

**MISSOURI  
CERTIFIED CROP ADVISER**

***PERFORMANCE OBJECTIVES***



**Effective November 2020**

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**Introduction**

The Certified Crop Adviser (CCA) program is a voluntary organization of professionals formed to establish a base standard of knowledge, skills, and abilities for individuals who advise farmers on crop management and production inputs. The goal of the CCA program is to demonstrate professionalism in providing economically and environmentally sound production advice to agronomic producers.

The CCA program is coordinated internationally (US, Canada, and Mexico) by the American Society of Agronomy ([www.certifiedcropadvisor.org](http://www.certifiedcropadvisor.org)). It is administered locally by a Missouri state board composed of representatives from agri-business, agricultural consulting, Missouri Extension Service, state and federal government agencies and farming.

In addition to passing both an international and state test, the applicant must also demonstrate work experience and/or education requirements and adhere to a Code of Ethics.

These Performance Objectives provide guidance to individuals preparing for the Missouri Certified Crop Adviser Exam. They supplement the International Performance Objectives and emphasize certain aspects of nutrient, soil and water, pest and crop management principles that are of particular importance in Missouri. Exam questions are based on these Performance Objectives and the International Performance Objectives as they apply to providing advice on crops grown in Missouri.

The Missouri Performance Objectives outline the knowledge and skill areas that Certified Crop Advisers in Missouri have indicated they need to effectively carry out their duties. These Performance Objectives cover the minimum level of fundamental principles considered essential for effective crop advising. Continuing education through board approved courses as well as individual learning to increase the knowledge and proficiency of each CCA is required throughout their career. The scientific basis of these Performance Objectives needs to be acquired through critical study of valid sources. Individual CCA's are expected to be able to critically evaluate the science and validity of various sources and be able to apply sound science and useful recommendations to solve crop production problems in Missouri.

**Table of Important Missouri Crops**

Alfalfa	Corn	Cotton	Grain Sorghum
Grass Legume Forages	Rice	Small Grains	Soybean

The crops in the table above are considered important crops in Missouri and will be the focus for the Performance Objectives, as well as the Missouri CCA Local Board Exam.

## **List of Acronyms to Know**

BMP – Best Management Practice  
CEC – Cation Exchange Capacity  
DAP – Diammonium Phosphate  
EC – Electrical Conductivity (of soil)  
ENM – Effective Neutralizing Material  
ET - Evapotranspiration  
FRAC – Fungicide Resistance Action Committee  
GDD – Growing Degree Day  
GIS – Geographic Information System  
GPS - Global Positioning System  
HRAC – Herbicide Resistance Action Committee  
IRAC – Insect Resistance Action Committee  
IPM – Integrated Pest Management  
LD<sub>50</sub> – Lethal Dose to 50% of a test population  
LSD – Least Significant Difference  
MAP – Monoammonium Phosphate  
PET – Potential Evapotranspiration  
RUSLE2 – Revised Universal Soil Loss Equation 2  
TMDL – Total Maximum Daily Load  
UAV – Unmanned Aerial Vehicle  
VRT – Variable Rate Technology  
WEPP – Water Erosion Prediction Project  
WOTUS – Water of the United States  
WSSA – Weed Science Society of America  
WUE – Water Use Efficiency

## Nutrient Management

### Competency Area 1. Basic Principles of Soil Fertility and Plant Nutrition

1. Know the 16 elements essential for plant growth and the ionic form(s) by which each is absorbed into plants.

Carbon	Boron	Iron	Phosphorous
Hydrogen	Calcium	Magnesium	Potassium
Oxygen	Chlorine	Manganese	Sulfur
Nitrogen	Copper	Molybdenum	Zinc

2. Of the 16 essential nutrients, identify each nutrient as a macronutrient, secondary nutrient or micronutrient.
3. Cation exchange capacity (CEC)
  - a. Be able to define CEC and understand how CEC is determined.
  - b. Understand the role CEC plays in plant nutrition.
  - c. Know the soil properties that affect CEC.
  - d. Understand the relationships among CEC, nutrient mobility and nutrient availability.
4. Understand how soil, climatic and nutrient properties affect movement and retention of nutrients in soil and water.
5. Understand how mineralization and immobilization affect nutrient availability.
6. Understand the 4R Nutrient Stewardship principles: right source, right rate, right time, right placement.
7. Understand nutrient needs specific to important crops in Missouri.

### Competency Area 2. Soil pH and Liming

1. Define soil pH and understand the scale upon which pH is based.
2. Know the natural processes and agronomic practices that change soil pH.
3. Know the effect soil pH has on nutrient availability, elemental toxicity and plant growth.
4. Understand the concept "Effective Neutralizing Material (ENM)" and how ENM is affected by lime material properties.
5. Know the types of liming sources used in Missouri and their properties.
6. Know how crop production practices and soil properties affect lime requirements.
7. Understand the difference between water pH and salt pH (pH<sub>s</sub>).

