

INTERNATIONAL CERTIFIED CROP ADVISER EXAM

PERFORMANCE OBJECTIVES

The American Society of Agronomy

Certified Crop Adviser Program



**American Society
of Agronomy**



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Table of Contents

FOREWORD	2
<u>NUTRIENT MANAGEMENT COMPETENCY AREAS:</u>	3
1. Basic Concepts of Plant Nutrition	
2. Basic Concepts of Soil Fertility	
3. Soil Testing and Plant Tissue Analysis	
4. Nutrient Sources	
5. Nutrient Placement and Timing	
6. Soil pH and Liming	
7. Nutrient Diagnostics	
8. Nutrient Management Planning	
<u>SOIL AND WATER MANAGEMENT COMPETENCY AREAS:</u>	12
1. Basic Soil Properties	
2. Site Characterization	
3. Soil Erosion	
4. Residue and Tillage Management	
5. Restrictive Soil Layers	
6. Soil Management Effects on Air Quality	
7. Water and Solute Movement	
8. Soil-Plant/Water Relations	
9. Irrigation and Drainage	
10. Water Quality	
<u>PEST MANAGEMENT COMPETENCY AREAS:</u>	21
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	
<u>CROP MANAGEMENT COMPETENCY AREAS:</u>	29
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. Crop Production Economics	

FOREWORD

Throughout history, a nation's success has been directly related to the success of its agriculture. Today, with less than 2 percent of the population engaged in production agriculture, the margin for error is small, and 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. These topics are 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. Performance Objectives are the heart of the CCA Program, as they outline the basic knowledge and skills required by individuals providing advice to crop producers. By mastering the Performance Objectives, one will possess the knowledge that the agricultural industry has deemed important for a Certified Crop Adviser to know.

These Performance Objectives are dynamic, and are upgraded as the needs of the crop production industry evolve. The original performance objective document was developed by Dr. Jim Vorst of Purdue University in 1992. Every four years, the exam modules are extensively reviewed and updated by a committee representing both the public and private sectors from across the U.S. and Canada. The revised modules are then reviewed by Certified Crop Advisers who provide input on the relative importance of the Performance Objectives, and on areas that need to be added or deleted. 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.

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 are specific Performance Objectives which describe the activity to be performed to demonstrate competency. All the questions on the international exam are based directly on these Performance Objectives. To assist in mastering the competencies required by CCA's, a glossary of many of the terms used for each module is available as a separate document.

Lastly, we gratefully acknowledge the researchers and educators that have provided the foundation of agricultural knowledge that this document is based upon, the countless hours of the individuals who have served on various performance objective review committees, and the literally thousands of subject matter experts and practitioners that have reviewed this document over the years.

The American Society of Agronomy
Certified Crop Adviser Program

NUTRIENT MANAGEMENT COMPETENCY AREAS:

- 1 - Basic Concepts of Plant Nutrition
- 2 - Basic Concepts of Soil Fertility
- 3 - Soil Testing and Plant Tissue Analysis
- 4 - Nutrient Sources
- 5 - Nutrient Placement and Timing
- 6 - Soil pH and Liming
7. - Nutrient Diagnostics
- 8 - Nutrient Management Planning

NUTRIENT MANAGEMENT PERFORMANCE OBJECTIVES

Competency Area 1. Basic Concepts of Plant Nutrition

1. List the 17 elements essential for plant nutrition:
 - a. C, H, O, N, P, K, Ca, Mg, S, Cl, Zn, Fe, Mn, Cu, B, Mo, Ni
2. List beneficial elements
 - a. Si, Na, Co, and Se
3. Classify the essential elements as macronutrient or micronutrient.
4. Describe the functions of N, P, K and S in plants.
5. Classify each macronutrient and micronutrient as mobile or immobile in the plant.
6. List chemical uptake forms of each macronutrient.
7. Describe how nutrient uptake changes as plant growth progresses from germination to maturity.

