Ontario Certified Crop Adviser Pre-Exam Workshop
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IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Nutrient Management

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Formed in 2007 from the Potash & Phosphate Institute, the **International Plant Nutrition Institute** is supported by leading fertilizer manufacturers.

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1. Describe the roles of nitrogen, phosphorus, potassium and magnesium in plants

- Nitrogen
  - Amino acids, proteins, enzymes, chlorophyll
- Phosphorus
  - Energy transfer: sugar phosphates, ATP
  - DNA, RNA
- Potassium
  - Water, turgor, stomates, disease suppression, enzyme activator
- Magnesium
  - Chlorophyll, enzyme activator, energy and P

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Nutrient Management #2

- Define base saturation
  - "the proportion of the soil's cation exchange capacity (CEC) that is occupied by exchangeable base cations"
  - Base cations: Ca^{++}, Mg^{++}, K^{+}, NH_4^{+}, Na^{+}
  - Acid cations: H^{+}, Al^{+++}
  - milliequivalent basis (meq/100g = cmol(+)/kg)

Soil pH	Base Saturation
4.5	~15-20%
5.5	~50%
6.5	~80%
7.5	~95-99%

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Nutrient Management #3 and #4

3. Influence of soil pH, clay, and organic matter on CEC and base saturation

4. Describe the difference between an estimated value for cation exchange capacity and an actual determination

- CEC - calculated from base cations + pH
  [meq Ca^{++} + Mg^{++} + K^{+} + H^{+}]
  - H^{+} estimated from pH

CEC = Ca/200 + K/390 + Mg/120 + 1.2(70-BpH*10)
(when pH>6, H^{+}=1.2; when pH>7, H^{+}=0)

- CEC can also be determined separately
  "true determination": barium as marker cation
- Rougher estimate: 2(%OM) + 0.5(%clay)

5. Define guaranteed analysis as outlined in the Fertilizers Act of Canada

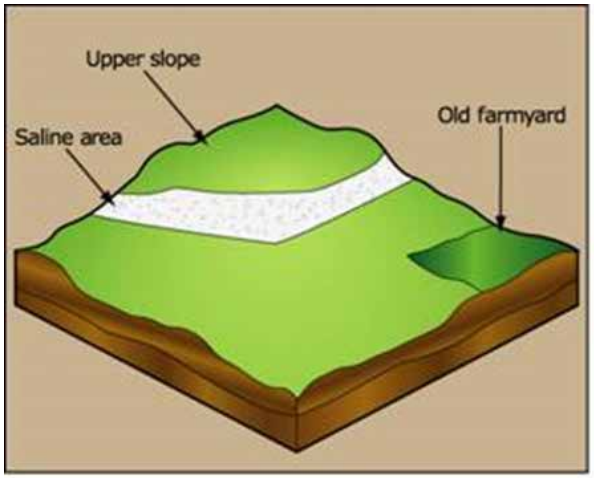
- % N-P_2O_5-K_2O-(other)
- N = total N
- P_2O_5 = available phosphate (or available phosphoric acid)
- K_2O = soluble potash
- All other nutrients = total element, label indicates which element is guaranteed
- e.g. 8-32-16-2.7Mg-5.5S-0.5Zn

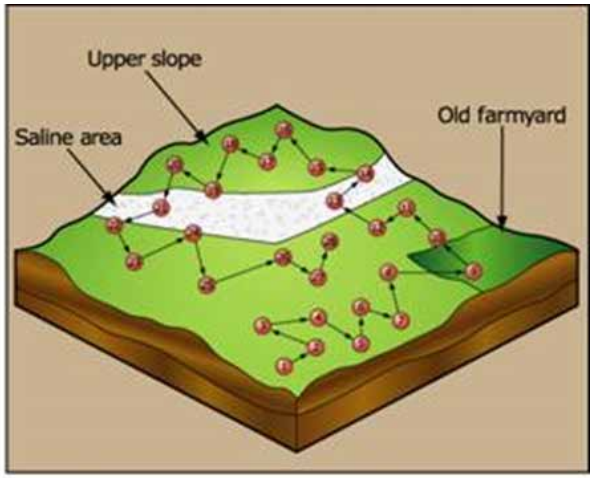
6. Describe the soil sampling procedures recommended in the Agronomy Guide for Field Crops, OMAFRA Publication 811

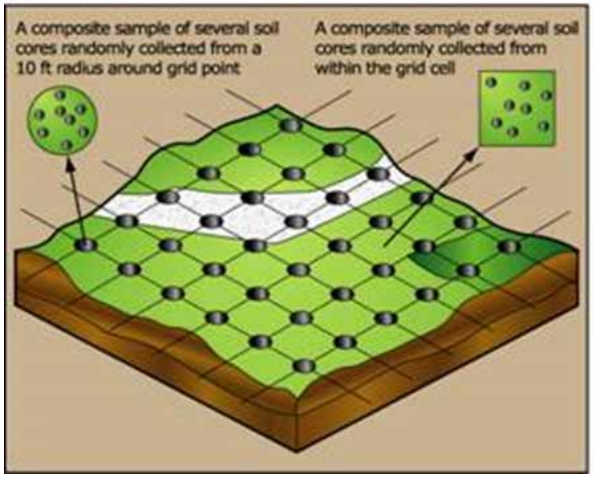
- Sampling depth
  - Plow layer, 0-15 cm (0-30 cm for nitrate)
- Sampling frequency
  - Once every 3-5 years, more frequent on sandy soils with high K crops
- Sampling area
  - <25 acres
- Number of cores
  - 20-25 (not less than one per acre), random

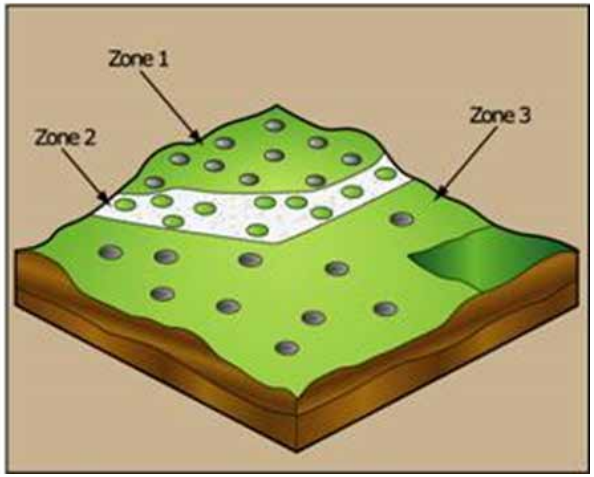
7. Describe methods used for site specific/intensive soil sampling and list their advantages and disadvantages

