INTERNATIONAL
CERTIFIED CROP ADVISER

PERFORMANCE OBJECTIVES

Prepared for
The American Society of Agronomy
by the
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Effective September, 2009

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FOREWORD

Throughout history, a nation's success has been directly related to the success of its agriculture. Today, with approximately 2% of the population engaged in production agriculture, the margin for error is small, and the effects of mismanagement extend well beyond the farm gate to all segments of society. Producers rely heavily on the advice of others. The Certified Crop Adviser (CCA) Program came into existence to insure that growers receive sound advice and recommendations.

The CCA program is built on the concept that there are certain things one must know in order to provide sound advice to producers. This is determined by asking a wide array of agriculturists involved in all aspects of crop production to tell us what a Certified Crop Adviser must know. We use this information to create the Competency Areas and Performance Objectives that follow. Every other year two of the four modules are extensively reviewed and updated by a committee representing both the public and private sector from across the U.S. and Canada. The revised modules are then reviewed by Certified Crop Advisers who provide input on relative importance of the Performance Objectives, and on areas that need to be added or deleted. By mastering the Performance Objectives, one will possess the knowledge that the agricultural industry has deemed important for a Crop Adviser to know.

These Performance Objectives are dynamic, and are upgraded as the needs of the crop production industry evolve. This ensures that the CCA program will remain a viable and useful tool which recognizes the high level of competence displayed by those who choose to earn this designation.

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INTRODUCTION

The Certified Crop Adviser (CCA) Performance Objectives outline the knowledge and skill areas that advisers themselves have indicated they need in order to effectively carry out their duties. Performance Objectives are the heart of the Certified Crop Adviser Program, as they outline the basic knowledge and skills required by individuals providing advice to crop producers.

To help you organize your learning, the Performance Objectives are divided into four modules: Nutrient Management; Soil and Water Management; Pest Management; and Crop Management. Each module contains several Competency Areas, which identify needed knowledge and skill areas. Within each Competency Area is one or more specific Performance Objective which describes the activity to be performed to demonstrate competency.

The Performance Objectives were originally developed by Dr. Jim Vorst of Purdue University. Two modules are reconstructed every two years by a committee of specialists from across the U.S. and Canada. Their work is evaluated and then modified by practicing Certified Crop Advisers.

Since the Performance Objectives have been developed over the material that Certified Crop Advisers need to know, they are the base on which the entire CCA program is built. The first step is adequately mastering the material covered in the Performance Objectives so you can demonstrate minimum competency by passing the CCA examination. All the questions on the international exam are based directly on these Performance Objectives.

Certified Crop Advisers should use the Performance Objectives to identify areas where they need to strengthen their proficiency. To assist in mastering the competencies required by CCA's, a glossary of terms for each module is included. The glossaries are not intended to be all-inclusive, but are to serve as sources of information for both mastering of basic knowledge and skill areas and a source of information for continuing education.

<u>NUTRIENT MANAGEMENT</u> COMPETENCY AREAS:

1. Basic Concepts of Plant Nutrition
2. Basic Concepts of Soil Fertility
3. Soil Testing and Plant Tissue Analysis
4. Nutrient Sources, Analyses, and Application Methods
5. Soil pH and Liming
6. Nutrient Management Planning

NUTRIENT MANAGEMENT

EXPERTISE WITHIN EACH COMPETENCY AREA:

COMPETENCY AREA 1. BASIC CONCEPTS OF PLANT NUTRITION

1. List the 18 elements essential for plant nutrition
2. Classify the essential elements as macronutrient or micronutrient
3. Describe the functions of N, P, and K in plants
4. Classify each macronutrient and micronutrient as mobile or immobile in the plant
5. List chemical uptake forms of each macronutrient
6. Describe how nutrient needs change as plant growth progresses from germination to maturity

COMPETENCY AREA 2. BASIC CONCEPTS OF SOIL FERTILITY

7. Describe the role of the following in supplying nutrients from the soil
   a. soil solution
   b. cation exchange sites
   c. organic matter
   d. soil minerals
   e. plant residue
8. Describe nutrient mineralization, immobilization, and uptake antagonism
9. Describe mass flow, diffusion, and root interception of nutrients
10. Describe how cation exchange capacity (CEC) influences nutrient mobility of the following
    a. calcium (Ca)
    b. magnesium (Mg)
    c. potassium (K)
11. Classify the following ions as mobile or immobile in the soil
    a. ammonium (NH_4^+)
    b. nitrate (NO_3^-)
    c. phosphate (PO_4^-)
    d. sulfate (K^+)
    e. potassium (Ca^{++})
    f. calcium
    g. magnesium (Mg^{++})

12. Describe how the following soil characteristics affect nutrient uptake
    a. texture
    b. structure
    c. drainage/aeration
    d. moisture
    e. pH
    f. temperature

13. Describe how the following affect the fate of N in soil
    a. fixation by clay
    b. ammonification/mineralization
    c. nitrification
    d. volatilization
    e. denitrification
    f. immobilization
    g. leaching
    h. symbiotic fixation
    i. plant uptake

14. Describe how the following soil factors affect symbiotic nitrogen fixation
    a. pH
    b. moisture
    c. nitrogen level
    d. presence of correct rhizobia species

15. Recognize how recommended nutrient level, and timing and method of nutrient application vary for different crops

16. Recognize how a cropping system influences the following
    a. soil fertility levels
    b. method of applying nutrients
    c. timing of applying nutrients

COMPETENCY AREA 3. SOIL TESTING AND PLANT TISSUE ANALYSIS

Soil Sampling and Soil Test Interpretation

17. Describe how the following affect soil sampling methods
    a. method of previous nutrient application
    b. nutrient stratification
    c. within-field soil and crop variability
    d. nutrient to be analyzed
    e. predictive vs. diagnostic sampling
    f. root zone depth
    g. crop to be grown
    h. tillage and planting system

18. Describe how to use soil analysis for
    a. problem solving/diagnosis
    b. nutrient program monitoring
    c. in-season nutrient management
    d. pre-season nutrient planning

19. Indicate how the following cause variability in soil test analysis
    a. time of sampling
    b. depth of sampling
    c. type of extraction method used
    d. method of preparing and shipping sample

20. Compare and contrast the following approaches for making nutrient recommendations
    a. sufficiency level
    b. soil buildup/drawdown
    c. base saturation
    d. maintenance/crop removal

21. Recognize how the following affect soil analysis interpretation
    a. probability of crop response to added nutrients
    b. reported nutrient sufficiency level
    c. units used to report results
    d. within-field variability
    e. environmental risk

22. Describe how to use the following to develop a soil sampling plan
    a. yield map
    b. soil survey map
    c. aerial imagery
    d. landscape position
    e. land use history

Plant Tissue Analysis

23. Use plant analysis information to determine if nutrient is at critical value, sufficiency level, luxury consumption, or toxicity level.

24. Recognize how the following affect plant tissue analysis results
    a. crop species
    b. growth stage
    c. plant part sampled
    d. crop stress level
    e. time of day sampled
    f. sample handling
    g. method and timing of nutrient application

25. Describe how to use plant tissue analysis for
    a. problem solving/diagnosis
    b. nutrient program monitoring
    c. in-season nutrient management

COMPETENCY AREA 4. NUTRIENT SOURCES, ANALYSES, AND APPLICATION METHODS

26. Describe how the following serve as plant nutrient sources
    a. organic matter
    b. irrigation water
    c. commercial fertilizer
    d. soil minerals
    e. animal manure/biosolids
    f. urban/industrial waste
    g. plant residue
    h. residual nutrients from fertilizers and manures
    i. shallow ground water

27. Describe how the following influence nutrient availability
    a. urease inhibitors
    b. polymers
    c. nitrification inhibitors
    d. chelated formulations

28. Describe desirable environmental conditions for using each of the materials listed in #27

29. Describe the physical form and analysis of each of the following nitrogen sources
    a. anhydrous ammonia
    b. urea
    c. ammonium nitrate
    d. urea/ammonium nitrate solution (UAN)
    e. ammonium sulfate
    f. calcium nitrate
    g. aqua ammonia
    h calcium ammonium nitrate (CAN)

30. Describe the physical form and analysis of each of the following phosphorus sources
    a. triple superphosphate
    b. monoammonium phosphate
    c. diammonium phosphate
    d. ammonium polyphosphate

31. Describe the physical form and analysis of each of the following potassium sources
    a. potassium chloride
    b. potassium sulfate
    c. potassium nitrate

32. Describe the chemical composition and use of each of the following calcium and/or magnesium sources
    a. calcitic lime
    b. dolomitic lime
    c. gypsum
    d. potassium magnesium sulfate

33. Convert fertilizer analysis of P and K from elemental to oxide form, and vice versa

34. Define the following commercial fertilizer terms
    a. total availability
    b. water solubility
    c. guaranteed analysis

35. Compare and contrast characteristics of organic and inorganic forms of N and P

36. Use nutrient analysis and soil analysis information to calculate fertilizer and/or manure application rates

37. Describe how the following affect nutrient availability from manure
    a. physical form
    b. animal source
    c. moisture content
    d. state/stage of decomposition
    e. application and timing method

38. Describe advantages and limitations of the following nutrient placement methods
    a. injection
    b. surface broadcast
    c. broadcast incorporated
    d. band
    e. fertigation
    f. foliar
    g. sidedress
    h. topdress
    i. seed placed

COMPETENCY AREA 5. SOIL pH AND LIMING

39. Define
    a. soil pH
    b. buffer pH
    c. acidity
    d. alkalinity
    e. lime requirement

40. Describe the long term change in soil pH from applying N

41. Describe how CEC, soil texture, tillage practices, and soil organic matter affect lime requirement

42. Describe how soil pH affects the availability of each macronutrient

43. Describe how liming materials increase soil pH

44. Describe how purity, fineness, and Calcium Carbonate Equivalent (CCE) affect neutralizing ability of liming materials

45. Calculate lime application rates to meet liming requirements

46. Indicate how soil pH affects availability of heavy metals to plants

47. Describe the effect of the following on soil pH
    a. elemental sulfur
    b. alum
    c. ammonium sulfate (AMS)
    d. gypsum
    e. calcium nitrate
    f. ammonium nitrate

COMPETENCY AREA 6. NUTRIENT MANAGEMENT PLANNING

48. Describe how to set a realistic yield goal by using information about
    a. production history
    b. soil productivity
    c. management level
    d. yield limiting factors

49. Use crop nutrient requirement, crop rotation/sequence, and soil analysis information to determine crop nutrient needs

50. Describe how to use the Phosphorus Index (P index) in nutrient management planning

51. Describe when to use N-based or P-based recommendations for manure/biosolid application

52. Given soil analysis recommendations and manure analysis, use manure and commercial fertilizer sources to construct a P-based and N-based nutrient application program

53. Define environmentally sensitive area

54. Describe the importance of the following components of an economically and environmentally sound nutrient management plan
    a. maps of facilities, fields, and soils
    b. environmentally sensitive areas
    c. cropping system
    d. expected yields
    e. results of soil, plant, water, and manure analyses
    f. quantification of nutrients from all sources available to the farm
    g. nutrient budget for each field
    h. recommendations of nutrient rate, timing, form, and method of application
    i. review and modification of plan as needed
    j. records of management practices

55. Describe how N and P loss from the following can affect the environment
    a. erosion
    b. runoff
    c. volatilization
    d. leaching
    e. denitrification

56. Describe how manure storage, handling, and application methods affect nutrient content and availability

57. Describe how to obtain a representative sample of manure or effluent

58. Describe how the following animal factors affect nutrient management
    a. animal age, size, species, and numbers
    b. type of production system

Nutrient Management Glossary

Acid soil: A soil that has a pH value less than 7.0.

