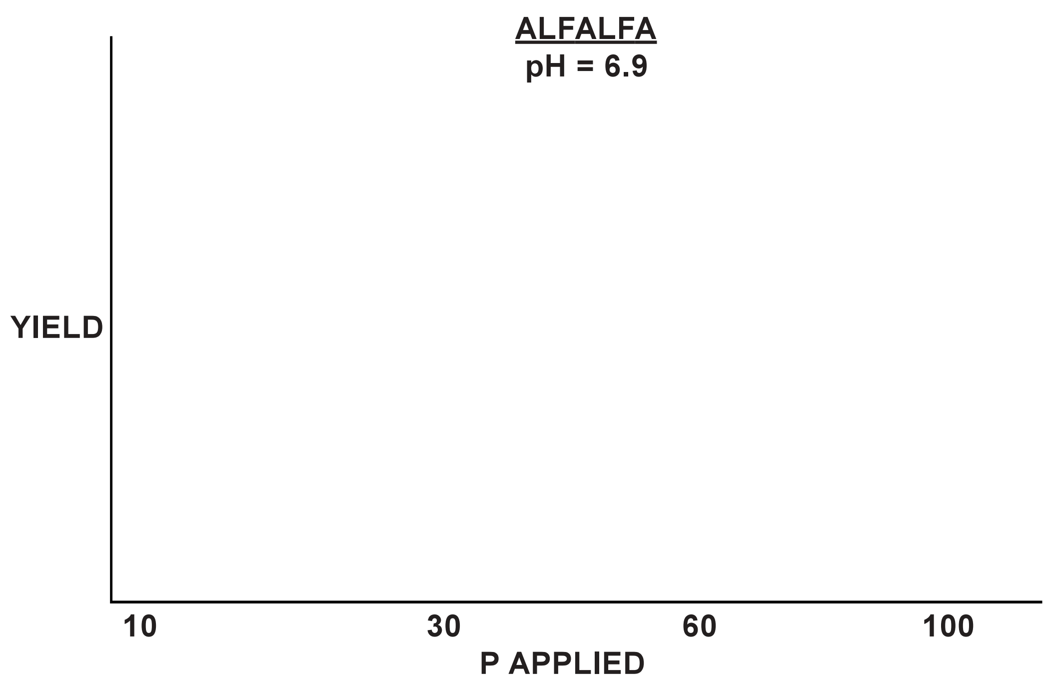
2.

–

Placement conditions and its effect on yield due to phosphorus:




ALFALFA
pH = 6.1
YIELD
10
30
60
100
P APPLIED


ALFALFA
pH = 6.9
YIELD
10
30
60
100
P APPLIED

◆

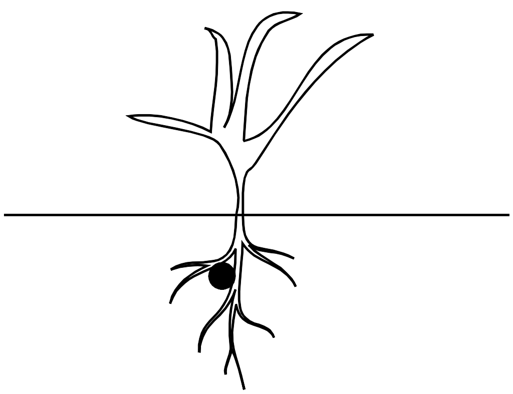
◆

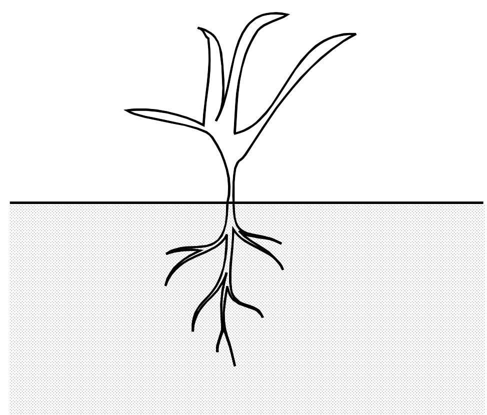
Nitrogen Banding: (usually below the seed)

–

–

–





LESSON 9
Foliar Fertilization

D. Foliar Fertilization

- Foliar fertilization has been practiced in many parts of the world for well over 100 years
- Foliar fertilization involves the application of nutrients in liquid and/or suspension to the foliar parts of the growing plants

1. Advantages of Foliar Fertilization:

-
- Results in rapid nutrient absorption and utilization by growing plants
-
-
-
- Can apply fertilizers in combination with herbicides, insecticides, and/or fungicides

2. Disadvantages of Foliar Fertilization:

-
- Some nutrients are in salt form, and consequently may damage leaves of plants if applied at too high of concentrations

-

-

- Plants intercept nutrients — little gets into soils — so you have the same problem again next year

- Often need to apply several times during season if dealing with an immobile nutrient (boron)

-

3. *Foliar Application:*

- Foliar nutrition — involves the absorption of nutrients by all above ground parts of the plant

-

  –

- Nutrients are applied to plant foliage as sprays

  – equipment used for applying pesticides is usually suitable for applying nutrients to crops

- Foliar feeding by aerial applications:

  –

–

- best method to use when ground equipment can not enter the field or where very large acreages must be covered quickly

- Ground spray equipment used for foliar application:

–

–

The spray may be applied through:

–

–

- multiple-nozzle, oscillating, or stationary cyclone type orchard sprayers

- For non-N applications, the concentration of a nutrient in solution is usually less than 2 percent

4. Orchards

- **Foliar feeding is the most common way to apply nutrients to orchards**
-
- **Only differences are that nutrient concentrations are higher and they are often applied at the latter part of the plant's dormant stage**
-

5. N Applications to Crops as a Foliar Spray:

-
- **A major problem associated with high foliar N applications is the potential of damage due to leaf burn**
- **This problem is more apparent in situations where the air temperature is above 60°F**
- **LEAF BURN — may often be severe enough to cut yields**
- **Yield reductions in wheat production due to leaf burn have been observed up to 60%**
-
-