- Grid sampling
- Soil map units
- Topography
- Management units





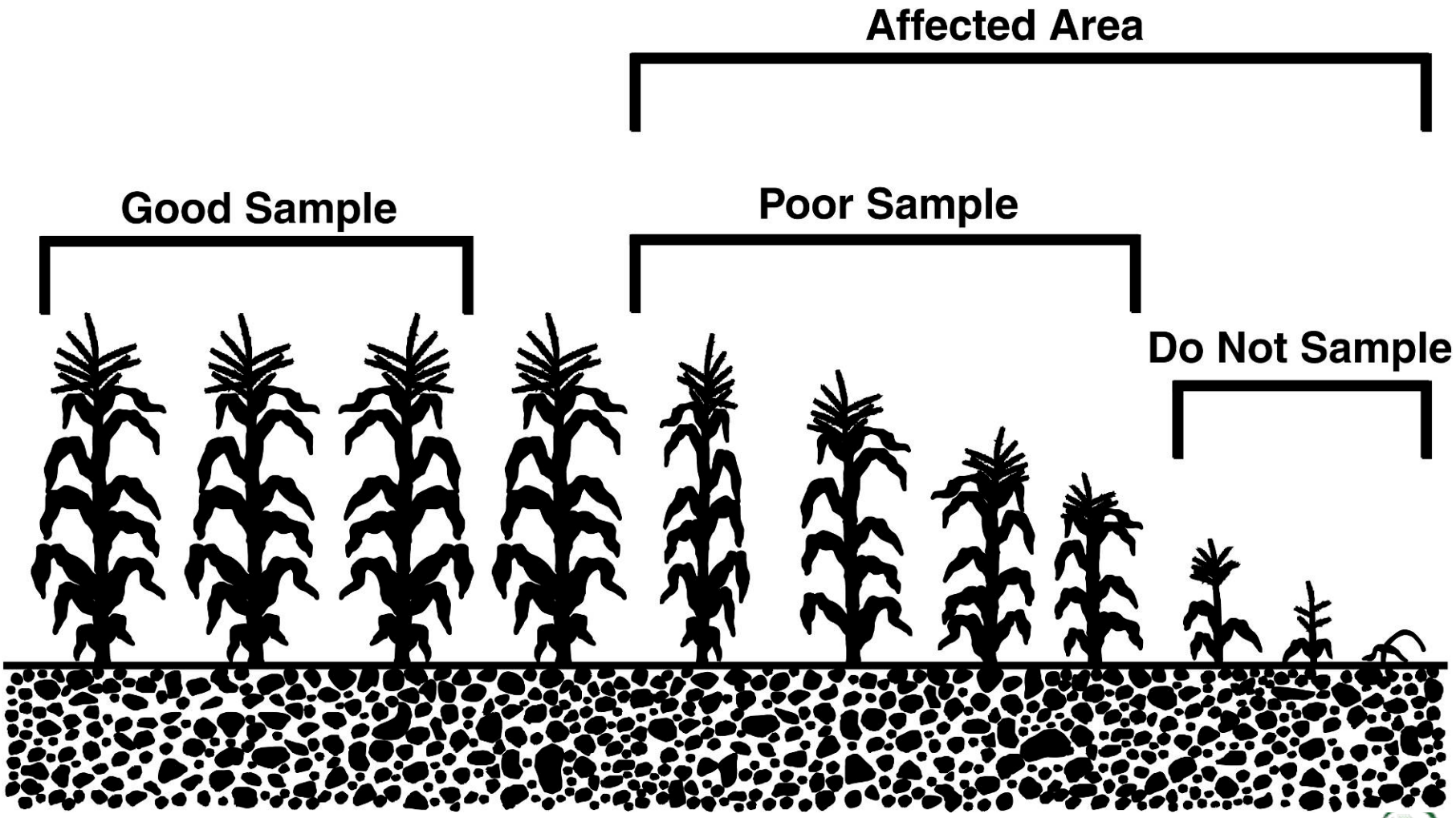




8. Describe the tissue sampling procedures recommended in OMAFRA Publication 811 for corn, soybeans, winter wheat and alfalfa

- Sample at least 20 plants, 100 g material
- Corn – Ear leaf at silking (mid third)
  - Whole plant at 5-6 leaf stage for P, Zn
- Soys – top fully developed leaf, 1st flower
- Wheat – top two leaves at heading
- Alfalfa – whole plant, late bud stage
- If sampling at other times, collect good and poor plants for comparison

Diagnostic Tissue Sampling



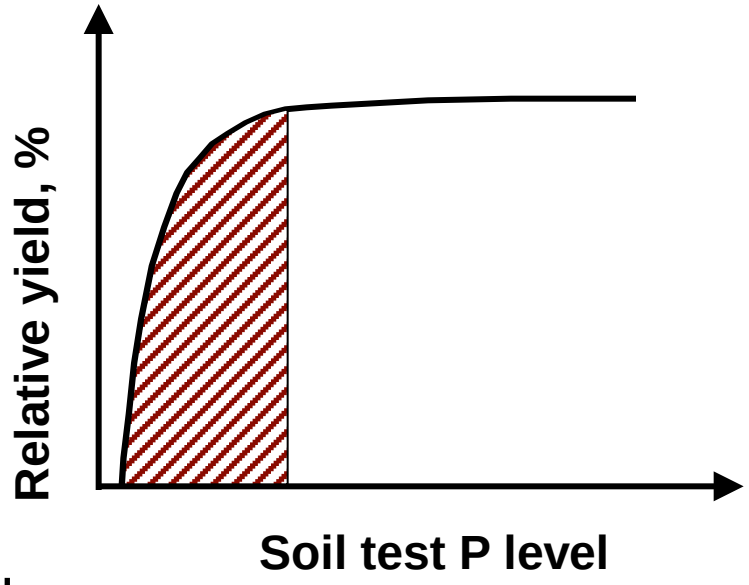
9. List advantages and disadvantages of the following three fertilizer recommendation approaches:

- a. cation saturation ratio

- b. nutrient build-up & maintenance
  - Least risk of yield loss from nutrient deficiency
- c. nutrient sufficiency
  - Least risk of profit loss from over-fertilization