Competency Area 2. Basic Concepts of Soil Fertility

1. 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.
2. Describe nutrient mineralization, immobilization, and uptake antagonism between ions.
3. Describe mass flow, diffusion, and root interception of nutrients.
4. Describe how cation exchange capacity (CEC) influences the mobility of cations and anions.
5. Classify the following ions as mobile or immobile in the soil:
 - a. ammonium (NH_4^+).
 - b. nitrate (NO_3^-).
 - c. phosphate (H_2PO_4^-).
 - d. sulfate (SO_4^{2-}).
 - e. potassium (K^+).
 - f. calcium (Ca^{2+}).
 - g. magnesium (Mg^{2+}).

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

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

8. Describe how the following soil factors affect symbiotic nitrogen fixation:
 - a. pH.
 - b. moisture.
 - c. available nitrogen level.
 - d. presence of compatible rhizobia species.
 - e. phosphorus, sulfur, molybdenum, and cobalt availability.

9. Describe how the following affect the fate of P in soil
 - a. fixation/saturation.
 - b. pH.
 - c. mineralization.
 - d. soil erosion.
 - e. soluble P transport.

Competency Area 3. Soil Testing and Plant Tissue Analysis

1. Describe how the following affect soil sampling:
 - a. method(s) 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.

2. 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.
3. Differentiate grid, zone, and whole field sampling approaches.
4. 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.
5. Indicate how the following cause variability in soil test analysis:
 - a. time of sampling.
 - b. depth of sampling.
 - c. extraction chemistry and detection method.
 - d. method of preparing and shipping sample.
 - e. number of cores per composite sample.
6. Compare and contrast the following approaches for making nutrient recommendations:
 - a. sufficiency level.
 - b. soil buildup/drawdown.
 - c. base saturation/nutrient balance.
 - d. maintenance/crop removal.
7. Recognize how the following affect soil analysis interpretation for crop management:
 - 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.
8. Describe how to use plant tissue analysis for
 - a. problem solving/diagnosis.
 - b. nutrient program monitoring.
 - c. in-season nutrient management.
9. 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/preparation.
 - g. method and timing of nutrient application.

10. Describe the probability of crop yield response to added nutrition when plant tissue nutrient concentration is
 - a. deficient.
 - b. critical value.
 - c. sufficiency level.
 - d. luxury consumption.
 - e. toxicity level.

11. Describe how the following methods are used to assess plant nutrient status:
 - a. proximal sensing (within 2 meters of the soil surface).
 - b. chlorophyll meters.
 - c. remote sensing.

Competency Area 4. Nutrient Sources

1. Describe how the following serve as plant nutrient sources:
 - a. organic matter.
 - b. irrigation water.
 - c. inorganic/organic fertilizers.
 - d. soil minerals.
 - e. animal manure/processed waste water.
 - f. urban/industrial byproducts/biosolids.
 - g. crop residue.
 - h. residual soil nutrients.
 - i. shallow ground water.

2. Describe how the following influence nutrient loss/availability:
 - a. urease inhibitors.
 - b. polymer coatings.
 - c. nitrification inhibitors.
 - d. chelated formulations.

3. Describe environmental conditions influencing the use of the materials listed in #2.

4. 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.

5. 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.

6. Describe the physical form and analysis of each of the following potassium sources:
 - a. potassium chloride.
 - b. potassium sulfate.
 - c. potassium nitrate.
 - d. potassium magnesium sulfate.
7. Convert fertilizer analysis of P and K from elemental to oxide form, and vice versa.
8. Define the following fertilizer terms:
 - a. total availability.
 - b. water solubility.
 - c. guaranteed analysis.
9. Use nutrient analysis and soil analysis information to calculate fertilizer and/or manure application rates.
10. Describe how the following affect nutrient availability from manure:
 - a. physical form.
 - b. animal source/ration.
 - c. moisture content/percent solids.
 - d. stage of decomposition/composting.
 - e. storage and handling.
 - f. application and timing method.
11. Describe the importance of collecting a representative sample of manure or effluent.