- Urea is the usual problem in situations where leaf burning occurs
- Most common foliar N sources are:

6. Solution N — Herbicide Tank Mixes:

- Foliar N applied as a tank mix with a herbicide often results in better weed control and yields than when applied separately

A. Topdress (Spring) N applications on winter wheat
N SOURCE: Solution 32
HERBICIDE: Bronate

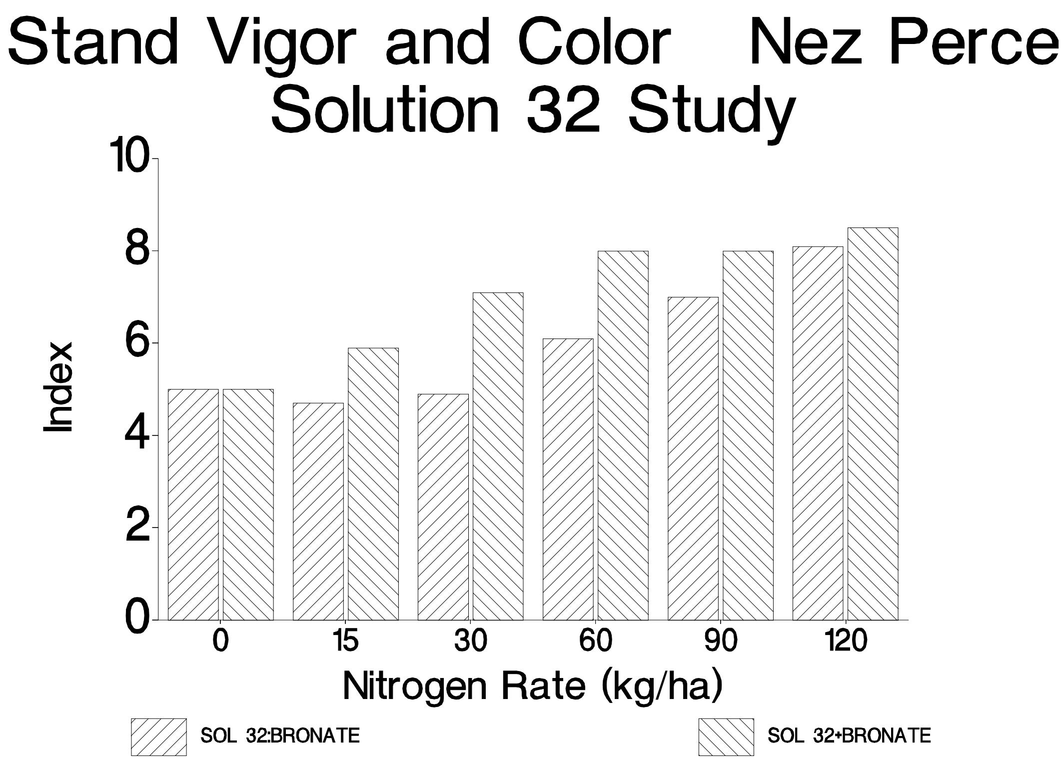


Figure 1. Comparison of Solution 32 - Bronate tank mixes with separate Solution 32, Bronate applications on stand vigor and color.

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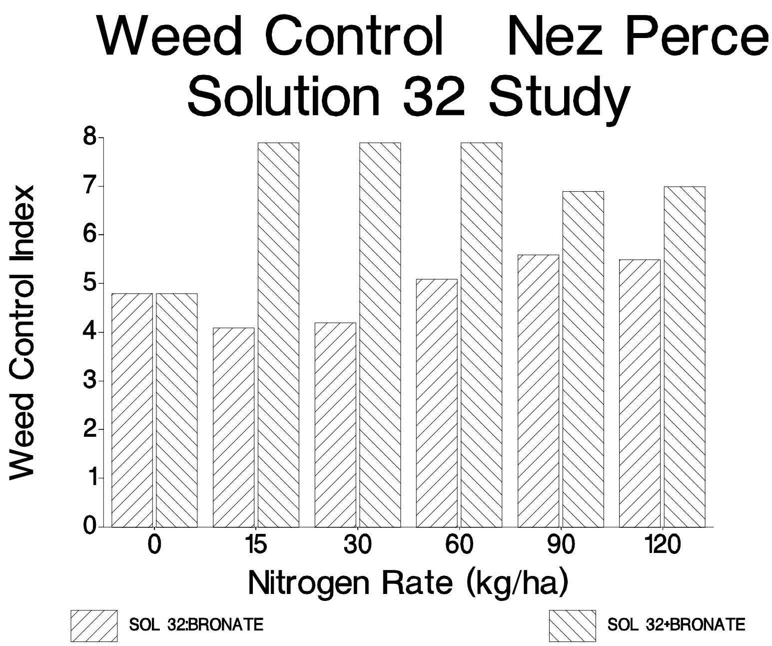

Figure 2. Comparison of Solution 32 - Bronate tank mixes with separate applications on weed control.