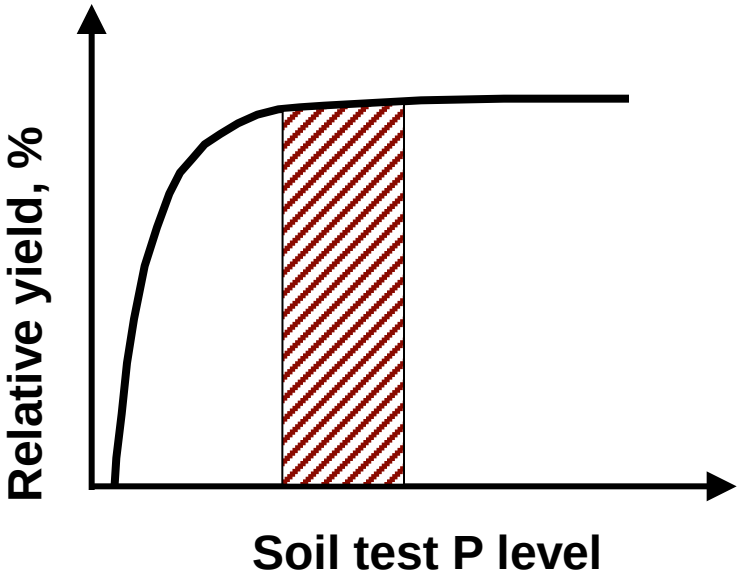
Approaches to Fertilization

- **<u>Sufficiency approach</u>**: Apply P to maximize net returns to fertilization in the year of application
  - Strategy: fertilize only when there is a good chance that a profitable yield response will be realized
  - Soil test levels kept in lower, responsive ranges
  - Normally adopted on land leased for short periods of time or when cash flow is limited



Approaches to Fertilization

- **<u>Build and maintenance approach</u>:** Remove P as a yield-limiting variable
  - Strategy: apply extra P (more than crop removal) to build soil tests to levels that are not yield-limiting



  - Soil test levels kept in higher, non-responsive ranges
  - Normally adopted on owned land or land leased for longer periods of time

11. Distinguish between extractable amount and total amount of nutrient in soil

- Nutrients exist in different forms in soil
- Soluble = nutrient in soil solution
- Available = soluble + loosely bound
  - Can be taken up by plant roots
- Unavailable = tightly bound or fixed within soil minerals
- Extractable = amount extracted by specific chemicals, related to available

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A. Incorrect concept of "available" nutrients as a discrete fraction in the soil

B. Correct concept of nutrient availability as a continuum in soil

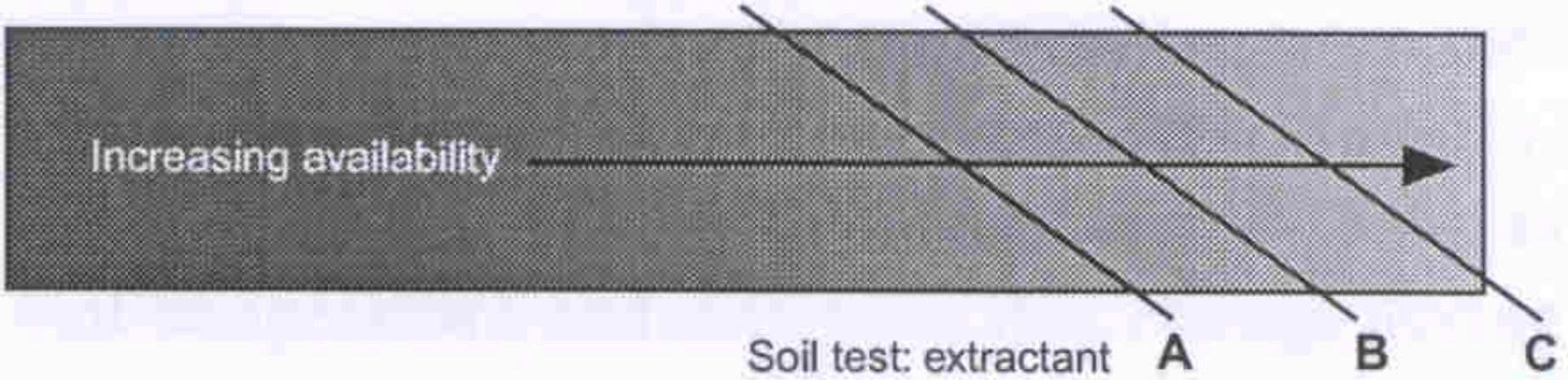

Figure 1. Concepts and relationships between available nutrients and soil test extractions.

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12. List nutrients for which there are soil tests accredited by the Ontario Soil Management Research and Services Committee as stated in OMAFRA publication 811.

- Nitrate-N
- Phosphorus
- Potassium, Magnesium
- Manganese
- Zinc
- Soil pH
- Buffer pH

13. Identify soil test extractants accredited for making fertilizer recommendations by the Ontario Soil Management Research and Services Committee as stated in OMAFRA Publication 811

- Nitrate-N – potassium chloride
- Phosphorus – sodium bicarbonate (Olsen)
- Potassium, magnesium – ammonium acetate
- Manganese – phosphoric acid + pH
- Zinc – DTPA + pH
- Soil pH – saturated paste
- Buffer pH – SMP buffer

14. Identify the limitations of using a non accredited soil test for the following nutrients :

- Phosphorus
- Sulphur
- Boron
- Calcium
- Copper
- Chlorine
- Iron
- Molybdenum

1. **Lack of calibration data.**
2. **Ineffectiveness of the test.**
3. **Non-accredited tests not accepted for NMPs.**

15. Interpret the information given on an accredited soil testing laboratory report

AGRI-FOOD LABORATORIES
Unit 1, 503 Imperial Road North, Guelph, Ontario N1H 6T9 (519) 837-1600

AgTest Farm Soil Report

AgTest

Report#

Sample ID	Lab #	pH	BpH	Total Salts mmhos/cm	Organic Matter %	Nitrogen NO3-N ppm	Phosphorus - P ppm Sodium Bicarb.		Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm
KS-3	1175305	6.6			3.4		15 M		193 VH	194 MH	1309
KS-2	1175306	7.3			13.5		59 VH		240 VH	288 MH	6165
SF-4	1175308	5.5	6.2		2.3		44 VH		197 VH	43 D	429

Sample ID	Zinc Zn ppm	Zn Index	Manganese Mn ppm	Mn Index	Copper Cu ppm	Iron Fe ppm	Boron B ppm	Texture	Cation Exchange MEQ/100g	Base Saturation K%	Mg%	Ca%	H%
KS-3	1.9 MH	21.8	8.4 MH	15.7				C	10	5.0	16	66	12
KS-2	4.6 H	30.9	6.5 MH	13.4				M	35	1.8	7	88	3
SF-4	1.9 MH	33.5	15.4 H	40.6				M	12	4.1	3	18	75