Competency Area 5: Nutrient Placement and Timing

1. Recognize how cropping systems influence the following:
 - a. soil fertility levels.
 - b. method of applying nutrients.
 - c. timing of nutrient application.
2. 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. in furrow (seed placed).

3. Describe advantages and limitations of the following times of nutrient application:
 - a. fall.
 - b. spring preplant.
 - c. at planting/pre-emergence.
 - d. post emergence.
 - e. split application.
4. Explain how the following factors affect seed germination when fertilizers are applied at planting
 - a. placement.
 - b. salt index.
 - c. form of fertilizer.
 - d. rate.

Competency Area 6. Soil pH and Liming

1. Define
 - a. soil pH.
 - b. buffer pH.
 - c. acidic.
 - d. alkaline.
 - e. lime requirement.
2. Be able to define the difference between buffer pH and water pH.
3. Describe the long term change in soil pH from applying nitrate vs ammonium fertilizer sources.
4. Describe how CEC, soil texture, tillage practices, and soil organic matter affect lime requirement.
5. Describe how soil pH affects nutrient availability.
6. Describe how liming materials neutralize soil acidity.
7. Describe how fineness and Calcium Carbonate Equivalent (CCE) affect neutralizing ability of liming materials.
8. Calculate lime application rates to meet liming requirements.
9. Describe the effect of the following on soil pH:
 - a. calcitic lime.
 - b. dolomitic lime.
 - c. elemental sulfur.
 - d. aluminum sulfate (alum).
 - e. ammonium sulfate (AMS).
 - f. gypsum.
 - g. potassium nitrate.
 - h. ammonium nitrate.

Competency Area 7. Nutrient Diagnostics

1. Be able to identify plant symptoms associated with:
 - a. Deficiency
 - b. Toxicity
2. Be able to explain why it would be a nutrient deficiency or toxicity and not a non-nutrient issue (i.e., crop injury from fertilizer applications, poor drainage, etc.)
3. Understand the timing of soil testing versus plant tissue testing for deficiency and toxicity symptoms.

Competency Area 8. Nutrient Management Planning

1. Describe the concept of adaptive management as it relates to nutrients.
2. Describe how to set a realistic yield goal by using information about
 - a. production history.
 - b. soil productivity.
 - c. management level (low versus high input).
 - d. yield limiting factors.
3. Use crop nutrient removal, cropping system, and soil analysis information to apply the 4R nutrient management principles of the right source, rate, time, and place.
4. Describe factors involved in phosphorus loss assessment at field scale.
5. Describe factors involved in nitrogen loss assessment at field scale.
6. Describe when to use N-based or P-based recommendations for manure/biosolid application.
7. Given soil analysis recommendations and manure analysis, use manure and other fertilizer sources to construct a P-based or N-based nutrient application program.
8. Describe how the following areas are environmentally sensitive:
 - a. surface waters.
 - b. sinkholes.
 - c. direct conduits to groundwater.
 - d. wetlands.
9. Describe the role of the following components of a 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.

10. Describe how N and P loss from the following can affect the environment:
- a. erosion.
 - b. runoff.
 - c. volatilization.
 - d. leaching.
 - e. denitrification.
 - f. tile drainage.

SOIL AND WATER MANAGEMENT COMPETENCY AREAS:

- 1 - Basic Soil Properties
- 2 - Site Characterization
- 3 - Soil Erosion
- 4 - Residue and Tillage Management
- 5 - Restrictive Soil Layers
- 6 - Soil Management Effects on Air Quality
- 7 - Water and Solute Movement
- 8 - Soil-Plant/Water Relations
- 9 - Irrigation and Drainage
- 10 - Water Quality

SOIL AND WATER MANAGEMENT PERFORMANCE OBJECTIVES

Competency Area 1. Basic Soil Properties

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 parent material and mineralogy influence background fertility.
5. Differentiate saline, sodic/natric, calcareous, acidic, and alkaline soils.
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 soil bulk density and understand what different values of bulk density mean.
15. Describe how farm equipment traffic, soil moisture, and residue management affect soil bulk density.