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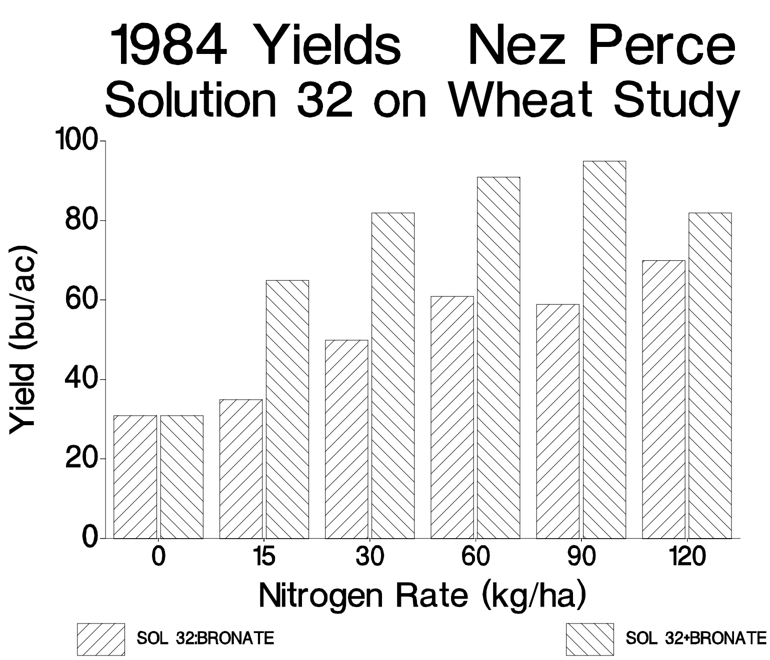

Figure 3. Comparison of Solution 32 - Bronate tank mixes with separate applications on yield.

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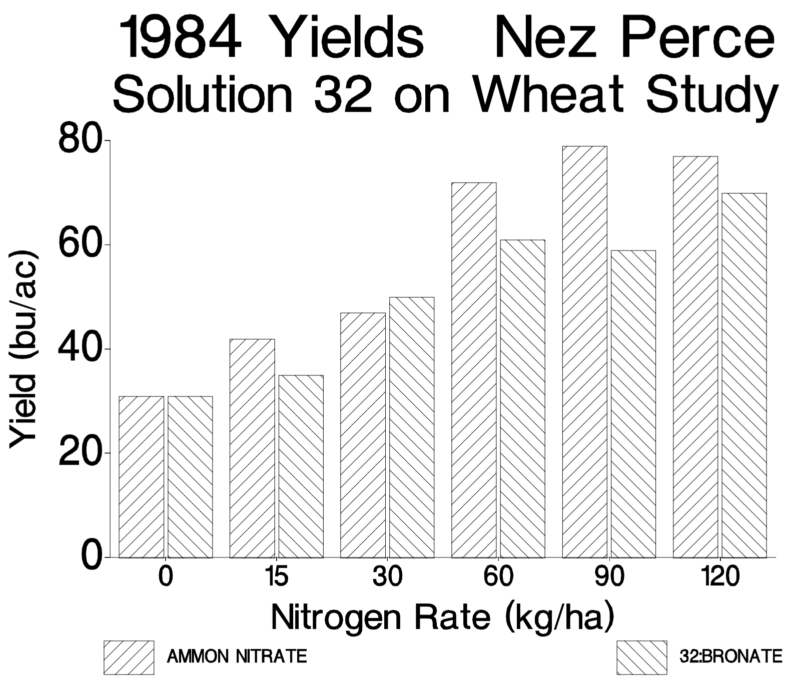

Figure 4. Comparison with solid ammonium nitrate.

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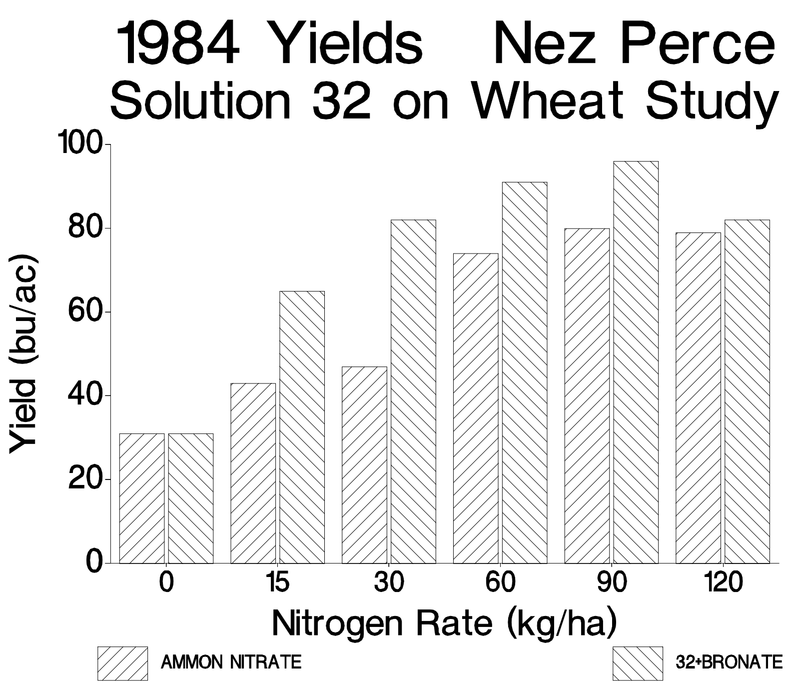

Figure 5. Comparison with solid ammonium nitrate.

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LESSON 10
Physical Properties of Fertilizers and Methods for Measuring Them
Particle Size
Segregation Properties

IV. Physical and Chemical Properties of Fertilizers

The PHYSICAL form of a fertilizer is important:

1.

2.

3.

4.

Most problems encountered with fertilizers probably are those resulting from deficiencies in PHYSICAL PROPERTIES:

1.

2.

3.

4.

5.