Aerobic: A condition identified by the presence of oxygen.

Agronomic nutrient rate: Amount of nutrients required by a crop for an expected yield, after all the soil, water, plant, and air credits are considered. Agronomic rates consider nutrient credits from all soil tests, legumes, manure residuals, and other nutrient credits supplied from any other source.

Alkaline soil: A soil that has a pH value greater than 7.0.

Alum: A potassium aluminum sulfate or ammonium aluminum sulfate

Ammonia (NH_3): See anhydrous ammonia

Ammonium (NH_4^+): A form of nitrogen that is available to plants from fertilizer and organic matter decomposition.

Ammonium nitrate solution: Non-pressure solution of ammonium nitrate in water usually standardized to 20% nitrogen used for direct application or for making multinutrient liquid fertilizer. Analysis is 20-0-0.

Ammonium phosphate: A group of phosphorus fertilizer manufactured by the reaction of anhydrous ammonia with superphosphoric acid to produce either solid or liquid fertilizer.

Ammonium sulfate: Fertilizer material with an analysis of 21-0-0. It also contains 24% sulfur.

Anaerobic: A condition identified by the absence of oxygen.

Anhydrous ammonia (NH_3): Fertilizer in pressurized gas form, made by compressing air and natural gas under high temperature and pressure in the presence of a catalyst. Value is 82-0-0.

Animal unit: 1000 pounds of live animal weight; a term used to determine volumes of animal manure produced.

Anion: An ion with a negative charge.

Anion exchange capacity: The sum total of exchangeable anions that a soil can adsorb. Expressed as centimoles of charge per kilogram ($cmol_c/kg$) of soil or milliequivalents per 100 g of soil (meq/100 g of soil).

Application rate: The weight or volume of a fertilizer, soil amendment, or pesticide applied per unit area.

Aqua ammonia: 20% anhydrous ammonia dissolved in water.

Available nutrient: A nutrient in a form that a plant can absorb.

Banded nutrients: Placing fertilizer nutrients in a band near the seed at planting, or surface or subsurface applications of solids or fluids in strips before or after planting.

Base saturation percentage: The proportion of the soil's cation exchange capacity occupied by basic cations.

Bioremediation: The use of biological agents to remove substances hazardous to human health or the environment from contaminated soil or water.

Biosolid: Any organic material, such as livestock manure, compost, sewage sludge, or yard wastes applied to the soil to add nutrients or for soil improvement.

Buildup and maintenance: Nutrients applied in order to build up a target soil test level and then maintained by annual addition of the quantity of nutrients expected to be removed in the harvested portion of the crop.

Buffer pH: A soil test procedure whereby the pH of the soil is measured in buffer solution. This measurement is used in estimating the lime requirement of the soil.

Calcitic lime: Limestone consisting of $CaCO_3$ based material with very low magnesium content.

Calcium carbonate equivalent (CCE): The liming potential of a material as compared to $CaCO_3$.

Cation: An ion that has a positive electrical charge. Common soil cations are calcium, magnesium, hydrogen, sodium, and potassium.

Cation exchange capacity (CEC): The amount of exchangeable cations that a soil can adsorb at a specific pH, expressed as milliequivalents per 100 g of soil as meq/100 g soil, or cmol charge/kg.

Cation exchange sites: Negative charged sites on the surfaces of clays and organic matter.

Chelated molecule: A large, water soluble organic molecule that binds with a free metal ion to form a water soluble compound. This process increases the amount of metal ion or atom dissolved in the water and the availability of that ion to plants.

Critical value: The point between sufficiency and deficiency levels for a nutrient.

Crop nutrient requirement: The amount of nutrients needed to grow a specified yield of a crop plant per unit area.

Crop removal rate: The amount of nutrients that are removed from the field in the plant harvest. This would include harvested fruit, grain, forage, and crop residues that are physically removed from the field.

Crop rotation: A planned sequence of crops growing in a regularly recurring succession on the same area of land.

Crop utilization rate: The total amount of nutrients required by the crop to produce both vegetation and grain, including nutrients used to produce roots, stems, crowns, and other unharvested plant parts as well as the harvested portion that is removed from the field.

Crop sequence: The order of crops planted and harvested in a field over a period of time.

Denitrification: The transformation of nitrates or nitrites to nitrogen or nitrogen oxide gas, occurring under anaerobic conditions.

Diammonium phosphate (DAP): Fertilizer containing both nitrogen and phosphorus with an analysis of 18-46-0.

Diffusion: The movement of particles from an area of higher concentration to an area of lower concentration.

Dolomitic lime: A naturally occurring liming material composed chiefly of carbonates of magnesium and calcium.

Elemental sulfur: Sulfur in the elemental form that must be oxidized by soil microbes to the sulfate form for plant uptake.

Environmentally sensitive area: Places on the landscape that can be readily impacted by human or natural activity so as to degrade the condition of the site.

Essential plant nutrients: Inorganic elements that are required for growth and development of plants.

Erosion: The wearing away of the land surface by running water, wind, ice, geological agents, or mechanical erosion.

Fertigation: Applying fertilizer through an irrigation system.

Fertilizer: Organic or inorganic material added to a soil to supply one or more nutrients essential to plant growth.

Fertilizer analysis: The composition of a fertilizer, expressed as a percent of total nutrients, for example total N, available phosphoric acid (P_2O_5), and water-soluble potash (K_2O).

Fertilizer suspension: A fluid fertilizer containing dissolved and undissolved plant nutrients. The undissolved nutrients are kept in suspension, usually by swelling type clays.

Field capacity: The amount of water a soil holds after free water has drained because of gravity.

Foliar fertilization: Application of a dilute solution of fertilizer to plant foliage, usually made to supplement soil-applied nutrients.

Green manure: Plant material incorporated into the soil while green or at maturity, for soil improvement.

Guaranteed analysis: Minimal percentages of available nutrients as stated on a fertilizer label.

Gypsum: Calcium sulfate ($CaSO_4 \cdot 2H_2O$) used to supply calcium and sulfur and to improve sodic soils.

Immobile nutrient: A plant nutrient that moves slowly in the soil or plant.

Immobilization: The conversion of an element from the inorganic to the organic form in microbial tissues resulting in that element not being readily available to other organisms or plants.

Impermeable layer: Soil layers, either natural or man-made, that resist penetration by fluids or roots.

Injection: The placement, by mechanical means, below the surface of soil.

Inorganic nitrogen: Mineral forms of nitrogen.

Inorganic phosphorus: A salt of phosphoric acid or any of its anions, usually orthophosphate or polyphosphate.

Leaching: The movement of material in solution along with movement of water through the soil.

Lime fineness: The particle size of limestone determined by the fineness of grinding. The finer the grind, the more reactive the material is in neutralizing acidity.

Lime material: A material capable of neutralizing soil acidity.

Lime purity: The measure of impurities in a given liming material, in order to estimate its neutralizing value.

Liming requirement: The amount of liming material required to change the soil pH to a specific value.

Luxury consumption: The absorption by plants of an essential nutrient in excess of their need for growth. Luxury concentrations in early growth may be used in later growth.

Macronutrient: A nutrient that a plant needs in relatively large amounts. Essential macronutrients are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S).

Mass flow: The movement of solutes associated with net movement of water.

Micronutrient: Nutrients that plants need in only small or trace amounts. Boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn) are considered micronutrients.

Mineralization: The conversion of an element by soil organisms from an organic form to an inorganic form.

Mobile nutrient: A nutrient that moves readily in the soil or plant.

Monoammonium phosphate (MAP): A fertilizer composed of ammonium phosphates, resulting from the ammoniation of phosphoric acid. Typically 11% N with an analysis of 11-52-0.

N-based nutrient application: The rate of application of a nitrogen containing material so the desired amount of nitrogen is applied, regardless of the amounts of other nutrients being applied in the material.

Nitrate (NO_3^-): An inorganic nitrogen form that is very soluble, easily leached from soils, and readily available to plants.

Nitrite (NO_2^-): A form of nitrogen that is the result of the first step in nitrification in soil as microbes convert NH_4 to NO_2. It is subsequently oxidized to nitrate (NO_3) by microbes.

Nitrification: The microbial process of converting ammonium to nitrite to nitrate.

Nitrification inhibitor: A chemical inhibitor that slows the conversion of ammonium to nitrate in the soil, reducing the risk of nitrogen loss from the field.

Nitrogen: An essential plant nutrient that is part of many compounds including chlorophyll, enzymes, amino acids, and nucleic acids.

Nitrogen index: An environmental risk assessment tool to determine the potential for nitrogen movement from agricultural lands by leaching, runoff or volatilization. The index is a function of the rate, form, timing and method of application of nitrogen sources, and the interaction of these factors with temperature and precipitation.

Nutrient buildup: An increase in soil analysis levels of a nutrient due to application of that nutrient at levels that exceed crop removal.

Nutrient drawdown: A decrease in soil analysis levels of a nutrient due to crop removal.

Nutrient management plan (NMP): A written plan that specifies the utilization of fertilizer, animal manures, and other biosolids.