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, cover crops and tillage/residue management affect the amount of carbon 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 availability.
 - g. tillage.
21. Explain how the C:N ratio affects organic material decomposition and nitrogen availability.
22. Define soil health
23. Describe how soil physical, chemical and biological properties affect soil health

Competency Area 2. Site Characterization

1. Differentiate O, A, B, and C soil horizons.
2. Define parent material.
3. Calculate the area of a field.
4. Describe how to determine slope.
5. Identify characteristics of well-drained and poorly drained soils.
6. Know how to identify the presence of surface and subsurface drainage.
7. Use a soil survey to locate soil mapping units on a tract of land.
8. Use a soil survey to determine soil characteristics of a field.
9. Describe the limitations of mapping scale when using soil surveys.

10. Explain how the following affect land use and management:
 - a. leaching potential.
 - b. erosion potential.
 - c. wetlands.
 - d. proximity to sensitive areas.
 - e. runoff potential.
 - f. soil drainage class.

Competency Area 3. Soil Erosion

1. Describe the processes of detachment, transport, and deposition for wind and water erosion.
2. Differentiate the following types of erosion:
 - a. sheet.
 - b. rill.
 - c. classic gully.
 - d. ephemeral gully.
 - e. surface creep.
 - f. saltation.
 - g. suspension.
 - h. tillage erosion.
3. 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 steepness.
 - e. vegetative and residue cover.
4. Explain how the following affect the rate of erosion by wind:
 - a. vegetative and residue cover.
 - b. wind velocity, direction and duration.
 - c. unsheltered distance.
 - d. soil surface roughness.
 - e. soil texture.
5. Define the concept of soil loss tolerance.
6. 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.

7. Explain how the following decrease erosion potential:
 - a. stripcropping.
 - 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.
 - k. grade stabilization structure.

Competency Area 4. Residue and Tillage Management

1. Describe how the presence of surface residue affects the following soil characteristics:
 - a. temperature.
 - b. erosion potential.
 - c. moisture.
 - d. organic matter.
2. Describe how residue cover and erosion potential differ among tillage systems.
3. Describe how to measure percent crop residue cover.
4. Describe the effects of biomass removal from a field on the following soil components:
 - a. organic matter.
 - b. structure.
 - c. fertility.
 - d. erosion by wind and water.
 - e. moisture.
 - f. carbon sequestration.
5. Describe how cropping systems and cover crops influence residue cover.
6. Explain how surface residue cover and tillage management influence soil health.

Competency Area 5. Restrictive Soil Layers

1. Describe characteristics of the following restrictive soil layers:
 - a. wheel track compaction.
 - b. tillage-induced compaction.
 - c. crusting.
 - d. naturally occurring layers.
 - i. textural discontinuities
 - ii. fragipans, duripans
2. Explain how restrictive soil layers hinder plant growth.

3. Explain how restrictive soil layers inhibit water, air, and nutrient movement.
4. Describe methods for preventing and alleviating restrictive soil layers.

Competency Area 6. Soil Management Effects on Air Quality

1. Describe how soil management practices affect
 - a. odor from manure and biosolids applications.
 - b. ammonia emissions.
 - c. particulate emissions i.e., dust, smoke, soot, combustion particles, chemical droplets.
 - d. release of volatile organic compounds.
 - e. greenhouse gases (carbon dioxide, methane, nitrous oxide, fluorinated gases)
2. Describe how soil management practices can affect climate change
 - a. carbon sequestration.
 - b. greenhouse gases.
 - c. ammonia emissions.
 - d. particulate emissions.
 - e. release of volatile organic compounds.

Competency Area 7. Water and Solute Movement

1. Explain how the following components influence the soil water cycle:
 - a. precipitation.
 - b. irrigation.
 - c. runoff.
 - d. soil water storage.
 - e. evapotranspiration
 - f. deep percolation/groundwater recharge.
 - g. infiltration.
 - h. groundwater discharge.
2. Describe how the following affect infiltration and runoff:
 - a. soil texture.
 - b. soil compaction
 - c. soil structure.
 - d. soil organic matter.
 - e. macropores.
 - f. landscape topography.
 - g. permeability.
 - h. surface residue cover.
 - i. surface roughness.