- Physical properties, unlike chemical properties, normally are NOT governed by laws (except LIME)

A. Particle Size

- Measurement of particle size is an important physical test that is routinely applied to fertilizer materials almost as frequently as chemical analysis

(i) Effects on agronomic response:

- fertilizers of very low water solubility must be ground to a very small size to ensure availability to plants

Examples:

- Rock phosphate —

- Lime (slags, $CaCO_3$), dolomite) —

- Most Micronutrient Salts —

- Fritted Micronutrients —

- Slow-Release Fertilizers — small particle size — large surface area — faster release rate

- The fine grinding required for these materials often results in UNDESIRABLE DUSTINESS and other HANDLING DIFFICULTIES

  - Due to these problems there has been a move to re-granulate these pulverized materials

    - especially true

In contrast there are some very water soluble materials — where its is desirable to have a LARGER GRANULE SIZE — so it won't react with the soil too quickly

- Other methods beside regranulation include:

  –

  –

These include:

Especially on acid soils of high P fixing capacity; an increase in fertilizer particle size up to 5 mm in diameter may be desirable

- Slow release — the larger the particle size — the slower the release rate

(ii) Effects on Storage and Handling

- Particle-size control of fertilizers is important to ensure satisfactory storage and handling properties
- Want particles large enough to eliminate dust

  –

  –

- Fertilizers should be free from particles small enough to generate dust

–

– Large size minimizes WIND DRIFT and reduces lodging of granules in tree and/or plant branches

–

(iii) Effects on blending properties

–

–

–

(iv) Screen Analysis Procedures

– Particle size distribution is measured by conducting a "Screen Analysis" (Sieve Analysis) on a representative sample

EQUIPMENT NEEDED:

1. A set of standard wire mesh test sieves 8 x 2 inches deep; largest on top, finest on bottom

2. A means for shaking the sieve stack. It is much preferred to use a mechanical shaker of which numerous models are offered; but can shake by hand

3. A balance for weighing the sample and size fractions developed in the sieve test

– Generally use a 200-5-- g sample; place sample on upper sieve;

–

–

– For testing granular fertilizers in U.S. — the following U.S. Standard mesh sieves are used:

B. Segregation Properties

- Segregation occurs when individual granules or particles in a fertilizer differ in physical properties to such an extent that they respond differently to mechanical disturbances caused by handling processes
- Trick is — to use particles of identical size; major problem occurs in bulk-blending plants

3 Distinct Types of Segregation:

1. SEGREGATION DUE TO VIBRATION:

–

–

–

2. SEGREGATION DUE TO FLOW (CONING)

–

–

–

3. SEGREGATION DUE TO BALLISTIC ACTION

–

–

–

LESSON 11
Granule Hardness
Bulk Density
Angle of Repose
Critical Relative Humidity
Apparent Specific Gravity

C. Granule Hardness

- **Fertilizer granules should have sufficient mechanical stability to withstand normal handling without fracturing and without excessive sloughing to form dust**

3 Types of Strength are Desirable:

1.

2.

3.

(i) Crushing Strength

–

TEST:

- **A granule which can be crushed between thumb and forefinger**
  SOFT
- **Between forefinger and hard surface**
  MEDIUM HARDNESS
- **If not crushed between forefinger and hard surface**
  HARD

(ii) Abrasion Resistance

–

MEASUREMENT:

– Use rotary drum; 100 g sample; 50 steel balls 5/16 inches diameter; rotate at 30 rps for 5 minutes; remove contents, screen, count percent degradation

Fertilizer	Abrasion % Separation	Crush Strength lbs
AN Prills	4.6	2.5-4
Prills	19.7	2
Granular	0.2	1.5-7
S. Granular	1.1	4.5-5.5
AP 11-55-0	1.3	4-6
SP 0-44-0	0.7	3.5-8

(iii) Impact Resistance

–

–

D. Bulk Density

<u>BULK DENSITY</u> — weight per unit volume of a bulk fertilizer

Value (BD) for this property is required for:

1.

2.

3.

Measured by:

– open top metal or plywood box; 1 x 1 x 1 ft. internal dimension

Procedure:

–

–

–

"PACKED" or "TAPPED" density

–

- Procedures routinely done with new batches of fertilizers — have an economic significance

Bulk densities of granular fertilizers vary from about 45 to 75 lb/ft^3 (0.72 to 1.2 tons/m^3)

	Bulk Density	Angle of Repose
OSP	60-70	30-35
TSP	55-65	30-35
Lime	80-95	45-50
U (prilled)	46	28
U (granular)	45-48	34-37
AS	63-66	29
MAP	60-65	30-35
DAP	60-65	30-35

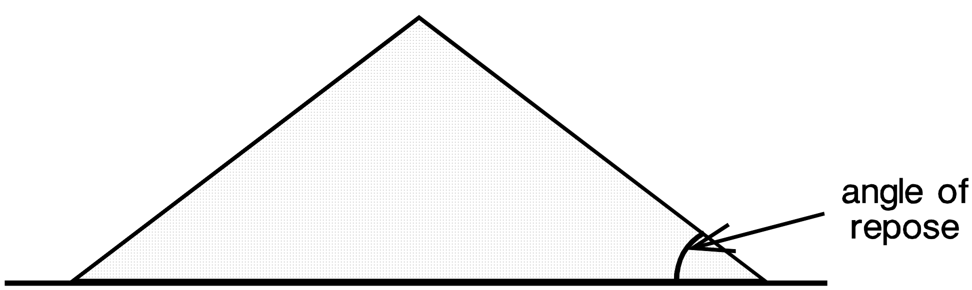
E. Angle of Repose

- **The angle with the horizontal at which the fertilizer will stand when poured or dropped into a pile from a fixed overhead point**

This property affects:

1.

2.