Organic nitrogen: Nitrogen that is bound with organic carbon and forms organic molecules.

Organic phosphorus: Phosphorus that is bound with organic carbon and forms organic molecules.

Orthophosphate: Inorganic form of plant available phosphorus.

P-based nutrient application: The rate of application of a phosphorus containing material so that the desired amount of phosphorus is applied, based on balancing the agronomic rate or crop removal rate of the crop with the amount of phosphorus contained in a material. This amount is regardless of the amounts of other nutrients being applied in the material.

P index: An environmental risk assessment tool for assessing the potential for phosphorus movement from agricultural lands. It is usually based on an estimation of potential soil erosion, the phosphorus soil test level, and phosphorus management practices such as rate of application, source of phosphorus, and timing and method of application.

P_2O_5: Phosphorus pentoxide; designation on the fertilizer label that denotes the percentage of available phosphorus expressed as P_2O_5.

Phosphorus: Essential nutrient for plants and animals. Component of cell walls, nucleic acids, and energy transfer molecules.

Plant available nitrogen (PAN): A calculated quantity of nitrogen made available during the growing season after application of fertilizer. PAN includes a percentage of the organic nitrogen, a percentage of the ammonium N, and all the nitrate nitrogen in the fertilizer.

Plant residues: Plant material that remains in the field after harvest.

Potash (K_2O): Term used to refer to potassium or potassium fertilizers.

Potassium: An essential plant nutrient involved in energy metabolism, starch synthesis, and sugar degradation.

Recommended rate: Amount of nutrients recommended on a soil test report or plant tissue analysis for a specific crop that meets but does not exceed the crop nutrient requirements. Recommended rates can also include nutrients used for soil test buildup.

Remote sensing: The collection and analysis of data from a distance, using sensors that respond to different heat intensities or light wavelengths.

Rhizobia: Bacteria capable of living symbiotically with higher plants by receiving food and carbon and provide a source of nitrogen to the plant.

Root interception: Method by which ions in the soil are intercepted by root growth.

Runoff: Portion of precipitation, snowmelt, or irrigation that moves by surface flow from an area.

Secondary nutrients: Those macronutrients (calcium, magnesium, and sulfur) used less often as fertilizers than the primary elements.

Sidedress: To apply a fertilizer, pesticide, or soil amendment to one side of a growing plant, either by surface application or injection.

Soil analysis: A chemical, physical, or biological procedure that estimates the plant availability of nutrients and soil quality characteristics to support plant growth.

Soil drainage: The process where water is moved by gravity, either by surface channels or internal pores in the soil profile.

Soil organic matter: The organic fraction of the soil exclusive of undecayed plant and animal residues. Often used synonymously with “humus”.

Soil pH: The degree of acidity or alkalinity of a soil, expressed on a scale from 0 to 14, with 7.0 indicating neutrality, increasing values indicate increasing alkalinity, while decreasing values indicate increasing acidity.

Soil productivity: A measure of the soil’s ability to produce a particular crop or sequence of crops under a specific management system.

Soil reaction: A quantitative term that describes the general degree of acidity or alkalinity of a soil.

Soil sampling: Process of obtaining a representation of an area of the soil or field by collecting a portion of the soil.

Soil solution: The aqueous liquid phase of the soil and its solutes contained in soil pores.

Soil structure: The combination or arrangement of primary soil particles into secondary soil particle units, or peds.

Soil test interpretation: Using soil analysis data to manage soil fertility and monitor environmental conditions.

Soil test level: The nutrient status of the soil, as indicated by analysis of a soil sample.

Soil test recommendation: The suggested amount of nutrients or soil amendment to be added to the soil to achieve expected crop yields based on the supplying power of the soil, air, and water.

Soil texture: The relative proportions of sand, silt, and clay in the soil.

Starter fertilizer: A fertilizer applied in relatively small amounts with or near the seed at planting.

Sufficiency level: a) For interpretation of plant analysis: A nutrient concentration in the plant tissue above which the crop is amply supplied, and below which the crop is deficient. b) For interpretation of soil analysis: A soil test level above which economic responses to applied fertilizer are unlikely to occur.

Subsurface band: To apply nutrients, pesticides, or soil amendments in narrow bands below the surface of the soil.

Surface band: To apply nutrients, pesticides, or soil amendments in narrow bands over the surface of the soil.

Surface broadcast: To apply nutrients, pesticides, or soil amendments uniformly over the surface of the soil.

Symbiotic N fixation: Conversion of molecular nitrogen (N_2) to ammonia and subsequently to organic nitrogen forms by organisms.

Topdress: To surface broadcast nutrients, pesticides, or soil amendments on the soil surface after crop emergence.

Total nitrogen: The sum of the organic and inorganic forms of nitrogen in a sample.

Toxicity level: A quantity of a material in plants, soil, or water that can harm or impair the physiological function of plants or soil.

Triple superphosphate: A product that has a guaranteed analysis between 40 and 50% available phosphoric acid. The most common analysis is 0-46-0.

Uptake antagonism: When the excess of one nutrient interferes with the uptake of another nutrient. Usually the nutrients in question may have a similar uptake mechanism by the plant.
Urea: A nitrogen fertilizer that is a white crystalline solid, very soluble in water, which has an analysis of 46-0-0.

Urea ammonium nitrate solution (UAN): A non-pressure nitrogen fertilizer solution containing urea and ammonium nitrate in approximately equal proportions dissolved in water. The nitrogen content of the fertilizer solution ranges from 28% to 32%.

Volatilization: The loss of a compound in gaseous form from a solid or liquid phase.

SOIL AND WATER MANAGEMENT COMPETENCY AREAS:

SOIL MANAGEMENT

1. Basic Soil Properties
2. Site Characterization
3. Soil Erosion
4. Residue Management
5. Restrictive Soil Layers
6. Soil Management Effects on Air Quality

WATER MANAGEMENT

7. Water and Solute Movement
8. Soil-Plant/Water Relations
9. Irrigation and Drainage
10. Water Quality

SOIL AND WATER MANAGEMENT

EXPERTISE WITHIN EACH COMPETENCY AREA:

SOIL MANAGEMENT

COMPETENCY AREA 1. BASIC SOIL PROPERTIES

Chemical

1. Define anion and cation

2. Define cation exchange capacity (CEC) and anion exchange capacity (AEC)

3. Describe how the following factors influence CEC
   a. percent clay
   b. type of clay
   c. percent organic matter
   d. pH

4. Describe how mineral solubility affects availability of nutrients

5. Differentiate saline, sodic, calcareous, acidic, and alkaline soils

Physical

6. Define soil texture

7. Use the textural triangle to identify soil textural class

8. Describe how particle size affects surface area and reactivity of soils

9. Describe how soil texture affects the water holding capacity, amount of plant available water, and wilting point of soils

10. Define soil structure

11. Differentiate the following types of soil structure
    a. blocky
    b. single grain
    c. granular
    d. platy
    e. massive
    f. prismatic/columnar

12. Describe how soil structure affects the following
    a. permeability
    b. root development
    c. water infiltration
    d. aeration

13. Describe how soil organisms and soil organic matter affect soil structure

14. Define bulk density

15. Describe how management practices affect soil bulk density

Biological

16. List sources of soil organic matter

17. Describe the physical and chemical properties of soil organic matter

18. Describe beneficial effects of soil organic matter

19. Describe how crop rotation and tillage affect the amount of carbon stored or sequestered in the soil

20. Explain how the following factors influence soil microbial activity
    a. temperature
    b. moisture
    c. soil pH
    d. organic matter
    e. salinity
    f. nitrogen application
    g. tillage

21. Explain how the C:N ratio affects organic material decomposition

COMPETENCY AREA 2. SITE CHARACTERIZATION

22. Differentiate O, A, B, and C soil horizons

23. Define parent material

24. Describe how to determine the area of a field

25. Describe how to determine slope of a landscape

26. Identify characteristics of well-drained and poorly-drained soils

27. Use a soil survey to locate soil types on a tract of land

28. Use a soil survey to determine soil characteristics of a field

29. Explain how the following affect land use and management
    a. leaching potential
    b. erosion potential
    c. wetlands classification
    d. proximity to sensitive areas
    e. runoff potential

COMPETENCY AREA 3. SOIL EROSION

30. Describe the erosion processes of detachment, transport, and deposition for wind and water erosion

31. Differentiate the following types of erosion
    a. sheet
    b. rill
    c. gully
    d. surface creep
    e. saltation
    f. suspension
    g. tillage erosion

32. Explain how the following affect the rate of erosion by water
    a. duration and intensity of rainfall
    b. soil texture and structure
    c. slope length
    d. slope percentage
    e. vegetative and residue cover

33. Explain how the following affect the rate of erosion by wind
    a. vegetative and residue cover
    b. wind velocity
    c. unsheltered distance
    d. soil surface roughness
    e. soil texture

34. Define the concept of soil loss tolerance

35. Describe how erosion affects the following
    a. crop yield potential
    b. water holding capacity
    c. nutrient content
    d. organic matter content
    e. infiltration
    f. water quality
    g. air quality

36. Explain how the following decrease erosion potential
    a. strip cropping
    b. contouring
    c. terraces
    d. grassed waterways
    e. surface residue
    f. cover crops
    g. row spacing and direction
    h. buffer strips
    i. surface roughness
    j. windbreaks

COMPETENCY AREA 4. RESIDUE MANAGEMENT

37. Describe how the following soil characteristics differ between clean-till and high surface residue management systems
    a. temperature
    b. erosion potential
    c. moisture
    d. organic matter

38. Describe how residue cover and erosion potential differ among the following tillage systems
    a. clean-till
    b. mulch-till/reduced-till
    c. direct seeding
    d. no-till/zero-till
    e. strip-till

39. Describe how to measure percent crop residue cover

40. State effects of biomass removal from a field on the following soil components
    a. organic matter
    b. structure
    c. fertility
    d. erosion
    e. moisture
    f. carbon sequestration

COMPETENCY AREA 5. RESTRICTIVE SOIL LAYERS

41. Describe characteristics of the following restrictive soil layers
    a. wheel track compaction
    b. tillage-induced compaction
    c. crusting
    d. naturally occurring layers