3. Describe how the following soil factors influence leaching:
 - a. infiltration.
 - b. permeability.
 - c. depth to restrictive layers.
 - d. water holding capacity.
 - e. texture.
4. Define preferential/macropore flow.
5. Describe how the following affect N, P, K, or S movement:
 - a. soil pH.
 - b. organic matter.
 - c. CEC.
 - d. soil texture.
 - e. nutrient form.
6. 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.
 - f. surface drainage.
 - g. subsurface drainage.
 - h. cover crops.
7. List the processes that transport nitrogen or phosphorus from a field.
8. List management practices that reduce phosphorus or nitrogen transport from a field.
9. Describe how lateral flow of shallow groundwater contributes to surface water contamination.

Competency Area 8. Soil-Plant/Water Relations

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

2. Describe how the following factors influence evapotranspiration:
 - a. wind.
 - b. temperature.
 - c. solar radiation.
 - d. relative humidity.
 - e. plant available water.
 - f. plant canopy.
 - g. crop residue surface cover.
3. Explain how excessive soil moisture affects plant nutrient uptake and availability.
4. Explain how soil moisture deficiency affects plant nutrient uptake and availability.

Competency Area 9. Irrigation and Drainage

1. Describe, understand, and provide advantages and disadvantages of the following irrigation methods:
 - a. furrow.
 - b. sprinkler (solid set, lateral move, center pivot).
 - c. drip/trickle.
 - d. flood.
 - e. subsurface.
2. Describe the following drainage methods
 - a. subsurface drain/tile.
 - b. ditch.
 - c. raised bed.
 - d. land leveling.
3. Explain how to use field soil moisture measurements and a water balance equation to schedule irrigation.
4. Define and describe how to calculate Water Use Efficiency (WUE).
5. Identify strategies to reduce irrigation runoff.
6. Describe how soil texture affects the pattern of tile drainage spacing and depth.

Competency Area 10. Water Quality

1. Describe how nutrients, pesticides, pathogens, and sediments move from agricultural sites to off-site areas.
2. Identify sources of information for water quality standards.
3. Define impaired waterbody.
4. Define and distinguish between eutrophication, hypoxia and anoxia.

5. Differentiate parts per million (ppm), milligrams per liter (mg/l), and milliequivalents per liter (meq/l).
6. Distinguish nitrogen analysis expressed as nitrate (NO_3^-) or nitrate-nitrogen (NO_3^- -N).
7. Identify health risks to humans when drinking water contains nitrate or coliform bacteria above the drinking water standard.
8. Recognize health risks associated with water containing high levels of nitrate to livestock production.
9. Describe how water contamination can occur at a wellhead.
10. Explain management practices that prevent contamination at a wellhead.
11. Explain the purpose of anti-backsiphoning devices.
12. Explain how sediment losses affect surface water quality.
13. Describe how the following components of biosolids affect surface water quality:
 - a. nutrients
 - b. pathogens
 - c. heavy metals
 - d. pharmaceuticals
14. Explain how nitrogen and phosphorus affect ground and surface water quality.
15. Explain the benefits of drainage control structures, bioreactors, filter/buffer strips, riparian zones/tree plantings, and managed wetlands on water quality.
16. Identify how salinity and sodicity affect crop productivity and environmental water quality.

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 PERFORMANCE OBJECTIVES

Competency Area 1. Basic Concepts of Pest Management

1. Define pest.
2. Define Integrated Pest Management (IPM).
3. Describe how to use the following strategies in an effective IPM program:
 - a. prevention.
 - b. avoidance.
 - c. monitoring.
 - d. suppression.
4. Describe 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.
5. List advantages of using IPM.
6. List limitations to implementing IPM.
7. Explain how the following factors affect 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.
 - h. equipment.
8. 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 over-summering characteristics.
 - d. feeding habits.
 - e. type of metamorphosis.
 - f. dispersal and movement characteristics.
9. Define and describe the differences between alternate hosts and alternative hosts.
10. Describe how the environment, host plant, and pathogen interact to result in plant disease.