LIME **UREA**

To measure:

–

–

F. Apparent Specific Gravity (ASG)

<u>ASG</u> Defined — the ratio of the weight of a single granule to that of an equal volume of water (at 4°C)

- **ASG is not a property that is measured frequently, but it has been of special interest in connection with studies of particle segregation characteristics and in the development of granulation processes**

G. Critical Relative Humidity (CRH)

CRH Defined — as that humidity of the atmosphere above which the material will spontaneously absorb moisture and below which it will not

i.e. 65% CRH — means absorb water above 65%

–

–

– A high CRH is desirable since it can be stored and handled under more humid atmospheric conditions without becoming wet and non-flowable

–

CRH — Measurement

– Many methods — DIRECT

– Expose sample to various controlled humidities and temperatures and determine at what humidity the sample gains weight

Critical RH of some fertilizers:

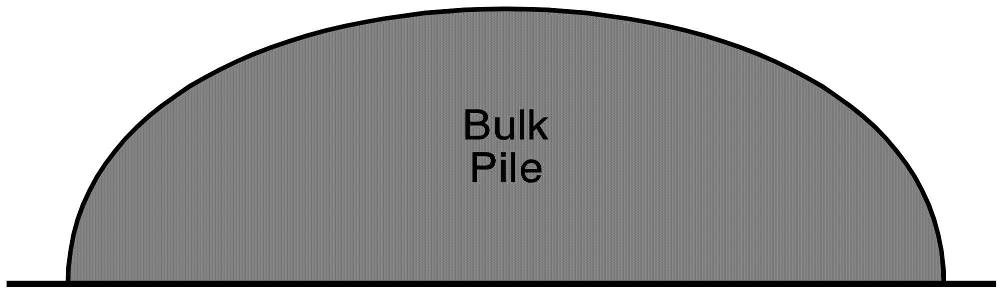
Fertilizer	CRH
$Ca(NO_3)_2$	46.7
NH_4NO_3	59.4
$NaNO_3$	72.4
Urea	72.5
Ammonium chloride	77.2
AS	79.2
DAP	82.5
KCl	84.0
KNO_3	90.5
MAP	91.6
K_2SO_4	96.3

- However, when bulk blended you get a lower CRH then either of the constituents

  –

CRH of Common Mixtures

Mix	CRH
$Ca(NO_3)_2 + KNO_3$	31.4
U + KCl	71.5
MAP + KCl	79.0
AS + DAP	72.0
U + DAP	62.0
U + MAP	65.2



The surface of bulk piles are frequently exposed to humid conditions

LESSON 12
Rate and Effects of Moisture Absorption
Caking of Fertilizers

H. Rate and Effects of Moisture Absorption

	Calcium Nitrate	Ammonium Nitrate	Sodium Nitrate	Urea	Ammonium Chloride	Ammonium Sulfate	Diammonium Phosphate	Potassium Chloride	Potassium Nitrate	Monoammonium Phosphate	Monocalcium Phosphate	Potassium Sulfate
Calcium Nitrate	46.7											
Ammonium Nitrate	23.5	59.4										
Sodium Nitrate	37.7	46.3	72.4									
Urea	—	18.1	45.6	72.5								
Ammonium Chloride	—	51.4	51.9§	57.9	77.2							
Ammonium Sulfate	—	62.3	—§	56.4	71.3	79.2						
Diammonium Phosphate	—	59*	—	62*	—	72*	—					
Potassium Chloride	<22.0	67.9§	66.9§	60.3	73.5	71.3§	<22.0	84.0				
Potassium Nitrate	31.4	59.9	64.5	65.2	67.9	69.2	31.4	78.6	90.5			
Monoammonium Phosphate	52.8§	58.0	63.8	65.2	—	75.8	52.8§	72.8§	59.8	91.6		
Monocalcium Phosphate	46.2	52.8	68.1	65.1	73.9	87.7	46.2	—§	87.8	88.8	91.6	
Potassium Sulfate	76.1§	69.2§	73.3	71.5	71.3	81.4	76.1§	81	87.8	79.0	—§	96.3

*** Approximate values obtained by TVA. Other data are from literature.**
§ Unstable salt pair; value given is for the stable pair.

Thus it is important to know:

1.

2.

- **Other exposure of fertilizers to humid atmospheres occurs during handling and spreading — in those cases most concerns center around:**

  –

4 Tests

–

–

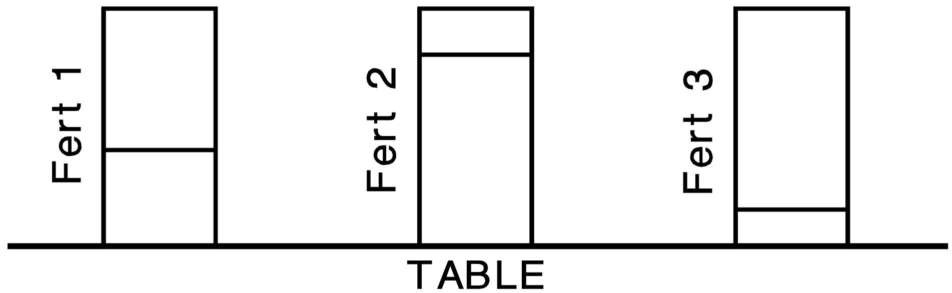
(i) <u>Laboratory Absorption-Penetration Tests</u>

<u>Principle:</u> exposure of a bulk fertilizer of known surface are to controlled temperature and humidity to measure:

1.

2.

–



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–

- Results of this test are indicative of expected bulk fertilizer behavior under steady, high humidity conditions

However, remember under normal storage conditions you get cycles

humid - dry - humid

and consequently may get a crust formed (self-sealing) during a dry cycle which may protect the rest of the material

(ii) Small Pile Tests

Bulk storage of fertilizers in open piles may incur either or both of 2 major problems:

1.

2.

Small pile tests are mimics of bulk storage conditions

- –

Exposure periods of 1-3 months; take samples at different depth, analyze moisture content, and loss of granule hardness

(iii) Protection of Bulk Storage

Fertilizers in bulk storage may require special protection from atmospheric moisture if one or more of the following conditions prevail:

1.

2.

3.

Precautions:

- **For small piles (100-300 tons)**
  - –
- **For large Piles (> 300 tons)**
  - –
  - –

(iv) Drillability Tests

–

$$\frac{\text{(flow rate after exposure)}}{\text{(flow rate before exposure)}} \times 100 = \%\ \text{relative drillability}$$

Procedure:

1.

2. Expose fertilizer to high humidity in shallow pans in a controlled humidity chamber for a given length of time

3.