42. Explain how restrictive soil layers hinder plant growth

43. Explain how restrictive soil layers inhibit water, air, and nutrient movement

44. Describe methods for preventing and alleviating restrictive soil layers

COMPETENCY AREA 6. SOIL MANAGEMENT EFFECTS ON AIR QUALITY

45. Describe how soil management practices affect
    a. odor from manure and biosolids applications
    b. ammonia emissions
    c. particulate emissions
    d. carbon sequestration
    e. release of volatile organic compounds

WATER MANAGEMENT

COMPETENCY AREA 7. WATER AND SOLUTE MOVEMENT

46. Explain how the following components interact to influence the soil water cycle
    a. precipitation
    b. irrigation
    c. runoff
    d. soil water storage
    e. evapotranspiration
    f. deep percolation/recharge
    g. infiltration

47. Describe how the following affect infiltration
    a. soil texture
    b. soil structure
    c. soil organic matter
    d. soil organisms

48. Describe how the following factors influence surface runoff
    a. infiltration
    b. landscape position
    c. permeability
    d. surface residue cover
    e. surface roughness

49. Describe how the following soil factors influence leaching
    a. infiltration
    b. permeability
    c. depth
    d. water holding capacity
    e. texture

50. Define preferential flow

51. Describe how the following affect N, P, K, or S movement
    a. soil pH
    b. organic matter
    c. CEC
    d. soil texture
    e. nutrient solubility

52. Describe how the following management practices affect the potential for solute movement
    a. timing of application
    b. rate of application
    c. erosion and runoff control
    d. irrigation
    e. type of tillage operation

53. List the processes that transport nitrogen or phosphorus from a field

54. List management practices that reduce phosphorus or nitrogen transport from a field

55. Describe how lateral flow contributes to surface water contamination

COMPETENCY AREA 8. SOIL-PLANT/WATER RELATIONS

56. Define the following soil water terms
    a. saturation
    b. field capacity
    c. permanent wilting point
    d. gravitational water
    e. plant available water

57. Describe how the following factors influence evapotranspiration
    a. wind
    b. temperature
    c. solar radiation
    d. relative humidity
    e. soil water status
    f. plant canopy
    g. crop residue surface cover

58. Explain how excessive soil moisture affects plant nutrient uptake and availability

59. Explain how soil moisture deficiency affects plant nutrient uptake and availability

60. Explain how salt index and placement of fertilizers affects germination

COMPETENCY AREA 9. IRRIGATION AND DRAINAGE

61. Describe the following irrigation methods
    a. furrow
    b. sprinkler
    c. drip/trickle
    d. flood
    e. subsurface

62. Describe the following drainage methods
    a. tile
    b. open ditch
    c. beds

63. Explain how to use field soil moisture measurements and the water balance equation to schedule irrigation

64. Describe how soil texture affects tile drainage spacing and depth

65. Identify methods to reduce irrigation runoff

COMPETENCY AREA 10. WATER QUALITY

66. Describe how nutrients, pesticides, and sediments move to off-site areas

67. Identify sources of information that provide water quality standards

68. Differentiate parts per million (ppm), milligrams per liter (mg/l), and milliequivalents per liter (meq/l)

69. Distinguish nitrogen analysis expressed as nitrate (NO^-_3) or nitrate-nitrogen (NO^-_3N)

70. Identify health risks to humans when drinking water contains nitrate-nitrogen or coliform bacteria above the drinking water standard

71. Recognize health risks to livestock of drinking high nitrate-nitrogen water

72. Describe how water contamination occurs at a wellhead

73. Explain methods of preventing contamination at a wellhead

74. Explain the purpose of anti-backsiphoning devices

75. Explain how high sediment levels affect surface water quality

76. Describe how the following components of biosolids affect surface water quality
    a. nutrients
    b. pathogens
    c. heavy metals
    d. pharmaceuticals

77. Explain how nitrogen and phosphorus affect ground and surface water quality

78. Explain the benefits of filter/buffer strips, riparian zones/tree plantings, and wetlands on water quality

79. Identify how salinity affects water quality

Soil and Water Management Glossary

A horizon: Mineral soil horizon formed at or near the soil surface. It displays the greatest amount of leaching and is usually higher in organic matter and biological activity than the deeper horizons.

Acid soil: A soil that has a pH value less than 7.0.

Aggregate, soil: A mass of fine soil particles held together by clay, organic matter, or microbial gums. Aggregates are part of soil structure.

Alkaline soil: A soil that has a pH value greater than 7.0.

Alluvium: A general term for all eroded material deposited by running water including gravel, sand, silt, and clay.

Anion: An ion with a negative charge.

Anion exchange capacity (AEC): The sum total of exchangeable anions that a soil can adsorb. Expressed as centimoles of change per kilogram ($cmol_c/kg$) of soil or milliequivalents per 100 g of soil (meq/100 g soil).

Aquifer: Layers of underground porous or fractured rock, gravel, or sand through which considerable quantities of groundwater can flow and which can supply water at a reasonable rate. May be classified as perched, confined, or unconfined.

Available nutrient: A nutrient in a form that a plant can absorb.

Available water: Portion of water in soil that can be readily absorbed by plant roots.

B horizon: The zone of accumulation of materials such as clay, iron, aluminum, and organic matter moving from the above horizons.

Bedrock: Solid, or consolidated, rock lying under the soil.

Biological oxygen demand (BOD): The amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water and used as a measure of the degree of water pollution.

Biomass: Plant and plant-derived material, including manure: includes forestry products, wood-processing wastes, wastes associated with food-processing operations, energy crops such as switchgrass and poplar trees, and agricultural crop residues such as corn stover and wheat straw.

Biosolid: Any organic material, such as livestock manure, compost, sewage sludge, or yard wastes applied to the soil to add nutrients or for soil improvement.

Blocky: Soil structure classification in which aggregates are in the shape of blocks or polyhedrons.

Buffer strip: Areas or strips of land maintained in vegetation and strategically located on the landscape to help control runoff, erosion, and entrap contaminants.

Buffering: The ability of a solution, like the soil solution or irrigation water, to resist changes in pH when acid or alkaline substances are added. Often used when speaking of soil to describe its resistance to pH changes when limed or acidified.

Bulk density: The mass of oven-dry soil per unit volume, usually expressed as grams per cubic centimeter.

C horizon: Zone of parent material; contains the material from which A and B horizons form.

Carbon sequestration: The process through which carbon dioxide from the atmosphere is absorbed by trees, plants, and crops through photosynthesis, and stored as carbon in biomass and soils.

Calcareous soil: A soil containing significant amounts of naturally occurring calcium carbonate, which fizzes when dilute acid is applied.

Capillary action: Movement of water in the soil through small soil pores.

Carbon-nitrogen (C:N) ratio: The ratio of the mass of carbon to the mass of nitrogen in soil, organic material, or plants.

Cation: An ion with a positive charge.

Cation exchange capacity: The amount of exchangeable cations that a soil can adsorb at a specific pH, expressed as centimoles of charge per kilogram ($cmol_c/kg$) of soil or milliequivalents per 100 g of soil (meq/100 g soil).

Clay: 1) The class of smallest soil particles, smaller than 0.002 millimeter in diameter. 2) The textural class with more than 40% clay and less than 45% sand, and less than 40% silt.

Claypan: A dense, compacted layer of clay found in the subsoil that limits or slows the downward movement of water through the soil.

Clean till: May be referred to as conventional tillage. Tillage where all plant residues are covered. Low surface residue levels provide little protection from wind and/or water erosion.

Coliform bacteria: Microorganisms, which typically inhabit the intestines of warm-blooded animals. They are commonly tested for in drinking water analyses to indicate pollution by human or animal waste.

Colloid: A very tiny particle capable of being suspended in water without settling out. Soil colloids have a charged surface that attracts ions.

Compaction (soil): Increasing the soil bulk density, thereby decreasing the soil porosity, by the application of mechanical forces to the soil.

Composite soil sample: A soil sample resulting from mixing together many individual samples.

Conservation tillage: A general term for tillage practices that leave crop residues on the soil surface to reduce erosion.

Contaminant: Any physical, chemical, biological, or radiological substance that is above background concentration but does not necessarily cause harm.

Contour: An imaginary line perpendicular to the slope that represents the same elevation.

Contour tillage: Tillage following the contours of a slope, rather than up and down a slope. Helps prevent erosion and runoff.

Crust: A thin layer of poorly aggregated surface soil formed by wetting and drying.

Deep tillage: Tillage deeper than that needed to produce loose soil for a seedbed, usually used to loosen a compacted subsoil.

Denitrification: The transformation of nitrate to gaseous forms of nitrogen, occurring under anaerobic conditions.

Discharge: Flow of surface water in a stream or the flow of ground water from a pipe, spring, ditch, or flowing artesian well.

Drainage: Rate and amount of water removal from soil by surface or sub-surface flow.

Ecosystem: Community of animals and plants and the physical environment in which they live.

Effluent: Discharge or emission of a liquid or gas.

Erosion: The wearing away of the land surface by running water, wind, ice, geological agents or mechanical actions, such as tillage or land leveling.

Eutrophication: A natural process of enrichment of aquatic systems by nutrients, primarily nitrogen (N) and phosphorus (P). Accelerated, or cultural, eutrophication, is caused by the addition of excess nutrients to a system. This results in excessive vegetative growth. Decomposition of this plant material can result in the depletion of oxygen in water, leading to the death of aquatic organisms.

Evapotranspiration (ET): Loss of water to the atmosphere from the earth's surface by evaporation and by transpiration through plants.

Fallow: Fields left idle on which vegetative growth is controlled by tillage or chemicals to accumulate water and/or mineral nutrients.

Field capacity: The amount of water a soil holds after free water has drained because of gravity.

Flood plain: Land near a stream that is commonly flooded when the water levels are high. Soil is built from sediments deposited during flooding.

Fragipan: A dense and brittle subsurface layer of soil that restricts root penetration and water movement.

Friable: The ease by which a moist soil can be crumbled.

Granular: Soil structure where the units are approximately spherical or polyhedral.

Gravitational water: Water that moves through the soil under the influence of gravity.

Groundwater: Water in the saturated zone below the soil surface.

Gully: A large channel in the soil, caused by erosion that is deep and wide enough that it cannot be crossed by tillage equipment.

Hardpan: A dense, hard, or compacted layer in soil that slows water percolation and movement of air and obstructs root growth. Pans may be caused by compaction, clay, or chemical cementation.