8. Know the desirable soil pH levels for crop growth
9. Understand the relationship between pH and aluminum toxicity.

### Competency Area 3. Major Nutrients

#### Nitrogen

1. Understand the nitrogen cycle including the processes of nitrification, mineralization, leaching, denitrification, volatilization and nitrogen fixation.
2. Recognize general N deficiency symptoms in leaves of grain and forage crops.
3. Recognize how crop characteristics, soil properties, cropping systems and crop management affect nitrogen fertilization including source, rate, timing and placement. Recognize availability of other nutrients and environmental conditions on nitrogen uptake and nitrogen use efficiency by crops.
4. Know the analysis, physical form and handling precautions of each of the following nitrogen fertilizer materials:
  - a. anhydrous ammonia
  - b. urea, ammonium nitrate
  - c. UAN solutions
  - d. ammonium sulfate
  - e. ammonium thiosulfate
5. Know the advantages and disadvantages of each nitrogen fertilizer material in relation to soil profile characteristics, cropping system, placement and tillage:
  - a. anhydrous ammonia
  - b. urea, ammonium nitrate
  - c. UAN solutions
  - d. ammonium sulfate
  - e. ammonium thiosulfate

#### Phosphorus

1. Recognize general phosphorus deficiency symptoms in grain and forage crops.
2. Recognize how crop characteristics, soil properties and crop management affect phosphorus fertilization requirements.
3. Understand how soil pH, clay type, organic matter and texture affect phosphorus retention and fixation.
4. Recognize the analysis, physical form and handling precautions of each of the following phosphorus fertilizer materials:
  - a. diammonium phosphate (DAP)
  - b. monoammonium phosphate (MAP)

- c. triple superphosphate
  - d. ordinary superphosphate
  - e. ammonium phosphate (includes ammonium polyphosphates)
5. Know the advantages and disadvantages of each phosphorus fertilizer material in relation to soil profile characteristics, cropping system, placement and tillage:
- a. diammonium phosphate (DAP)
  - b. monoammonium phosphate (MAP)
  - c. triple superphosphate
  - d. ordinary superphosphate
  - e. ammonium phosphate (includes ammonium polyphosphates)

### Potassium

1. Recognize general potassium deficiency symptoms in grain and forage crops.
2. Recognize how cropping systems and soil properties affect potassium fertilization requirements.
3. Understand how CEC, clay type and soil texture affect potassium retention, fixation and availability.
4. Recognize the analysis, physical form and handling precautions of each of the following potassium fertilizer forms: potassium chloride, potassium sulfate, potassium nitrate.

### Sulfur, Calcium and Magnesium

1. Recognize the general Sulfur deficiency symptoms in grain and forage crops.
2. Understand the relationship between climatic conditions, organic matter, CEC, and pH.
3. Recognize the analyses and characteristics of the following S materials:
  - a. ammonium sulfate
  - b. elemental S
  - c. gypsum
  - d. magnesium sulfate
4. Understand how CEC, clay type, organic matter and soil profile characteristics influence Ca and Mg reactions and availability.
5. Be able to describe the relationship between Ca, Mg and problems such as grass tetany.
6. Know how to select appropriate Ca and Mg sources including magnesium sulfate, gypsum and dolomitic limestone.

#### Competency Area 4. Micronutrients

1. Recognize deficiency symptoms for the following micronutrients: zinc, manganese, iron and boron.
2. Understand soil properties and nutrient interactions that affect availability of these mineral elements (Zn, Mn, Fe, B).
3. Recognize toxicity symptoms for aluminum, manganese and boron.
4. Understand soil properties and nutrient interactions that affect availability of these mineral elements (Al, Mn, B).
5. Understand methods used to correct micronutrient deficiencies including foliar and soil applications.

#### Competency Area 5. Nutrient Management Planning

1. Know the elements of a Comprehensive Nutrient Management Plan and nutrient management plans and how these elements fit together.
2. Understand recommended soil sampling and handling procedures including: time of sampling, depth of sampling, frequency of sampling and sampling density.
3. Discuss the pros and cons of grid sampling versus zone soil sampling.
4. Know recommended plant parts and stages of development for plant nutrient analysis of the important crops for Missouri.
5. Understand the principles of each of the following philosophies of soil test interpretation and recommendations: sufficiency; buildup/drawdown and maintenance; and basic cation saturation ratio.
6. Understand soil test and plant nutrient analysis reports and be able to make economically and environmentally sound nutrient application recommendations.
7. Be able to calculate:
  - a. guaranteed analysis of a fertilizer blend
  - b. pounds of nutrient per acre for a fertilizer application
8. Understand nutrient availability from organic nutrient sources listed below, including proper sampling, sample handling, analysis and interpretation procedures:
  - a. animal wastes
  - b. sludges
  - c. legumes
  - d. soil organic matter
  - e. cover crops



9. Understand Missouri Department of Natural Resources regulations on manure and nutrient application rates.
10. Know the factors to consider when selecting fields and crops most suitable for manure applications.
11. Understand how the process of nutrient management planning protects both surface and groundwater resources.