Sample ID	Sodium Na ppm	Sulphate SO4 ppm	Chloride Cl ppm	Aluminum Al ppm	K/Mg Ratio	Exchangeable Acidity	%CEC from OM	Target OM %	Aggregate Stability		
KS-3					1.0		72.80	3.41	Fair		
KS-2					0.8		98.00	9.00	Good		
SF-4					4.6		18.40	4.15	Fair		

Agri-Food Recommendations

Sample ID	Crop to be Grown	Yield Goal	N	P_2O_5	K_2O	Magnesium	Calcium	Sulphur	Zinc	Manganese	Copper	Iron	Boron	Lime te/ha
			(lb / ac)											
KS-3	corn	150 bu/ac	150	50	90	10			1.0	1.5				
KS-3	soybeans	45 bu/ac		30	40	10				1.5				
KS-3	wheat, winter	90 bu/ac	75	50	40	10			1.0	1.5				
KS-2	corn	150 bu/ac	110		60	15				1.5				
KS-2	soybeans	45 bu/ac				15				1.5				
KS-2	wheat, winter	90 bu/ac	75			15				1.5				
SF-4	corn	150 bu/ac	160	20	90	30								3
SF-4	soybeans	45 bu/ac			40	30								3
SF-4	wheat, winter	90 bu/ac	75	20	40	30								5

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New Soil Test Categories

Probability of response to applied nutrients at different soil test levels

Response Category	**Probability of profitable response to applied nutrients**
High Response (HR)	High (most of the cases)
Medium Response (MR)	Medium (about half the cases)
Low Response (LR)	Low (few of the cases)
Rare Response (RR)	Rare (very few of the cases)
No or Negative Response (NR)*	Not profitable to apply nutrients*

*adding nutrients to soils with these levels of nutrients may reduce crop yields or quality by interfering with the uptake of other nutrients.

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16. Calculate the amounts and rates of fertilizer needed to meet specific soil test recommendations

Example: The recommended application rate for nitrogen is 145 kg N/ha, phosphorus 80 kg P_2O_5/ha and potassium 130 kg K_2O/ha. The available fertilizer materials are urea (46-0-0), diammonium phosphate (DAP, 18-46-0) and muriate of potash (KCl, 0-0-60). What combination of these materials is needed to give this recommended rate?

Given these materials, you would calculate the amount of DAP required first, since this fertilizer is your only source of phosphorus, and it will supply nitrogen as well. The rate of DAP required is 80 x 100 ÷ 46 = 174 kg DAP/ha.

Since DAP is 18% nitrogen, there would be 18 ÷ 100 x 174 = 31 kg N/ha applied in the DAP. Therefore you will only need 114 kg N/ha (i.e., 145-31=114) to be supplied by the urea: rate of urea required is 114 x 100 ÷ 46 = 248 kg urea/ha.

The amount of KCl required would be 130 x 100 ÷ 60 = 217 kg KCl.

17. Describe the role of soil testing, plant tissue testing and visual plant symptoms in a fertilization program.

- Soil testing – to plan and select inputs
- Tissue testing – diagnose problems, yield limitations
- Visual symptoms – diagnose problems

18. Describe the different forms of nitrogen found on a manure analysis report

- Total N
- Ammonium N
  - Immediately available, subject to loss
- Organic N = Total N minus NH_4-N
  - Slowly available as organic matter breaks down (20-30% in first year)

19. Calculate the credits for N,P, and K from manure in the year of application and subsequent years based on an analytical report

- Nitrogen
  - Page 38-40, Publication 811
- Phosphorus
  - % P X 2.29 = % total P_2O_5
  - % total P_2O_5 X 0.4 = available P_2O_5
- Potassium
  - % K X 1.20 = % total K_2O
  - % total K_2O X 0.9 = % available K_2O

20. Describe how nutrient credits from animal manures, biosolids and legumes influence fertilizer recommendations

- Manure – Credits for NPK, based on estimated nutrient availability
- Biosolids – Credits for NP
- Legumes – Credits for N

21. Define calcareous soil

- Any soil containing free lime (calcium carbonate or calcium magnesium carbonate)
- Generally high pH (>7.5)
- React with dilute HCl to form CO_2 gas bubbles

22. Describe the influence of the following factors on soil pH: slope position, parent material, texture

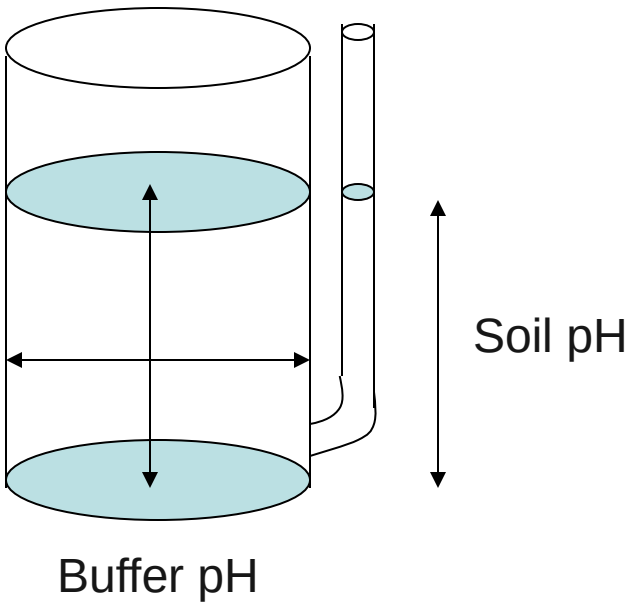
- Soil pH and topography
  - Ontario: calcareous soils (calcium carbonate)
  - $CaCO_3$ and $MgCO_3$ - alkaline or basic pH (>7)
  - valleys tend to lower pH than hilltops because:
    - 1) runoff results in more leaching through valley soils
    - 2) better plant growth and OM in valley
    - 3) erosion
  - exception: sandy knolls - buffer capacity

23. Describe the advantages of proper lime incorporation

- Lime is insoluble in alkaline conditions
- High concentration of lime increases pH
- Therefore liming effect does not diffuse very far though the soil
- Proper incorporation mixes the lime thoroughly with the soil so that the lime particles are close to the soil particles

24. Distinguish between soil pH and buffer pH

- Soil pH measures H^+ concentration in soil solution
- Buffer pH measures acidity in solution plus adsorbed to soil particles
- SMP buffer starts at pH 7.5, and is decreased by H^+ in soil



25. Describe how the recommended Ontario Soil test (OMAFRA pub. 811) uses soil pH and buffer pH to determine soil lime requirements.