Hazardous waste: Solid, liquid, or gaseous substance which, because of its source or measurable characteristics, is classified under state or federal law as potentially dangerous and is subject to special handling, shipping, and disposal requirements.

Heavy metals: Refers to: lead, copper, zinc, mercury, arsenic, cadmium, nickel, and selenium. Some states may list additional metals.

Highly erodible land: A soil mapping unit with an erodibility index of 8 or more.

Horizon (soil): A horizontal layer of soil, created by soil-forming processes, that differs in physical or chemical properties from adjacent layers.

Humus: Highly decomposed organic matter that is dark-colored and highly colloidal.

Hydrologic cycle: Movement of water in and on the earth and atmosphere through processes such as precipitation, evaporation, runoff, and infiltration.

Hygroscopic water: Water held tightly by adhesion to soil particles. Cannot be used by plants and remains in soil after air-drying. Can be driven off by heating.

Infiltration: Entry of water from precipitation, irrigation, or runoff into the soil profile.

Irrigation: Application of water to supplement natural rainfall.

Landscape position: Using topography and/or slope characteristics to separate a field into different zones having similar soil characteristics and crop productivity.

Lateral flow: Movement of water horizontally below the soil surface, usually along an impervious layer.

Leaching: The movement of material in solution by the drainage of water through the soil.

Loading: Amount of a substance entering the environment (soil, water, or air).

Mapping unit (soil): Basis for setting boundaries in a soil map. May include one or more soil series.

Mass flow: The movement of solutes associated with net movement of water.

Massive soil: A structureless soil.

Mineral soil: A soil whose traits are determined mainly by its mineral content; mineral soils contain less than 20 or 30 percent organic matter in the US and Canada, respectively.

Mineralization: The conversion of an element by soil organisms from an organic form to an inorganic form.

Minimum tillage: Tillage methods that involve fewer tillage operations than clean tillage does.

Mottling: Spots of different colors in a soil reflecting whether iron in the soil is reduced (greenish-grey colors when poorly drained) or oxidized (reddish-brown colors when well drained). Usually indicative of cycling between poor and good aeration.

Muck: An organic soil in which the organic matter is mostly decomposed.

Mulch: Natural or artificial layer of plant residue or other material covering the land surface which conserves soil moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Mulch till: A full-width tillage and planting combination that leaves some plant residues or other material on the soil surface.

Non-point source (NPS) contamination: Water contamination derived from diffuse sources such as construction sites, agricultural fields, and urban runoff.

No-till/Direct seeding/Zero-till: Method of growing crops that involves no seedbed preparation prior to planting.

O horizon: A surface soil horizon primarily composed of organic matter.

Organic matter: The organic fraction of the soil exclusive of undecayed plant and animal residues.

Organic soil: Soil containing more than 20 or 30 percent organic matter in the US and Canada, respectively.

Peat: Unconsolidated soil material consisting of undecayed or slightly decayed organic matter that has accumulated underwater where low oxygen conditions inhibit decay.

Ped: A natural soil aggregate, such as a granule or prism.

Percolation: Downward movement of water through soil or rock.

Permanent wilting point: The soil water content at which most plants cannot obtain sufficient water to prevent permanent tissue damage.

Permeability: Capacity of soil, sediment, or porous rock to transmit water and gases.

pH: Numerical measure of hydrogen ion concentration, with a scale of 0 to 14. Neutral is pH 7, values below 7 are acidic, and values above 7 are alkaline.

Platy: A soil structure consisting of soil aggregates that are developed predominantly along the horizontal axis; laminated; flaky.

Point source contamination: Water contamination from specific sources such as leaking underground storage tanks, landfills, industrial waste discharge points, or chemical mixing sites.

Potable: Water that is suitable for drinking.

Preferential flow: The rapid movement of water and its constituents through the soil via large and continuous pores.

Prismatic (columnar): Soil structure where the individual units are bounded by flat or slightly rounded vertical faces. Units are distinctly longer vertically, and the faces are typically casts or molds of adjoining units. Vertices are angular or sub-rounded; the tops of the prisms are somewhat indistinct and normally flat.

Recharge: Downward movement of water through soil to groundwater.

Recharge area: Land area over which surface water infiltrates into soil and percolates downward to replenish an aquifer.

Restrictive layer: A nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restricts roots or otherwise provide an unfavorable root environment.

Rill: A channel in the soil caused by runoff water erosion that is small enough to be erased by tillage.

Riparian zone: Land adjacent to a body of water that is at least periodically influenced by flooding.

Runoff: Portion of precipitation, snowmelt, or irrigation, which moves by surface flow from an area.

RUSLE II: Revised Universal Soil Loss Equation: An equation for predicting, *A*, the average annual soil loss in mass per unit area per year, and is defined as, $A = RKLSCP$, where *R* is the rainfall factor, *K* is the soil erodibility factor, *L* is the length of slope, *S* is the percent slope, *C* is the cropping and management factor, and *P* is the conservation practice factor.

Saline soil: A non-sodic soil containing sufficient soluble salt to adversely affect the growth of most crops.

Salinity: An index of concentration of dissolved salts in the soil.

Saltation – Movement of individual soil particles/small aggregates by wind, in which the particles are lifted as much as 12 inches above the soil surface, then travel a short distance before dropping back to the soil surface. From 50 to 80 percent of total soil transport by wind is by saltation.

Saturated zone: Portion of the soil or rock profile in which all pores are filled with water.

Sediment: Eroded soil and rock material, and plant debris, transported and deposited by wind or water.

Sheet and rill erosion: A water erosion process caused by raindrop impact on the soil surface and a thin layer of water (sheet) moving over the soil surface.

Single grain: A structureless soil in which each particle exists separately as in sand.

Sodic soil: Soil high in sodium and low in soluble salts.

Soil loss tolerance (T value): (i) The maximum average annual soil loss that will allow continuous cropping and maintain soil productivity without requiring additional management inputs. (ii) The maximum soil erosion loss that is offset by the theoretical maximum rate of soil development, which will maintain an equilibrium between soil losses and gains.

Soil structure: The combination or arrangement of primary soil particles into secondary soil particle units, or peds.

Soil survey: The examination, description, and mapping of soils of an area according to the soil classification system.

Soil texture: The relative proportions of sand, silt, and clay.

Solubility: Amount of a substance that will dissolve in a given amount of another substance, typically water.

Solute: A substance that is dissolved in another substance, thus forming a solution.

Stomate: Opening in the surface of a leaf through which water vapor, carbon dioxide, and oxygen pass.

Strip-till: A tillage and planting system that disturbs a relatively narrow area of the soil (normally 8 to 10 inches wide), into which the crop is planted and some or all of the crop fertilizer is applied. The area between the tilled strips is left undisturbed, which reduces the potential for soil erosion.

Surface creep: Movement of sand-sized particles/aggregates by wind, in which the particles roll along the soil surface. Surface creep may account for 7 to 25 percent of total transport by wind.

Suspension: Movement of fine (<0.1 mm) soil particles by wind. The particles are dislodged from the soil surface, are small enough to remain in the air mass for an extended period. From 20 percent to more than 60 percent of an eroding soil may be carried in suspension.

Tillage erosion: The downslope displacement of soil through the action of tillage operations.

Tillage pan: Also known as a plow pan. A subsurface layer of soil having a bulk density that is higher than the layer either above or below it. The compaction is caused by the forces exerted during tillage operations.

Tilth: Physical condition of the soil in terms of how easily it can be tilled, how good a seedbed can be made, and how easily seedling shoots and roots can penetrate.

Volatile organic compounds (VOC): Some carbon containing chemicals that readily evaporate and undergo a photochemical reaction with potentially harmful health effects.

Volatilization: The loss of a compound in gaseous form.

Water holding capacity: Similar to field capacity; the amount of water a soil holds after free water has drained because of gravity.

Watershed: All land and water that drains runoff to a stream or other surface water body.

Water table: Upper surface of the ground water or layer of soil saturated with water.

WEPS (Wind Erosion Prediction System): A process-based daily time-step model that simulates weather (wind speed and direction, precipitation, and evapotranspiration) and field conditions (crop growth, surface roughness, crop residue, and windbreaks or barriers) to predict soil erosion by wind.

Wetlands: An area characterized by periods of inundation, hydric soils, and hydrophytic vegetation.

PEST MANAGEMENT COMPETENCY AREAS:

1. Basic Concepts of Pest Management
2. Sampling and Monitoring
3. Identification
4. Decision-Making Guidelines
5. Pest Management Strategies
6. Environmental Stewardship
7. Health and Safety

PEST MANAGEMENT

EXPERTISE WITHIN EACH COMPETENCY AREA:

COMPETENCY AREA 1. BASIC CONCEPTS OF PEST MANAGEMENT

Principles of Integrated Pest Management (IPM)

1. Define IPM

2. Describe how to use the following strategies to construct an effective IPM program
   a. Prevention
   b. Avoidance
   c. Monitoring
   d. Suppression

3. Describe how to use each of the following steps of an IPM program
   a. sampling and monitoring
   b. identification
   c. determining need for control
   d. evaluating control options
   e. implementation
   f. evaluation and record-keeping

4. List advantages of using IPM

5. List limitations to implementing IPM

Pest-Ecosystem Interactions

6. Explain how the following factors affect insect pest population development
   a. pathogens, predators, and parasites
   b. host plants
   c. initial pest population
   d. temperature
   e. moisture
   f. soil characteristics and conditions
   g. wind

7. Explain how the following characteristics of insects influence their ability to cause damage
   a. developmental time and seasonal period of activity
   b. reproduction rate and number of generations per season
   c. overwintering and oversummering characteristics
   d. feeding habits
   e. type of metamorphosis
   f. dispersal and movement characteristics

8. Describe how the environment, host plant, and pathogen interact to result in plant disease

9. Describe how the following plant pathogens survive and disperse
    a. fungi
    b. bacteria
    c. nematodes
    d. viruses

10. Describe how temperature and moisture affect survival of pathogens that are
    a. soil borne
    b. residue borne
    c. found in or on live plant hosts

11. Describe how the following pathogens infect plant tissue
    a. fungi
    b. bacteria
    c. nematodes
    d. viruses

12. Describe how the following weed factors affect the ability of weeds to survive and be competitive
    a. growth rate
    b. seed production
    c. seed dormancy
    d. reproduction method
    e. light, temperature, moisture, and humidity
    f. life cycle
    g. physical characteristics of the plant