11. Describe how the following plant pathogens survive between crops, move from field to field, and infect plant tissue:
 - a. fungi.
 - b. bacteria.
 - c. nematodes.
 - d. viruses.

12. 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.

13. Describe how the following factors affect the competitive ability of weed population
 - 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.

14. Describe competitive interactions between crops and weeds.

Competency Area 2. Sampling and Monitoring

1. List advantages and limitations of the following insect sampling methods:
 - a. direct observation.
 - b. sweep nets and drop cloths.
 - c. insect traps.

2. 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.
 - f. aerial or satellite imagery.
 - g. forecasting models.

3. Describe how the following pest distribution patterns affect monitoring and management:
 - a. clumped.
 - b. uniform.
 - c. border effect.

4. Describe how to obtain, prepare and ship samples of the following to a laboratory for evaluation:
 - a. weeds.
 - b. insects.
 - c. diseased plants.
 - d. soil for nematode analysis.
5. Explain why supporting information is important when submitting a sample for evaluation.

Competency Area 3. Identification

1. 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.
2. Use the following to identify mites and insects:
 - a. type and number of legs.
 - b. type of mouth parts.
 - c. wing characteristics.
 - d. life cycle.
3. Identify immature and adult stages of the following:
 - a. aphids.
 - b. beetles.
 - c. flies.
 - d. leafhoppers.
 - e. mites.
 - f. moths.
 - g. thrips.
 - h. true bugs.
 - i. whiteflies.
4. 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.

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

6. 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

1. Distinguish action threshold from economic injury level.
2. Use information about cost of control, potential pest damage, and crop value to determine economic injury level.
3. Describe how natural enemies impact pest population projections.
4. 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.
 - g. future cropping plans.
 - h. crop biotech traits.
 - i. refuge locations.

Competency Area 5. Pest Management Strategies

1. Distinguish conventional resistance from transgenic resistance.
2. Describe how the following crop genetic traits affect pest management:
 - a. Bt modified crops.
 - b. herbicide resistance.
3. List advantages and limitations of incorporating multiple traits into crops through transgenic techniques.

4. Explain how pests can overcome host resistance.
5. Explain the role of susceptible refuge host populations in managing insect resistance.
6. Explain how the following influence pest management decisions:
 - a. cropping sequence/future crop rotation restrictions.
 - 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.
7. Describe practices used to minimize introducing pests into fields.
8. Describe the concept of critical weed free period.
9. Identify the following biological control agents:
 - a. lacewings.
 - b. ground beetles.
 - c. lady beetles.
 - d. minute pirate bugs.
 - e. Damsel bugs.
 - f. parasitic wasps.
 - g. predatory mites.
 - h. spiders.
 - i. syrphid fly larvae.
10. Explain advantages and limitations of using biological control agents in crop production.
11. Explain how the following pesticide characteristics affect pesticide selection:
 - a. mode of action.
 - b. site of action
 - c. chemical and physical properties.
 - d. toxicity to non-target organisms.
 - e. efficacy on target organisms.
 - f. environmental hazard.
 - g. persistence.
 - h. selectivity.
 - i. phytotoxicity to crop.

12. 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.
 - k. future cropping plans.
 - l. soil characteristics.
13. Describe how to prevent pest resistant populations of insects, weeds, and diseases.
14. Describe how to manage herbicide resistant weed populations.
15. Distinguish between contact and systemic pesticides.
16. Describe how the following affect the efficacy of water-applied pesticides:
 - a. water hardness.
 - b. water pH.
 - c. water contaminants (clays and organic matter).
 - d. chemical compatibility.
17. Describe how the following affect pest resistance to pesticides:
 - a. selection pressure.
 - b. resistance mechanisms.
 - c. pest reproduction methods.
18. List factors that increase the risk of crop injury from pesticides.
19. 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. carrier volume
 - i. spray adjuvants.
20. List advantages and limitations of ground vs. aerial application methods.