4. Continue exposure and remeasure delivery rate for additional time periods until flow is seriously impaired

(v) Lab Flowability Tests

– 500 g test sample; place in inclined rotary pan; place in humidity chamber, high RH, rotate at 12 rpms, measure time you have free-flowing material in pan

I. Caking of Fertilizers

CAKING: Agglomeration or lumping

–

– These crystals usually develop during storage — due to internal chemical reactions or thermal effects

- Contrary to popular belief, caking in storage usually is not the result of absorption of water but usually due to the presence of excess water left in the granule during manufacture

(i) <u>Effects of Moisture Content</u>

- The amount of water allowed to remain in a fertilizer at the time of its manufacture has a great effect on its tendency to cake in storage

-

-

Desirable Levels of Product Moisture:

0 – 0.5% H_2O:

–

–

–

–

–

0.5 – 1.0% H_2O:

–

1.0 – 1.5% H_2O:

–

–

1.5 – 2.0% H_2O:

–

> 2.0% H_2O:

–

(ii) <u>Effects of Particle Size and Hardness</u>

◆ **Production of large fertilizer particles with an absence of fines; reduces the number of contact points between particles and thus reduces caking**

–

◆ **Mechanical weakness of granules usually promote excessive caking. Under the pressure of storage piles, weak granules tend to DEFORM and form relatively large areas of contact between the granules.**

(iii) <u>Effects of Conditioners</u>

Definition — a material added to a fertilizer to promote the maintenance of good physical conditions (flowability) during storage and handling

◆

◆ Usually it is preferable to use other means — such as good drying because of expense

◆ A good modern conditioner is diatomaceous earth — it functions as:

1.

2.

– where caking does occur — the presence of a conditioner usually weakens the bonds resulting in less severe caking

◆ LIQUID CONDITIONERS — function as crystal modifiers to inhibit or weaken crystal bonds

◆ A few conditioners are listed as INTERNAL conditioners ⟶ added into fertilizer formulations before granulation, they act internally, usually as hardeners or crystal modifiers to improve storage properties

UREA — FORMALDEHYDE used; 0.2-0.5% as a hardener and anti-caking agent

◆ Solid Conditioning Agents:

–

–

–

–

– usually 1-4% by weight in formulation

AN 35% N
33.5% with conditioner

- Desirable properties:

1.

2.

3.

- Adherence of solid conditioners is usually done by spraying a small amount of oil (0.2 to 0.5%) either before or after conditioner application

LESSON 13
Chemical Compatibility in Fertilizer Blends
Dustiness and Conditioner Adherence
V. Micronutrients

(iv) <u>Effects of Storage Temperature</u>

The higher the storage temperature the greater the likelihood of caking of some fertilizers — so keep the fertilizer cool!!!!

-

  –

  –

  –

(v) <u>Effects of Storage Pressure</u>

- **If a fertilizer has a tendency to cake in storage, high storage pressure should be avoided**

-

-

- **30-40 stacks are not uncommon with some fertilizers of low caking tendency**

- Average pressure on a fertilizer bag at bottom of a stack can be calculated by measuring the bearing area on the bag (contact area between the bags) and dividing the weight of the stack by this area

(vii) Large Bag Storage Tests

The caking tendency of a fertilizer can be evaluated by a storage test, under pressure, in standard-size moisture proof fertilizer bags

Advantages:

1.

2.

Disadvantages:

1.

2.

3.

4.

5.

Procedure:

1. **Test made in 50 lb size fertilizer bags of monofilm polyethylene with 7 mil wall thickness**

2. **From 1 to 5 bags are stacked vertically, and a 17- by 30-inch piece of plywood is placed on the top bag. The 10-100 lb bags of sand are stacked on the plywood board**

   – **The resulting pressure on the test bags is equivalent to that at the bottom of a 20 bag stack of 50 lb bags**

3. **Tests are conducted in unheated warehouses, windows open — for a typical warehouse setting**

4. **Inspections made at 1, 3, 6, 9, and 12 month intervals**

Products that develop any appreciable amount of caking in 1 month are very likely to develop more serious caking during longer storage

Just because no caking in 1 month doesn't mean no caking later

Inspection:

A. **Remove sand bags and inspect for "BAG SET" — feel bag and record set as:**

   none – 0
   light – L
   medium – M
   hard – H

   –

B. **Drop bag on thin side once from 3 ft height onto CONCRETE floor to simulate action of NORMAL HANDLING. Cut bag open, screen gently (without lump breakage) to determine the proportion of +½ inch lumps.**

C. Hardness of lumps are then rated by hand crushing. Ratings:

L –

M –

H –

D. Results reported to give:

(1)

(2)

(3)

i.e., M–10–L

–

J. Chemical Compatibility in Fertilizer Blends

- The first step toward making a good bulk blended fertilizer of good quality is the choice of ingredients that are chemically compatible

- Chemical incompatibility of materials may take one or more of the following forms:

1.

2.

3.

4.

Method of detection — use a “single bottle method.” Basically the procedure consists of:

–

–

–

–

Inspection will reveal

–

-

Example:

Urea + AN = CRH of 18%

–

◆

AN	**TSP**	**KCl**
U	**OSP**	**K_2SO_4**
AS	**DAP**	
	MAP	

X – incompatible
L – limited compatibility
OK – compatible

	AN	U	AS	TSP	OSP	DAP	MAP	KCl	K_2SO_4
AN									
U	X								
AS	OK	OK							
TSP	OK	L	OK						
OSP	OK	L	OK	OK					
DAP	OK	OK	OK	L	L				
MAP	OK	OK	OK	OK	OK	OK			
KCl	OK	OK	OK	OK	OK	OK	OK		
K_2SO_4	OK	OK	OK	OK	OK	OK	OK	OK	

- **With the major N, P, and K sources only problems are with:**

AN-U; U-TSP; U-OSP; TSP-DAP; OSP-DAP

K. Dustiness and Conditioner Adherence

- **Dustiness has recently become more of a problem because:**

  1.