13. Describe competitive interactions of
    a. crops on weeds
    b. weeds on crops

COMPETENCY AREA 2. SAMPLING AND MONITORING

14. List advantages and limitations of the following insect sampling methods
    a. direct observation
    b. presence/absence sampling
    c. sweep nets and drop cloths
    d. insect traps

15. Describe how the following aid in monitoring pests
    a. weather data
    b. level of infestation or infection
    c. time of the year
    d. crop growth stage
    e. pest development stage

16. Describe how to obtain a representative sample from the following pest distribution patterns
    a. clumped
    b. uniform
    c. border effect
    d. random

17. Describe how to prepare and ship samples of the following to a laboratory for evaluation
    a. weeds
    b. insects
    c. diseased plants
    d. soil for nematode analysis

18. Explain why supporting information is important when submitting a sample for evaluation

19. List the advantages and disadvantages of the following to monitor pest infestation and/or infection
    a. remote sensing
    b. forecasting models
    c. GPS/GIS

COMPETENCY AREA 3. IDENTIFICATION

20. Explain how to use the following information to help identify a pest
    a. crop grown
    b. time of year
    c. symptoms and patterns of damage
    d. distinguishing characteristics of pest
    e. distribution in field

21. Use the following to identify mites and types of insects
    a. type and number of legs
    b. type of mouth parts
    c. wing characteristics
    d. life cycle

22. Identify the following
    a. aphids
    b. beetles
    c. flies
    d. leafhoppers
    e. mites
    f. moths
    g. thrips
    h. true bugs
    i. whiteflies

23. Use the following plant characteristics to differentiate weeds
    a. cotyledons
    b. arrangement, shape, and vein pattern of leaves
    c. ligules
    d. auricles
    e. hairiness
    f. shape, color, and size of seed
    g. stem shape
    h. root system

24. Identify plant damage caused by the following non-pest factors
    a. wind
    b. temperature extremes
    c. rain, hail, and ice
    d. moisture extremes
    e. sunlight
    f. pesticide phytotoxicity
    g. nutrient deficiency and toxicity
    h. soil compaction
    i. lightning
    j. mechanical or animal

25. List advantages and limitations of using the following diagnostic tools
    a. hand lens
    b. digital camera
    c. picture references
    d. dichotomous keys

COMPETENCY AREA 4. DECISION-MAKING GUIDELINES

26. Define economic threshold and economic injury level

27. Describe how natural enemies impact pest population projections

28. Use information about the following to make pest management decisions
    a. current crop pest data from monitoring and scouting
    b. pest history
    c. pesticide history
    d. cropping history
    e. fertility level
    f. soil, weather, and crop condition

29. Use information about cost of control, potential pest damage, and crop value to decide if pest control is necessary

COMPETENCY AREA 5. PEST MANAGEMENT STRATEGIES

Genetic

30. Explain the role of susceptible refuge host populations in managing insect resistance

31. List advantages and limitations of incorporating multiple traits into crops through transgenic techniques

32. Explain how pests overcome host resistance

Cultural and Mechanical

33. Explain how the following influence pest management decisions
    a. cropping sequence
    b. strip cropping
    c. row spacing and plant population
    d. planting date
    e. harvest date and method
    f. tillage
    g. crop residue
    h. nutrient status
    i. water resources
    j. variety selection

34. Describe methods to minimize introducing pests into fields

35. Describe the concept of critical weed free period

Biological

36. Identify the following biological control agents
    a. lacewings
    b. ground beetles
    c. lady beetles
    d. minute pirate bugs
    e. nabids
    f. parasitic wasps
    g. predatory mites
    h. spiders
    i. syrphidfly larvae

37. Explain advantages and limitations of using biological control agents in crop production

Chemical

38. Explain how the following pesticide characteristics affect pesticide selection
    a. mode of action
    b. chemical and physical properties
    c. toxicity to non-target organisms
    d. efficacy on target organisms
    e. environmental hazard
    f. persistence
    g. selectivity
    h. phytotoxicity to crop

39. Explain how the following factors affect pesticide selection
    a. existing or potential pesticide resistance
    b. economics
    c. application method
    d. field history
    e. pest identity, stage, and level
    f. weather conditions
    g. crop growth stage
    h. label restrictions
    i. pre-harvest intervals
    j. environmental risks

40. Describe how a pest population develops resistance to pesticides

41. Describe how to manage herbicide resistant weed populations

42. Distinguish contact and systemic pesticides

43. Describe how the following affect pest resistance
    a. selection pressure
    b. resistance mechanisms
    c. pest reproduction methods

44. List factors that increase the risk of crop injury from pesticides

45. Explain how the following affect pesticide coverage
    a. wind speed
    b. nozzle characteristics
    c. boom height and configuration
    d. evaporation rate
    e. spray viscosity
    f. spray pressure
    g. ground speed
    h. spray adjuvants

46. List advantages and limitations of ground vs. aerial application methods

47. Identify plant injury symptoms caused by the following herbicide mode-of-action groups
    a. photosynthesis inhibitors
    b. cell membrane disruptors
    c. growth regulators
    d. pigment inhibitors
    e. root/shoot growth inhibitors
    f. amino acid synthesis inhibitors
    g. ALS inhibitors

48. Explain the importance of the following when applying herbicides to herbicide-resistant crops
    a. identifying the field
    b. matching the correct herbicide with the hybrid/variety
    c. scouting

49. Describe the toxicity and persistence of the following insecticide families
    a. organophosphates
    b. carbamates
    c. synthetic pyrethroids
    d. neonicotinoids

50. Recommend insecticide timing and placement based on the following types of insecticide activity
    a. contact
    b. stomach poison
    c. systemic
    d. ovicidal
    e. juvenile hormone

51. Describe how the following fungicide characteristics affect their use
    a. contact vs. locally systemic vs. systemic
    b. pre vs. post infection timing
    c. seed vs. soil vs. foliar applied
    d. broad spectrum vs. narrow spectrum
    e. mode of action

COMPETENCY AREA 6. ENVIRONMENTAL STEWARDSHIP

52. Read and follow pesticide label instructions

53. Describe how solubility, persistence, and soil adsorptive characteristics of a pesticide affect soil and water quality

54. Evaluate a site's vulnerability to soil and water contamination from pesticides

55. Describe the following Worker Protection Standards for handling pesticides
    a. Re-Entry Interval (REI)
    b. information exchange requirements
    c. Personal Protective Equipment (PPE) required by law
    d. emergency assistance requirements
    e. oral and posted warning requirements
    f. site decontamination procedures

56. Define the following terms associated with pesticide use
    a. point source pollution
    b. non-point source pollution
    c. parts per million (ppm) and parts per billion (ppb)
    d. pesticide residue tolerance in the crop
    e. best management practices

57. Explain how the following factors affect spray drift
    a. wind speed
    b. nozzle characteristics
    c. boom height and configuration
    d. evaporation rate
    e. spray viscosity
    f. spray pressure
    g. ground speed

58. Describe how the following affect potential for pesticide loss from a field
    a. residue management
    b. buffer strips
    c. contour or strip farming
    d. subsurface drainage

59. Explain how the presence of endangered species or species at risk affect pesticide selection and application

COMPETENCY AREA 7. HEALTH AND SAFETY

60. List pesticide modes of entry into the human system

61. Define chronic and acute pesticide poisoning

62. Recognize symptoms of acute pesticide poisoning

63. List possible chronic effects of pesticide poisoning

64. Describe procedures to follow if a pesticide gets on skin, in eyes, mouth or stomach, or is inhaled

65. Describe protective gear to use while mixing and applying pesticides

66. Describe proper cleanup procedures for application equipment and protective gear

67. Describe proper procedures for disposing of pesticides and pesticide containers

68. Describe how to store pesticides safely and securely

69. List procedures for handling a pesticide spill

Pest Management Glossary

Abiotic: Non-living, physical or chemical, includes solar radiation, temperature, humidity, and pH; used in context of an effect, such as abiotic injury.

Action threshold: The pest density at which a pest management tactic must be implemented in order to avoid economic loss.

Active ingredient: The chemical in a formulated product that is responsible for the herbicidal/insecticidal/fungicidal effects as indicated on the product label.

Acute exposure: Contact with a pesticide or toxin over a short period of time.

Adjuvant: Substance that enhances the effectiveness of a pesticide.

Bacteria: Unicellular organisms that include free living, saprophytic, and parasitic forms.

Banded pesticides: Pesticide application either over the rows or in-between the rows to reduce the overall application rate per acre.

Beneficial organisms: Organisms that reduce pest numbers or improve soil or plant quality.

Best Management Practice (BMP): Also called Good Farming Practices. Practices recognized as effective and practical means for producing a crop in an economically and environmentally sound way.

Biological pest control: The process of conserving, augmenting or introducing beneficial living organisms to reduce a pest population or its impacts. It includes the use of insects, nematodes, mites, fungi, bacteria, viruses, plants, vertebrates, and other living organisms.

Biological pesticides: Pesticides derived from living organisms such as Bt (*Bacillus thuringiensis*).

Biotic: Pertaining to living organisms.

Broad-spectrum pesticide: Pesticides that are toxic to a wide range of organisms.

Carcinogen: Substance that may initiate cancerous tumor formation in animals.

Chemical pest control: The use of pesticides to reduce a pest population or its impacts.

Chronic exposure: Contact with a pesticide or toxin over a long period of time, usually at low levels.

Common pesticide name: Name given to a specific pesticide active ingredient. Many pesticides are known by a number of trade or brand names, but have only one recognized common name.

Contact pesticide: A pesticide that is toxic to an organism by contact rather than a result of translocation or ingestion.

Cultural pest control: The use of practices other than chemical and biological controls to reduce a pest population or its impacts. Such practices include tillage, row spacing, irrigation, fertility, timely harvest, and all forms of mechanical pest control.

Economic Injury Level: The pest damage level at which the cost of controlling the pest population equals the value of the crop lost.

Economic Threshold (Action Threshold): Pest density at which control measure should be taken to avoid crop value loss from reaching the Economic Injury Level. By implementing a management strategy when Economic Threshold is reached and keep pest populations from reaching the Economic Injury Level.

Fumigant: Gaseous phase of a pesticide used to destroy insects, pathogens, weed seeds, or other pests in soil or grain bins.