21. 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. seedling root growth inhibitors.
 - f. seedling shoot growth inhibitors.
 - g. amino acid synthesis inhibitors.
 - h. nitrogen metabolism inhibitors.
 - i. lipid synthesis inhibitors.

22. 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.
 - d. identify crop and variety/hybrid in adjacent fields

23. Describe the importance of rotating among pesticide sites of action.

24. 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.

25. 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

1. Discuss the importance of reading and following pesticide label instructions.
2. Describe how solubility, persistence, and soil adsorptive characteristics of a pesticide affect soil and water quality.
3. Evaluate a site's vulnerability to soil and water contamination from pesticides.

4. 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 current crop and future crops.
 - e. pesticide residue levels in the soil.
 - e. best management practices (BMPs).

5. 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.
 - h. adjuvants.
 - i. carrier volume
 - j. temperature inversion.

6. 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.

7. Explain how the presence of endangered species/species at risk affects pesticide selection and application.

Competency Area 7. Health and Safety

1. List pesticide modes of entry into the human body.
2. Describe procedures to follow if a pesticide gets on skin, in eyes, mouth or stomach, or is inhaled.
3. Define chronic and acute pesticide poisoning.
4. Recognize symptoms of acute pesticide poisoning.
5. List possible chronic effects of pesticide poisoning.
6. 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.

7. Describe required proper cleanup procedures for application equipment and protective gear.
8. Describe proper procedures for disposing of pesticides and pesticide containers.
9. Describe how to store and transport pesticides safely and securely.
10. List procedures for responding to an accidental pesticide release or spill.

CROP MANAGEMENT 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 - Crop Production Economics

CROP MANAGEMENT PERFORMANCE OBJECTIVES

Competency Area 1. Cropping Systems

1. List advantages and limitations of monoculture and crop rotation.
2. Describe the role of the following in a cropping system:
 - a. fallow.
 - b. green manure crops.
 - c. cover crops.
 - d. nurse 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.
 - f. herbicide choice.
 - g. fertility management.
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.
 - f. water management (precipitation, irrigation, and drainage).
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. soil limiting factors.
 - g. water management.
 - h. first cropping choice.
 - i. environmental impacts.
6. Define and distinguish allelopathy and autotoxicity.

Competency Area 2. Hybrid and Variety Selection

1. Define cultivar or variety.
2. Differentiate hybrid and open-pollinated varieties.

3. 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 tolerance and sensitivity.
 - g. harvestability.
 - h. end use.
 - i. value added trait.
4. Define transgenic crop and genetically modified organism (GMO).
5. Explain why randomization and replication are important in field trials.
6. Understand how to use mean separation techniques such as least significant difference (LSD) values to interpret differences among varieties or hybrids.
7. Describe how plant variety protection laws affect the use of seed.

Competency Area 3. Crop Establishment

1. Understand how to use seed tag information to determine seed quality.
2. Describe how pre-harvest and harvest conditions influence seed quality.
3. Describe how storage time, handling, and storage conditions affect seed quality.
4. Describe advantages and limitations of using seed treatments to
 - a. facilitate pest control.
 - b. facilitate seed handling and planting.
 - c. enhance nutrient uptake and use.
5. Describe advantages and limitations of bacterial inoculants for legumes.
6. Describe how seed treatments, storage time, handling, and storage conditions affect quality and use of bacterial inoculants for legumes.
7. Describe uses and limitations of the warm and cold germination tests.
8. List benefits of using certified seed.
9. Use purity, germination, hard seed, and seed size information to calculate a seeding rate.
10. Define seed lot.

11. Describe how the following factors affect seed germination:
 - a. soil temperature.
 - b. soil moisture.
 - c. seed/soil contact.
12. Describe how depth of planting affects crop emergence.
13. List conditions that influence recommended planting depth.
14. Identify factors that influence planting date.
15. Identify consequences of seeding earlier or later than optimum.
16. Describe how the following factors affect seeding rates:
 - a. planting practices.
 - b. soil tilth.
 - c. soil salinity.
 - d. environmental conditions.
 - e. crop residue.
 - f. seed size.
 - g. seed quality.
17. Describe advantages and limitations of applying fertilizer at seeding.
18. Calculate plant population in a field.
19. Differentiate seeding rate, plant population, and harvest population.