- Soil pH determines if lime is required
- Buffer pH determines how much lime is required (Table 2-11, page 32, Publication 811)

26. Based on OMAFRA pub 811, define neutralizing value, fineness rating and agricultural index of liming materials.

- Neutralizing value = calcium carbonate equivalent
- Pure $CaCO_3$ = 100
- Fineness rating = reactivity
  - > 10 mesh = 0
  - 10-60 mesh = 40
  - < 60 mesh = 100
- Ag Index = NV * FR/100

Ag Index Exercise

- Dolomitic Limestone from a quarry has a Neutralizing Value of 104%
- 10% remains on a 10 mesh screen
- 40% passes through a 60 mesh screen
- What is the Ag Index?
- Ag Index = NV * FR/100 = 104%*(.5*50+40) = 104%*65 = 68

27. Calculate lime application rates using an accredited soil testing report and the neutralizing value and fineness rating of the liming material.

- Exercise:
  - Soil pH = 4.8 Target pH = 6.5
  - Buffer pH = 5.8
- Recommended Lime = 12 T/ha of lime with Ag Index 75
  - Neutralizing Value = 80
  - 25% > 10 mesh; 25% <60 mesh
- Ag Index = 80*(.5*.4 + .25) = (80*.45) = 36
- Application = 12 * 75/36 = 25 T/ha

28. Determine when to use dolomitic versus calcitic lime to correct soil pH

- Mg soil test < 100 – use Dolomitic Lime
- Mg soil test > 100 – use either Dolomitic or Calcitic Lime, whichever is most economical.
- There is no advantage to using Calcitic lime over Dolomitic Lime in most Ontario soils.

29. List recommended soil pH ranges for: corn, soybeans, wheat, barley, and alfalfa

- Recommended pH ranges:
  - corn 5.1-7.0 (5.5 on lighter texture)
  - soybeans 5.5-7.0
  - wheat 5.5-7.0
  - barley 6.2-7.0
  - alfalfa 6.2-7.4

29. List recommended soil pH ranges for: corn, soybeans, wheat, barley, and alfalfa

- Soil pH at which lime is recommended:

Crop	Sands & Silts		Clays	
	min	target	min	target
alfalfa	6.1	6.5	6.1	6.5
barley/oats/wheat	6.1	6.5	5.6	6.0
soybeans	5.6	6.0	5.6	6.0
corn	5.6	6.0	5.1	5.5

30. Rank the relative toxicity to corn, wheat and soybean seedlings of fertilizer materials.

- Urea > KCl > DAP > AN > MAP
- Soybean > Corn > Wheat

31. Identify factors affecting the amount of fertilizer that can safely be applied in a band near the seed

- Fertilizer Material
- Quantity of N + K
- Row Spacing
- Sensitivity of Crop
- Soil Type
- Weather

32. Identify safe limits for seed placed fertilizer for corn, soybeans, wheat, canola, and cereals.

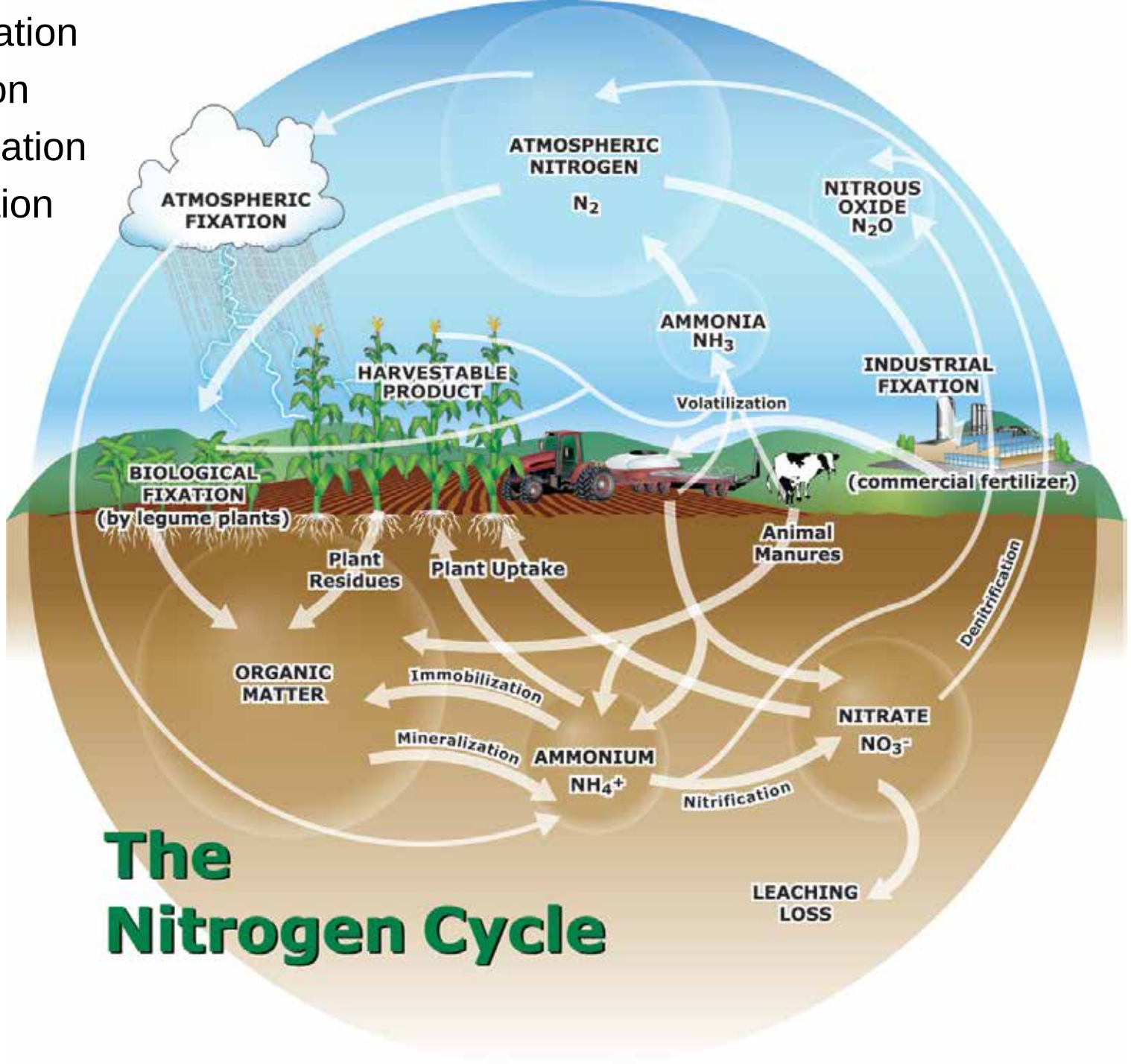
- Maximum Safe Rates of Nutrients (Table 2-30, page 47, Publication 811)
- **Safe limits for seed-placed fertilizer**
  - soybeans: zero
  - fall-seeded cereals: 15 kg/ha N or 30 kg/ha of N+K_2O; no DAP or urea
  - spring-seeded cereals: 35-45 kg/ha N or 55-70 kg/ha of N+ K_2O; less with DAP, urea, or sand
  - corn: 9 kg/ha N+K_2O in 30” rows; 15.5 kg/ha P_2O_5
  - canola: no N or K; only TSP or MAP up to 20 kg/ha P_2O_5