  2.

- **Granulation does much to reduce dustiness but frequently does not solve the problem**

Common causes of dustiness of granular products include the following:

1.

2.

3.

4.

L. Melting Point

-

-

M. Physiological Acidity and Basicity of Fertilizers

- The use of fertilizers in agriculture often tends to change the pH of a soil

-

- The physiological reaction of a fertilizer should not be confused with the chemical reaction

  – i.e. Urea $\longrightarrow$ hydrolyzes in the soil to form ammonia $\longrightarrow$ thus initially raising the pH of the soil near the granule to pH 9

- The effect of a single year's application of a fertilizer is very small however, the cumulative effects over a long time period are very important!!

Classification of Elements

Acid-forming	Equiv acidity, kg of $CaCO_3$ per kg of element
S	-3.12
Cl	-1.41
P	-1.62
N	-1.79

Base-forming	kg of $CaCO_3$ per kg of element
Ca	+2.50
Mg	+4.12
Na	+2.18
K	+1.28

V. Micronutrients

Can apply:

-

-

-

Micronutrient salts:

-

-

-

Other Common Materials:

-

-

-

LESSON 14
Slow Release Fertilizers

Nitrogen Use Efficiency (NUE)

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PROBLEMS:

–

–

–

A. Slow Release Fertilizers

1. Objectives

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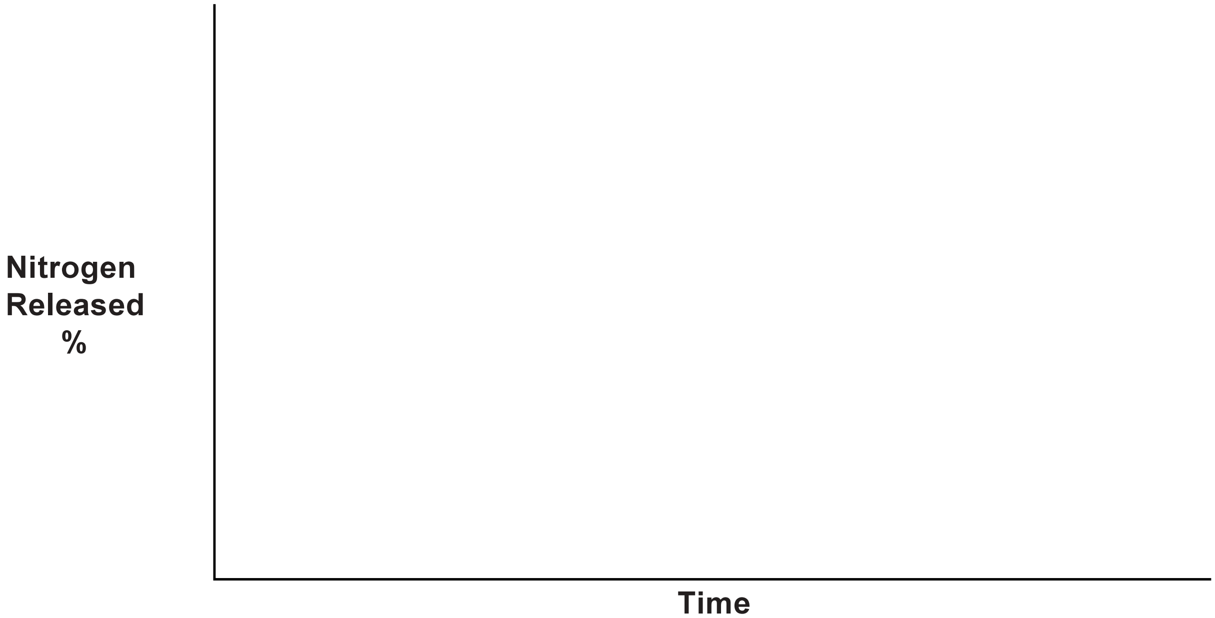
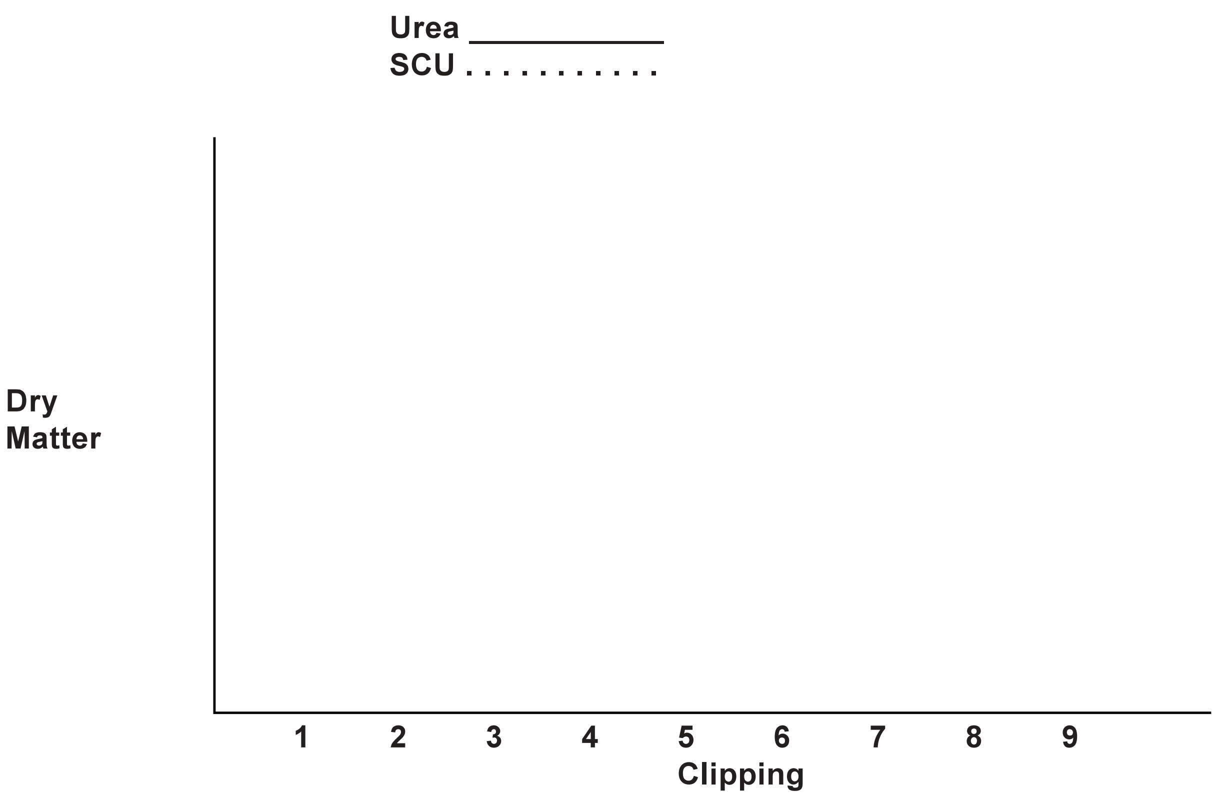
– **Reduce salt damage**