Competency Area 4. Crop Growth, Development, and Diagnostics

1. Describe characteristics of the following growth stages:
 - a. germination and emergence.
 - b. vegetative.
 - c. flowering.
 - d. seed development.
 - e. physiological maturity.
2. Describe how temperature and moisture extremes affect crops at the growth stages listed in #1.
3. Define growing degree day.
4. Use growing degree days to determine rate of crop development.
5. Describe how day length affects flowering in short day, long day, and day neutral crops.
6. Locate the growing points in grasses and broadleaf plants.

7. Describe how the following factors affect crop canopy closure:
 - a. row spacing.
 - b. plant population.
 - c. plant growth habit.

8. Differentiate the following:
 - a. summer annual.
 - b. winter annual.
 - c. biennial.
 - d. perennial.

9. 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.
 - h. salinity
 - i. soil organic matter

10. Describe the effect of tap and fibrous root systems on
 - a. nutrient uptake.
 - b. water uptake.
 - c. erosion control.
 - d. soil structure.
 - e. ability to penetrate restrictive layers.

11. Describe how the following affect the economics of replanting:
 - a. original planting date
 - b. population of surviving plants.
 - c. expected date of replanting.
 - d. pesticides applied.
 - e. stand uniformity.
 - f. pest pressure.
 - g. nutrients applied.
 - h. crop insurance.
 - i. seed company replant policy.
 - j. weather information

12. Use information about the following to diagnose a cropping problem:
 - a. pattern and history of problem in the field.
 - b. cropping history.
 - c. field preparation.
 - d. weather information.
 - e. management practices.
 - f. equipment function.
 - g. traits and seed treatments.
 - h. pesticide history.
 - i. soil characteristics.

Competency Area 5. Applied Information Technologies

1. Differentiate precision and accuracy.
2. Define global positioning system (GPS).
3. Describe how the following precision agriculture tools are used in crop management:
 - a. guidance systems.
 - b. remote sensing.
 - c. geographic information systems (GIS).
 - d. crop management zone.
 - e. variable rate technology (VRT).
4. Differentiate management zone, grid, and field composite approaches to precision farming.
5. Describe how the following factors affect yield variability within a field:
 - a. soil texture.
 - b. soil organic matter.
 - c. soil moisture.
 - d. topography.
 - e. pest distribution.
 - f. previous management.
 - g. salinity.
 - h. nutrient status and pH.
 - i. drainage.
 - j. erosion (wind and water)
 - k. soil mapping unit
 - l. inherent soil quality
6. Use a map legend to identify information on a GIS field map.
7. Use latitude and longitude coordinates to locate a point in a field.

Competency Area 6. Harvest and Storage

1. 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.
2. Describe how the following factors influence post-harvest crop quality during 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
3. Describe how to maintain purity of an identity-preserved (IP) crop at planting, harvest, storage, and delivery.
4. List the consequences of not maintaining the purity of an identity-preserved (IP) crop.
5. Recognize excessive crop loss or low quality factors in harvested product caused by improper harvesting procedures.
6. Describe how the following affect food safety:
 - a. worker/equipment sanitation.
 - b. water sources/irrigation testing.
 - c. buffer zones.
 - d. pesticide use.
 - e. record keeping.

Competency Area 7. Crop Production Economics

1. 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.
 - g. marketing

2. Describe how the following affect crop management decisions:
 - a. crop prices.
 - b. input costs.
 - c. availability, skill, and cost 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.
 - j. return on investment
 - k. overhead costs
 - l. access to markets
3. Differentiate commodity crops from specialty crops.
4. Describe how the following factors influence crop prices received by the grower:
 - a. basis.
 - b. supply and demand.
5. Describe how growing transgenic crops can affect marketing.