Break Time!

33. Identify how nitrogen is gained, lost and transformed in the soil through:

- Mineralization
- Nitrification
- Immobilization
- Volatilization
- Fixation
- Leaching

- Mineralization
- Nitrification
- Immobilization
- Volatilization
- Fixation
- Leaching



34. Describe how nitrogen gains, losses, and transformations in the soil influence nitrogen availability to plants and nitrogen fertilization practices

- Mineralization
- Nitrification
- Immobilization
- Volatilization
- Fixation
- Leaching

35. Describe the advantages and limitations of the soil nitrate-nitrogen test for corn and barley.

- Advantages:
  - Direct measure of available N from soil
- Limitations:
  - Soil N keeps changing
  - Spatial variability
  - Must be taken at a very busy time of year (pre-sidedress = June)
  - Questionable accuracy when soil has received manure or with previous legumes

36. Describe how topography can influence soil nitrate levels

- Topography and soil nitrate
  - consider organic matter, microbial activity, & water content
  - more nitrate downslope or in valleys
  - denitrification can reduce nitrate in valleys
- Depressional areas = more organic matter = more mineralization = more nitrate
- Depressional areas = longer duration of saturated conditions = more denitrification = less nitrate

37. Recognize nitrogen deficiency symptoms on corn, soybeans, alfalfa, and cereals.

- Corn – pale green to yellow, older leaves first. Chlorosis down midrib of lower leaves
- Soys – pale green to yellow plants, particularly older leaves – poor nodulation
- Alfalfa – same as soys
- Cereals – pale green to yellow plants, stunted, lower leaves most affected

N deficient corn

38. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat, and forage production

• Anhydrous ammonia	82-0-0
• Urea	46-0-0
• Ammonium nitrate	34-0-0
• Calcium ammonium nitrate	27-0-0
• Ammonium sulfate	21-0-0
• Urea-ammonium nitrate (UAN)	28-0-0 to 32-0-0
• Polymer-coated urea	44-0-0 (or less…)

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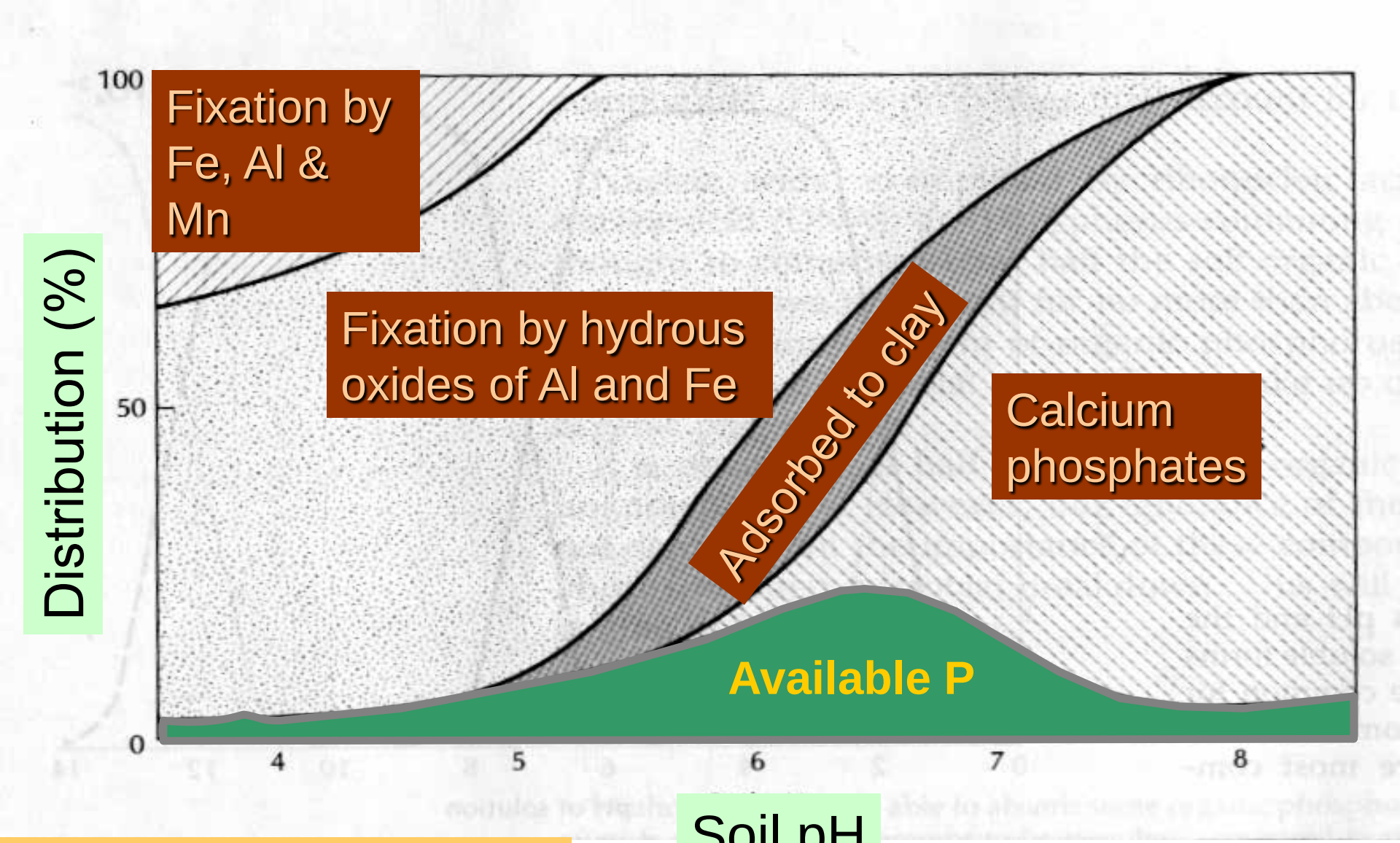
39. Describe how soil chemical properties affect phosphorus mobility in the soil and availability to plants.