Fungi: Organisms which lack chlorophyll and vascular tissue and range in form from a single cell to a body mass of branched filamentous hyphae that often produce specialized fruiting bodies. Fungi cannot produce their own food.

Genetic resistance: Genetically based mechanisms within host plants which hinder pest development.

Good Farming Practices: See BMP

Herbicide carryover: Occurs when a herbicide does not break down during the season of application and persists in sufficient quantities to injure succeeding crops.

Host: A living organism serving as a food source and refuge for a parasite.

Integrated pest management (IPM): A sustainable approach that combines the use of prevention, avoidance, monitoring and suppression strategies in a way that minimizes economic, health, and environmental risks.

LD50 or LC50: The lethal dose of a substance that kills for 50% of the test organisms expressed as milligrams (mg) per kilogram of body weight. It is also the concentration expressed as parts per million (ppm) or parts per billion (ppb) in the environment (usually water) that kills 50% of the test organisms exposed.

Mechanical pest control: A component of cultural pest control that uses physical methods to reduce a pest population or its impacts. Mechanical controls include cultivation, hoeing, hand weeding, mowing, pruning, or vacuuming.

Mode of action: The mechanism by which pesticides affect target organisms.

Narrow-spectrum pesticide: Pesticides that act on a limited range of species.

Non-point Source (NPS) Pollution: Contamination derived from diffuse sources such as construction sites, agricultural fields, and urban runoff.

Parasite: An organism which lives on or in another living organism and obtains part or all of its nutrients from that other living organism.

Parasitoid: An insect that feeds on and develops in another insect, and causes death in the host insect.

Parts per billion (ppb)/ Parts per million (ppm): A means of expression concentration: parts of analyte per billion/million parts of sample.

Pathogen: Living agents that cause diseases in plants and animals.

Pest: Organism that directly or indirectly causes damage to crops.

Pest density: The number of pests per unit area or plant structure.

Pesticide resistance: The inherited ability of an organism to survive and reproduce following exposure to a dose of pesticide normally lethal to the wild type.

Persistence: Ability of a pesticide to resist degradation as measured by the period of time required for breakdown of a material. Depends on environmental conditions and chemical properties.

Personal Protective Equipment: Clothing and protective devices required by EPA to be worn by users of pesticide products.

Phytotoxic: Injurious or toxic to plants.

Plant disease triangle: Diagrammatic representation of the three key factors contributing to plant diseases: 1) susceptible hosts, 2) pathogen presence, 3) proper environmental conditions.

Plant parasitic nematodes: Microscopic, non-segmented roundworms that usually survive in soil, and invade plant roots.

Point source pollution: Contamination from specific identifiable source.

Postemergence: Applied after emergence of the specified weed or planted crop.

Preemergence: Applied to the soil surface prior to emergence of the specified weed or planted crop.

Preplant incorporated (PPI): Applied and tilled into the soil before seeding or transplanting.

Race or strain: Organisms of the same species and variety that differ in their ability to parasitise varieties of a given host, or that differ in their reaction to pesticides.

Reduced-risk pesticides: These are pesticides which: 1) reduce pesticide risks to human health; 2) reduce pesticide risks to nontarget organisms; 3) reduce the potential for contamination of valued, environmental resources.

Re-entry interval: A time period set by EPA that restricts individuals from entering a pesticide-treated area.

Refugia: Areas, untreated with pesticides, provided to preserve susceptible populations of pests.

Sampling: Any valid method to determine a representative value for a field parameter.

Scouting: Sampling or observing crops to determine levels of pest populations and disease; also used to assess crop health and yield potential, and levels of beneficial insects.

Selectivity: Pesticides that are toxic primarily to the target pest (and perhaps a few related species), leaving most other organisms, including natural enemies, unharmed.

Selection Pressure: An action, event, or chemical that preferentially allows survival of one group over another.

Setback: The distance from sensitive areas, such as surface water, wetlands, or tile drain inlets, where no pesticides are to be applied.

Spray drift: Movement of airborne spray droplets of a pesticide outside the intended area of application.

Surfactant: A material that favors or improves the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of pesticides in solution.

Systemic: Not localized; movement away from the area of application to other plant tissues through translocation.

Tank mix: A mixture of two or more compatible pesticides intended for simultaneous application.

Tolerance: The inherited ability of a species to survive and reproduce after pesticide treatment. Also refers to the ability of a crop to yield satisfactorily in presence of pests or adverse environmental conditions.

Toxicity: Degree to which a pesticide is poisonous; the ability of a substance to interfere adversely with the vital processes of an organism.

Trade name: Name given to a product sold by a company to distinguish it from similar products made by other companies.

Transgenic resistance: An organism whose genome has been modified to incorporate pest resistance by the introduction of external DNA sequences into the germ line or gene transfer from outside the normal range of sexual compatibility.

Transgenics (bioengineered organisms): Plants or animals that contain DNA derived from a foreign plant or animal.

Translocation: Actively moved within and between plant tissues and organs.

Trap crop: A crop that attracts and concentrates insect pests.

Vapor drift: The movement of chemical vapors from the area of application.

Viruses: Non-cellular parasites/pathogens comprised of a protein shell and a simple genetic core, usually RNA in plant viruses.

Worker Protection Standard: EPA regulations requiring protective clothing and practices designed to protect users of pesticides by reducing pesticide exposure.

<u>CROP MANAGEMENT</u> COMPETENCY AREAS:

1. Cropping Systems
2. Hybrid and Variety Selection
3. Crop Establishment
4. Crop Growth, Development, and Diagnostics
5. Applied Information Technologies
6. Harvest and Storage
7. Managing Production Risk

CROP MANAGEMENT

EXPERTISE WITHIN EACH COMPETENCY AREA:

COMPETENCY AREA 1. CROPPING SYSTEMS

1. List advantages and limitations of monoculture crop and crop rotation systems

2. Describe the role of the following in a cropping system
   a. fallow
   b. green manure crops
   c. cover crops
   d. companion crops

3. Describe how cropping sequence in a rotation influences
   a. tillage options
   b. residue management
   c. moisture availability
   d. pest management
   e. yield potential

4. Compare clean-till and high surface residue management systems for the following
   a. crop rooting patterns
   b. seed placement
   c. pest management
   d. stand establishment
   e. fertilizer placement

5. Describe how the following affect the conversion of non-cropland to cropland
   a. existing vegetation
   b. pest management
   c. nutrient availability
   d. yield potential
   e. erosion potential
   f. other environmental impacts

6. Define allelopathy

7. Identify sources of information on organic standards and production practices

COMPETENCY AREA 2. HYBRID AND VARIETY SELECTION

8. Define cultivar or variety, and hybrid

9. Differentiate hybrid and open-pollinated varieties

10. Describe how the following influence hybrid or variety selection
    a. maturity
    b. yield potential
    c. adaptation to soil and climatic conditions
    d. yield stability among years and locations
    e. pest resistance and tolerance
    f. herbicide sensitivity
    g. harvestability
    h. end use
    i. value added trait

11. Define transgenic crop

12. List advantages and limitations of growing transgenic crops

13. Explain why randomization and replication are important in field trials

14. Use least significant difference (LSD) values to interpret differences among varieties or hybrids

COMPETENCY AREA 3. CROP ESTABLISHMENT

Seed Quality

15. Use seed tag information to determine seed quality

16. Describe how pre-harvest and harvest conditions influence seed quality

17. Describe how storage time, handling, and storage conditions affect seed quality

18. Describe advantages and limitations of using seed treatments to
    a. facilitate pest control
    b. facilitate seed handling and planting
    c. manage germination timing
    d. enhance nutrient uptake and use

19. Describe advantages and limitations of bacterial inoculants

20. Describe how storage time, handling, and storage conditions affect quality and use of bacterial inoculants

21. Describe uses and limitations of the standard germination test

22. Define Pure Live Seed (PLS)

23. Use purity and germination information to calculate a seeding rate

Planting Practices

24. Describe how the following factors affect seed germination
    a. soil temperature
    b. soil moisture
    c. seed/soil contact

25. Describe how depth of planting affects crop emergence

26. List conditions that alter recommended planting depth

27. Identify factors that influence planting date

28. Identify consequences of seeding earlier or later than optimum

29. Describe how the following factors affect seeding rates
    a. planting practices
    b. soil tilth
    c. environmental conditions
    d. crop residue
    e. seed size
    f. seed quality

30. Describe advantages and limitations of applying fertilizer at seeding

31. Calculate plant population in a field

32. Differentiate seeding rate, plant population, and harvest population

COMPETENCY AREA 4. CROP GROWTH, DEVELOPMENT, AND DIAGNOSTICS

33. Describe characteristics of the following growth stages
    a. germination and emergence
    b. vegetative
    c. flowering
    d. seed development
    e. physiological maturity

34. Describe how temperature and moisture extremes affect crops at the growth stages listed in #33.

35. Define growing degree unit

36. Use growing degree units to determine rate of crop development

37. Describe how daylength affects flowering in short day, long day, and day neutral crops

38. Locate the growing points in grasses and broadleaf plants

39. Describe how the following factors affect crop canopy closure

    a. row spacing
    b. plant population
    c. plant growth habit

40. Differentiate the following

    a. summer annual
    b. winter annual
    c. biennial
    d. perennial

41. Describe how the following soil factors affect crop root growth

    a. pH
    b. moisture and temperature
    c. texture and structure
    d. nutrient status
    e. fertilizer placement
    f. soil borne pests
    g. compaction

42. Describe the effect of tap and fibrous root systems on

    a. nutrient uptake
    b. water uptake
    c. erosion control
    d. soil aggregation
    e. ability to penetrate compacted layers

43. Describe how the following affect the economics of replanting

    a. expected date of replanting
    b. population of surviving plants
    c. pesticides applied
    d. stand uniformity
    e. pest pressure

44. Use information about the following to diagnose a cropping problem

    a. pattern of problem in the field
    b. cropping history
    c. field preparation
    d. weather information
    e. management practices
    f. equipment function

COMPETENCY AREA 5. APPLIED INFORMATION TECHNOLOGIES

45. Differentiate precision and accuracy

46. Define the following precision agriculture terms

    a. global positioning systems (GPS)
    b. remote sensing
    c. geographic information systems (GIS)
    d. variable rate technology (VRT)
    e. crop management zone

47. Describe how the following factors affect yield variability in a field

    a. soil texture
    b. soil organic matter
    c. topography
    d. pest distribution
    e. previous management
    f. salinity
    g. nutrient status and pH
    h. drainage