2. Release Pattern



3. Properties of Controlled-Release Fertilizers



4. Economics

   Urea —

   SCU —

   N need = 120 lbs N

Urea $^{120}/_{.50}$ =

SCU $^{120}/_{.70}$ =

In this case the slow-release saved money

B. A "New" Approach to Improving NUE

- Control the rate of N dissolution

1. Approach #1

This can be done by:

(i)

(ii)

2. Approach #2

This can be done by:

(i)

C. Concepts of "Slow-release"

For N fertilizers — strategies:

1.

2.

3. Reduction of N loss via ammonia (NH_3) evolution or denitrification following nitrification

<u>Terms:</u>

Slow release Slow acting Controlled release Metered release	release N to the soil solution in a matter that matches the needs of the growing plant

Delayed release — little or no N is available for an initial time period

4 types of slow-release N fertilizers:

1.

2. Materials of limited water solubility containing plant-available forms of N

   –

3. Materials of limited water solubility — which during their chemical and/or microbial decomposition — release plant-available N

–

4. **Water soluble or relatively water soluble materials that gradually decompose — releasing plant available N**

   –

D. Coated Materials

1. Sulfur-coated urea

SCU — developed by TVA

–

- **Molten S is sprayed on a falling curtain of preheated urea particles in a rotating drum. A sealant is then applied to close pores in the S coating, followed by a conditioner.**

2. Polymer-coated fertilizers

Osmocote —

- **The thickness and composition of the coating controls the release rate**

3. Matrixes and Encapsulations

Matrix — soluble fertilizer is dispersed into asphalts, gels, oils, paraffins, polymers, resins, or waxes

Encapsulations — a group of fertilizer particles rather than single particles

4. Frits

-

-

-

E. Uncoated Organic Materials

1. Urea-Aldehyde Condensation Products

- **Urea + aldehydes → forms compounds that are sparingly soluble in water**

a. ureaform (UF)

–

–

b. Crotonylidene Diurea (CDU)

–

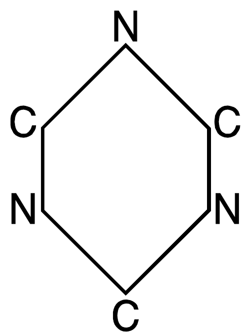
c. Isobutylidene Diurea (IBDU)

–

–

2. Triazines (Urea Pyrolyzates)

- Urea + heat + ammonia + pressure



3. Oxamide

–

–

4. Guanylurea

- polymerizing cyanamide → dicyandiamide

↓

then hydrolysis with H3PO4 or H2SO4

↓

guanylurea phosphate
or
guanylurea sulfate

LESSON 15
Alternative Products in Agriculture

NAMES

-
-
-

VII. Alternative Products in Agriculture

New agricultural products appear on the market in a steady stream

- –
- –
- – **The questionable products are seldom worthless but may be worth very little in relation to their cost**
- – **A "wonder product" is often sold as a cure-all for practically all soils and crops**
- –
- –
- – **What are university responsibilities?**
  - –
  - –

National wonder products:

- **Willard Water — 60 Minutes**
-
- **Oxygen Plus**
-

Claims are usually made for all the good things that can happen to a soil:

1. **Increase in soil water holding capacity**
2.
3.
4. **Increase nutrient holding capacity and nutrient availability**
5. **Improved soil structure and aggregate stability**
6.
7.
8. **Increased disease and insect resistance**
9.
10.

11. Increased base exchange capacity

12.

13.

14. Increased water use efficiency; decreased water evaporation

15.

TYPES OF ALTERNATIVE PRODUCTS:

1. Soil Additives

Function: reportedly replace or supplement commercial fertilizers

Examples:

–

–

2. Soil Amendments

Function: improves the soil's physical or chemical properties

Examples:

–

- adding a few hundred pounds of soil amendments — will have nil influence on these properties

3. *Microbial or Bacterial Inoculants*

Function: increase numbers of beneficial organisms already present

***note: *Rhizobium* and mycorrhizae are legitimate**

Examples:

–

– **Green algae to improve soil structure**

–

–

4. *Supplemental Organic Materials*

Function: increase levels and activity of soil organic matter

Examples:

–

–

– **How can 2 lbs/acre of humus increase the OM level in a soil with 2% OM?**

soil with 2% OM:

2% = 40,000 OM + 2 lbs = 40,002 lbs!

5. Plant Growth Regulators (PGRs)

Function: stimulate plant growth processes

- –

- –

- **not all PGRs are beneficial to plants**

Examples:

- –

- –

- **stimulate early root growth**

What responses should be given to questions about wonder products?

- **Attacking their validity is difficult!**
- –

- –

- **In time products fade from the market;**
  -
  -