Fixation of Added P



Source: NC Brady, 1990. The Nature and Properties of Soils.

40. Describe the advantages and disadvantages of seed-placed, banded and broadcast fertilizer phosphorus placement methods.

- Seed placed
- Banded
- Broadcast

41. Recognize phosphorus deficiency symptoms on corn, soybeans, alfalfa, and cereals.

- Symptoms are not clear cut
- Stunting, darker green plants, may show purpling on the leaves

42. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat and forage production

- Triple superphosphate (TSP)
  - 0-46-0
- Monoammonium phosphate
  - 11-52-0
- Diammonium phosphate
  - 18-46-0
- Liquid phosphorus (ammonium polyphosphate) fertilizers
  - 10-34-0

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43. Describe how soil chemical and physical properties affect potassium fertilizer availability, mobility, and leaching

- Soil pH
- Soil texture
- Clay mineralogy
  - Potassium fixation

44. Recognize potassium deficiency symptoms on corn, soybeans, alfalfa and cereals.

- Corn – Yellowing on margin of lower leaves, stunted plants, poor grain fill
- Soybeans – Yellowing of margins of lower leaves
- Alfalfa – white speckles on older leaves, particularly near margins
- Cereals – Stunting, yellowing of lower leaves, lodging

Potassium Deficiency in Conservation Tillage

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45.Recognize luxury consumption and its effects on forage quality for ruminant livestock

- Crop takes up more than it needs for growth and reproduction
- Extra K accumulates in plant tissue, raising K concentration in forages
- High K in forage can create a cation-anion imbalance in freshening dairy cows, leading to increased milk fever

46. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat, and forage production

Muriate of potash	0-0-60
Sulfate of potash	0-0-50-18S
Sulfate of potash magnesia	0-0-22-11Mg-22S

47. Describe how soil chemical and physical properties affect magnesium availability, mobility, and leaching

- Mg soil test
- Soil texture
- Clay mineralogy
  - weathering

48. Recognize magnesium deficiency symptoms on corn, soybeans, and forages

- Corn – pale green to yellow striping of leaves, base to tip. Older leaves reddish.
- Soybeans – pale green between veins of lower leaves, leaf margins eventually curl down and entire leaf yellow except base
- Alfalfa – pale green colour in older leaves, stunted, low vigour plants, rusty specks between veins


Mg Deficient Corn

49. Describe the agronomic advantages and disadvantages of each of the following magnesium sources :

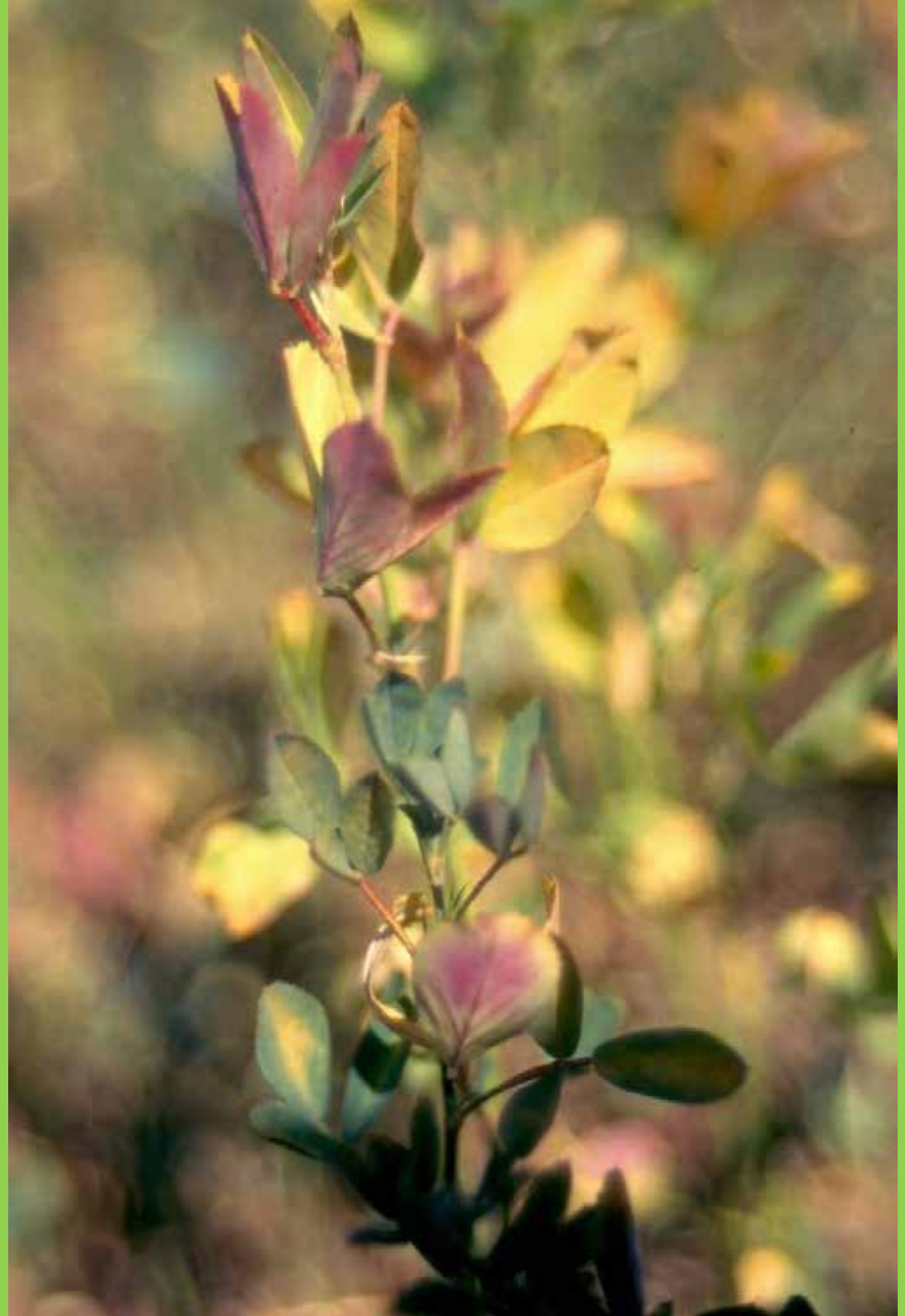
- Sulfate of potash magnesia
  - 0-0-22-11Mg-22S
- Magnesium sulfate
  - Epsom salts, 9% Mg
- Dolomitic lime
  - 6-13% Mg