48. Use a map legend to identify information on a GIS map

49. Use geographical coordinates to locate a tract of land

50. Use latitude and longitude coordinates to locate a point in a field

51. List advantages and limitations of guidance and data logging systems

COMPETENCY AREA 6. HARVEST AND STORAGE

52. Describe how the following factors influence when to harvest

    a. crop moisture percentage
    b. hybrid or variety characteristics
    c. end use
    d. weather
    e. pest damage

53. Describe how the following factors influence crop quality in storage

    a. temperature
    b. moisture
    c. aeration
    d. stored product pests
    e. crop condition and moisture at harvest
    f. post-harvest handling
    g. length of storage
    h. amount of foreign material
    i. sanitation of storage facilities

54. List the consequences of not maintaining the purity of an identity-preserved (IP) crop

55. Describe how to maintain purity of an identity-preserved (IP) crop at planting, harvest, delivery, and storage

56. Recognize excessive crop loss or low quality factors in harvested product caused by improper harvesting procedures

COMPETENCY AREA 7. MANAGING PRODUCTION RISK

57. Describe how to use the following to manage production risk

    a. crop selection
    b. hybrid or variety selection
    c. planting and harvest date
    d. crop rotation
    e. pest and nutrient management
    f. record keeping

58. Describe how the following affect crop management decisions

    a. crop prices
    b. input costs
    c. availability and skill of labor
    d. equipment
    e. weather
    f. cash flow
    g. crop insurance
    h. farm programs
    i. field proximity to sensitive areas
    j. time constraints
    k. pest threat

Crop Management Glossary

Accuracy: The ability of a measurement to match the actual value of the quantity being measured.

Allelopathy: Any harmful effect of one plant or microorganism on other organisms through the production and release of chemical compounds into the environment.

Annual, summer: Plants whose seeds germinate in the spring, the plants produce seed and die the same fall

Annual, winter: Plants whose seeds germinate in the fall, the plants produce seed in the spring and die in the summer.

Anther: The pollen-bearing male portion of a stamen.

Anthesis: The time of flowering in a plant.

Applied Information Technology: Using advanced information technology to make better decisions in crop, soil, and environmental management systems.

Biennial plant: A flowering plant that takes 12-24 months to complete the life cycle. It grows vegetative the first year and reproduces the second year.

Biomass: The mass of a specific plant or plant part in a given area, usually expressed as weight or volume per unit area.

Boot stage: A grass growth stage when an inflorescence is enclosed by the sheath of the uppermost leaf, just prior to inflorescence emergence.

Clean till: Tillage where all plant residues are covered to prevent growth of all vegetation except that of the crop being produced.

Companion crop: A crop sown with another crop, especially one that will emerge and develop slowly. Also called a nurse crop.

Competition: The simultaneous demand by two or more organisms for limited environmental resources.

Continuous cropping: Growing a crop in a field every year.

Cover crop: A crop grown to: 1) protect the soil from erosion during periods when it would otherwise be bare; 2) scavenge excess nutrients from a previous crop to prevent nutrient loss; or both.

Crop management zone: A sub-region of a field that has a relatively uniform combination of yield-limiting factors where a single level of crop management is appropriate.

Crop residue: Plant material remaining in the field after harvest.

Crop rotation: The practice of growing different crops in a planned regular sequence on the same land.

Cropping pattern: The yearly sequence and spatial arrangement of crops, or crops and fallow, in a given area.

Cultivar: A variety, strain, or race that has originated and persisted under cultivation, or was specifically developed for crop production.

Day neutral crop: A crop whose flowering is not influenced by day or night length.

Desiccation: The removal of moisture from a material.

Determinate plant: A plant that initiates flowering based on day length, with the change from vegetative to reproductive growth over a relatively short time.

Double cropping: The practice of consecutively producing two crops of either like or unlike commodities on the same land within the same year.

Dough stage: Stage of seed development at which the endosperm is pliable, like dough, defined as the time when 50% of the seeds on an inflorescence have dough-like endosperm.

Evaporation: The process in which a liquid is changed into a gas.

Evapotranspiration: The loss of water from a given area by both evaporation from plant and soil surfaces, and transpiration from plants.

Fallow land: Land not being used to grow a crop, but on which plant growth is controlled with tillage or herbicides. Used to store water, control weeds, and increase available soil nutrients.

Fibrous root system: A plant root system having a large number of small, finely divided, widely spreading roots, but no large individual roots; common with grass species.

Flag leaf: The uppermost leaf on a fruiting grass stem. The leaf immediately below the inflorescence.

Flowering stage: The physiological stage when anthesis occurs in a plant, or flowers are visible in nongrass plants.

Genetically Modified Organism (GMO/GM): See also transgenic. A living entity that has been modified or transformed through recombinant DNA technology.

Geographic coordinates: The system of latitude and longitude that defines the location of any point on the earth's surface.

Geographic Information Systems (GIS): A computer system for measuring and relating environmental and crop data to positions on Earth’s surface.

Germination: The resumption of growth of a seed embryo after a period of dormancy. Requires a favorable environment of adequate water, oxygen, and suitable temperature.

Germination test: A method to measure seed viability, when placed under favorable environmental conditions.

Global Positioning System (GPS): A system that uses a number of orbiting satellites to identify a location on Earth, based on longitude, latitude, and altitude.

Green manure: Living plant material incorporated into the soil while green for soil improvement.

Growing Degree Unit (GDU): Heat accumulation, calculated by subtracting a base temperature from an average of the maximum and minimum daily temperatures for an area.

Growth regulator: A substance that when applied to plants in small amounts either inhibits, stimulates, or otherwise modifies the growth process.

Harvest index: The quantity of harvestable biomass produced per unit of total biomass.

Harvest population: The number of harvestable plants per unit area remaining at the end of a growing season.

Heading: The developmental stage of a grass plant from initial emergence of the inflorescence from the boot until the inflorescence is fully emerged.

Hybrid: First generation progeny resulting from the controlled cross-fertilization between individuals that differ in one or more genes.

Identity-preserved (IP) crop: A crop in which specific genetic traits are known to exist.

Indeterminate plant: Plant whose flowering is not affected by day length, and continues vegetative growth after reproductive growth has begun.

Inflorescence: The flowering part of a plant or arrangement of flowers on a stalk.

Inoculant: A seed or soil additive, typically some type of bacteria or fungi, that enhances plant growth and development.

Intercropping: Growing two or more crops together in the same field at the same time.

Irrigation efficiency: The ratio of the amount of water actually consumed by a crop or stored in the root zone on an irrigated area to the amount of water applied to the area.

Least Significant Difference (LSD): A statistical range test used to determine true differences among treatment means.

Lodging, root: Condition in which stalks or stems fall due to a weak root system, root damage, or soil condition.

Lodging, stalk: Condition in which stalks or stems break or fall above the soil surface, because of weak stalk, damage, or weather events.

Long day crop: Crop in which flowering occurs when night length is less than the crop's required critical length.

Maturity: The developmental stage when a plant reaches maximum dry matter production, yield, or desirable quality.

Milk stage: In grain, the stage of development following pollination in which the endosperm appears as a whitish liquid like milk.

Monoculture: Growing the same crop continuously in the same field, year after year.

Open pollinated: Plants pollinated by the wind, insects, birds or animals, and not by human manipulation.

Organic farming: Crop production systems that do not use synthetic pesticides or fertilizers

Panicle: A grass inflorescence, the main axis of which is branched, and whose branches bear loose flower clusters.

Perennial plant: Plants that have vegetative structures that allow them to live more than 2 years.

Photoperiodism: The growth and flowering response of plants in relation to changes in the length of daylight hours.

Physiological maturity: Plant growth stage representing the end of reproductive development, where the maximum dry weight has been accumulated.

Pollination: The transfer of pollen from the anther to the stigma of a flower.

Precision: The ability of a measurement to be consistently reproduced.

Precision agriculture: Using the best technologies to identify and manage in-field soil and crop variability to improve production and economic return.

Pure live seed: Percentage of pure germinating seed, calculated as: pure seed percentage x germination percentage/100.

Radicle: The first root of a plant that elongates during germination of a seed and forms the primary root.

Randomization: A random arrangement of treatments or plots, in order to obtain representative data for an experiment.

Relay cropping: A system in which one crop is planted into a standing crop prior to harvest of the established crop, which does not hinder the yield of either crop.

Remote sensing: The collection and analysis of data from a distance, often using sensors that respond to different heat intensities or light wavelengths.

Replication: Repeating plots or treatments in an experiment in order to increase precision.

Resistance, pest: Genetic ability to avoid, repel, or limit attack by a pest by genetic manipulation.

Resistance, pesticide: The inherited ability of an organism to survive and reproduce following exposure to a dose of pesticide normally lethal to the wild type.

Rhizobium: Bacteria which fix atmospheric nitrogen in nodules on the roots of legume plants.

Self pollinated: A plant pollinated by its own pollen.

Short day crop: A crop in which flowering is initiated when the crop's critical night length is exceeded.

Stigma: The female part of a flower where pollen is deposited.

Taproot: The primary root of a plant formed in direct continuation with the root tip or radicle of the embryo. Forms a thick, tapering main root from which arise smaller, lateral branches.

Tilth: Physical condition of the soil that defines how easily it can be tilled, how good a seedbed can be made, and how easily seedling shoots and roots can penetrate.

Tolerance: The inherited ability of a species to survive and reproduce after pesticide treatment. Also refers to the ability of a crop to yield satisfactorily in presence of pests or adverse environmental conditions.

Transgenic: Plants or animals that contain DNA derived from a foreign plant or animal.

Variable Rate Technology (VRT): The ability to vary the application of crop production inputs based on criteria for crop response or soil conditions. Allows for the targeted application of inputs at varying rates across a field.

Variety: A taxonomic subdivision of selectively bred individuals that are distinct, uniform, and stable, that are often referred to as a cultivar when registered for use.

Vegetative: 1) The non-reproductive parts of plants. 2) The non-reproductive stage of plant development.

Vernalization: Exposure of germinating seeds or plants to low temperatures to induce flowering.

Viability: A measure of the potential for seeds to germinate, grow, and develop normally under favorable conditions.

Yield map: The pattern of crop yield in a field based on data collected using a yield sensor on a harvester, and geographic positioning of these yield values using a Global Positioning System.