50. Recognize the deficiency symptoms of :

- Zinc in corn
  - Broad white band at leaf base, “white-bud”
- Manganese in soybeans
  - Interveinal chlorosis
- Manganese in cereals
  - Stunting, yellowing of crop, grey speck of oats
- Boron in alfalfa
  - Rosetting, yellow-red-purple leaflets, reduced flowering and seed set

Zn Deficient Corn

Mn Deficient Soys



B Deficient Alfalfa

Cu Deficient Wheat

51. Describe how the interaction between the following can affect crop nutrition :

- Phosphorus and zinc
- Potassium and magnesium
- pH and zinc
- pH and manganese
- Manganese and newly drained fields
- Weather conditions and boron

52. Describe the components used to calculate the zinc and manganese indexes

- Manganese index reported = 498 + 0.248 (phosphoric acid extractable Mn in mg/L of soil) - 137 soil pH + 9.64 (soil pH)^2

- Zinc index reported = 203 + 4.5 (DTPA extractable soil zinc in mg/L of soil) - 50.7 soil pH + 3.33 (soil pH)^2

53. Describe the advantages and limitations of foliar and soil applied (banded or broadcast) micronutrient applications

- Advantages and Limitations are specific to each nutrient
  - Mn
  - Zn
  - Cu
  - B
  - Cl
  - Fe, Mo

54. Describe the following forms of micronutrients

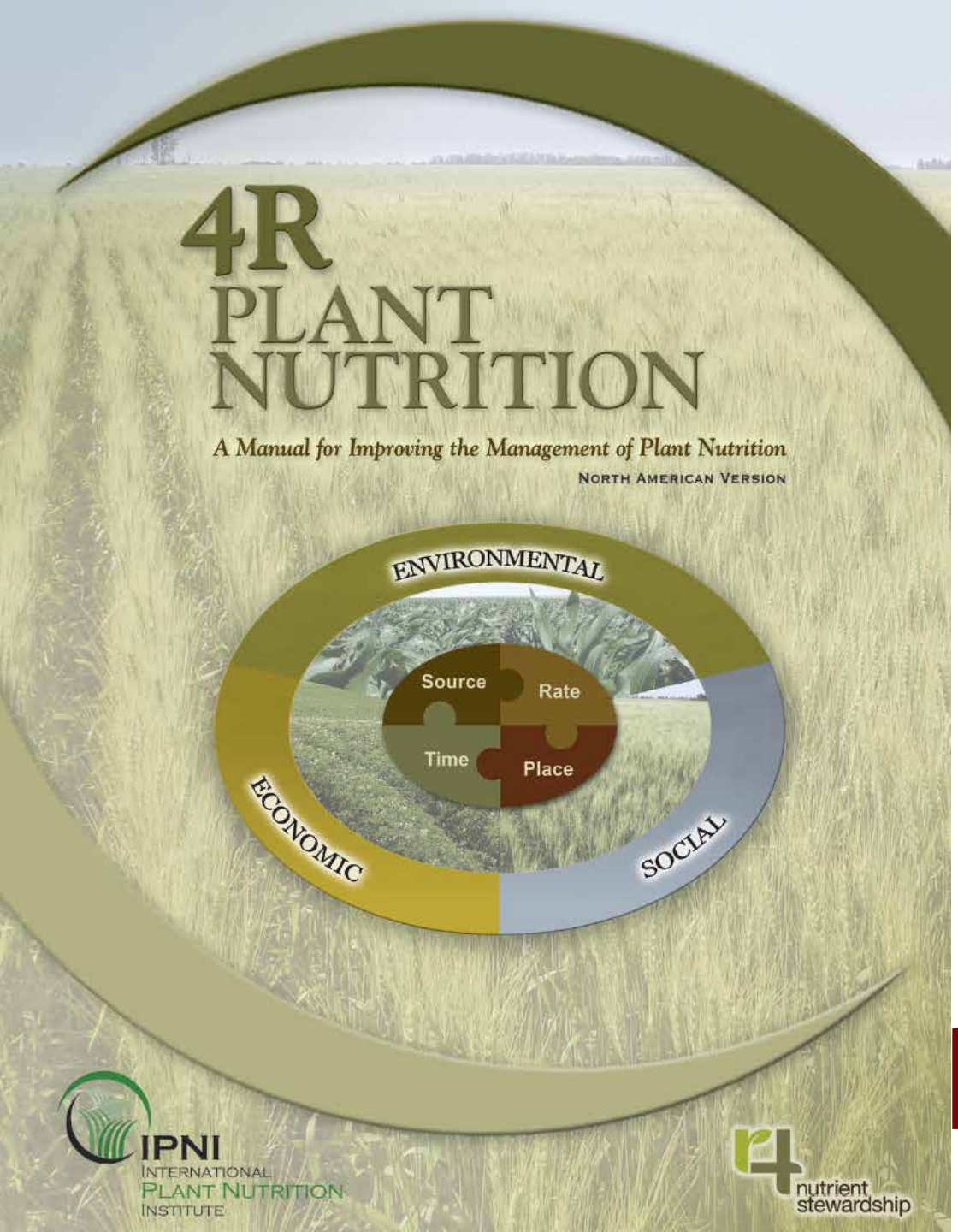
- Sulfates
- Oxides
- Oxy-sulfates
- Chelates

55. Describe the risks associated with over application of micronutrient fertilizers

- Economic
- Phytotoxicity – Boron
- Interference with other micronutrients

56. Recognize the contribution of manure and biosolids to secondary and micronutrient supply.

- Biosolids (and manures) can contain substantial amounts of secondary and micronutrients, particularly zinc (Zn).
- Research has shown higher concentrations of Zn in crop products harvested from biosolids-treated land.
- When biosolids have been stabilized with lime, the effects of application on soil pH need to be taken into account.
- As soil pH rises, deficiencies of some micronutrients, particularly manganese, can become more frequent.



Thank you

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