#### Competency Area 6. Environmental Effects of Nutrient Loss

1. Understand the process by which excess nutrients lead to eutrophication, hypoxia and other impacts on surface water quality.
2. Understand the process by which excess nutrients lead to impacts on ground water quality and safety.
3. Know the importance of nutrients relative to other pollutants (organics, metals, sediment and pathogens) in different types of water bodies both adjacent to cropping areas and downstream, i.e. drinking water supplies, fisheries and recreational areas.
4. Know Best Management Practices (BMPs) to minimize movement of agricultural nutrients to surface and ground water resources.

## **Soil and Water Management**

### Competency Area 1. Soil Surveys and Landscapes

1. Know how to use both digital and printed soil survey reports and maps and how they provide a resource inventory including:
  - a. drainage classes
  - b. soil profile depth
  - c. soil slope
  - d. landscape position
  - e. parent material
  - f. natural vegetation
  - g. capability classes
  
2. Understand the relationship among soil series, soil map units, soil phases and landscape position.

### Competency Area 2. Physical Properties of Soil

1. Understand soil texture, bulk density and structure.
2. Know, understand, and interpret the relationship of plant available water, field capacity, wilting point and their relationship to soil physical properties.
3. Understand how soil physical properties influence:
  - a. water holding capacity
  - b. water infiltration
  - c. internal drainage/permeability
  - d. air exchange
  - e. root growth
4. Understand how agronomic practices affect soil structure.
5. Recognize the effects of, plant cover, residue and tillage on soil micro-climate including temperature, heat transfer and moisture.
6. Soil Compaction
  - a. Understand how soil compaction occurs and how compaction can be prevented or corrected.
  - b. Know the relationship between soil physical properties and compaction potential.
  - c. Recognize plant and soil symptoms of soil compaction and impermeable layers (natural versus management induced).
  - d. Understand how soil texture is related to soil compaction.

### Competency Area 3. Soil Biology

1. Understand soil organic matter components and rates of decomposition.
2. Define soil organic matter and its relationship organic carbon and be able to convert between the two.
3. Understand the relationship of organic matter to soil color, soil structure and nutrient supply.
4. Understand how soil organic matter is increased or decreased by agronomic practices.
5. Understand the importance of soil microorganisms to soil health and how these microbes can be affected by weather, soil chemistry, soil physical properties and agronomic practices.
6. Understand how the C:N ratio affects plant available N.
7. Understand how soil biology affects soil respiration and how tests can be used to indicate levels of soil respiration and soil health.

### Competency Area 4. Soil Water

1. Understand factors that influence water infiltration and runoff.
2. Understand soil properties that influence water and solute movement across land surfaces and through soil profiles (vertically and laterally).
3. Recognize practices used to control excess soil water including surface and sub-surface drainage.
4. Irrigation
  - a. Define water use efficiency (WUE) and how it relates to irrigation.
  - b. Recognize advantages and disadvantages of irrigation methods.
  - c. Understand the principles of fertigation.
  - d. Know the water requirements for the important crops in Missouri at different crop stages of development and estimate the inches of water needed for irrigation.
  - e. Be able to estimate economic yield loss from moisture stress and make irrigation decisions based on this information.
5. Know how to use water conserving practices in crop management.

### Competency Area 5. Plant-Water Relations

1. Define evapotranspiration (ET) and potential evapotranspiration (PET).
2. Understand how ET and PET are used to make decisions about irrigation.

3. Describe how wind, temperature, solar radiation, relative humidity, leaf area and growth stage of the crop affect ET.
4. Explain how crop residue/soil cover impacts evaporation and soil temperature.
5. Understand air vs water in the soil pore spaces and how it will affect movement of water/nutrients within the root zone.
6. Understand how saturation percentages within the soil profile affects plant growth.
7. Understand clay pan interaction with soil water and how it may affect crop growth.
8. Understand and be able to identify redoximorphic features in the soil profile and how it may affect plant growth.

#### Competency Area 6. Erosion and Soil Conservation

1. Understand water and Best Management Practices (BMPs) used to decrease and manage water erosion.
  - a. Rill and sheet erosion
2. Understand the factors involved in soil erosion by wind and Best Management Practices (BMPs) used to decrease and manage wind erosion.
3. Understand how soil physical properties, landscape characteristics, rainfall duration and intensity, wind velocity, residue cover and crop cover affect soil erosion.
4. Recognize the factors of the Revised Universal Soil Loss Equation (RUSLE2) that are used to estimate soil loss and be aware of other soil loss equations that may be in use such as the Water Erosion Prediction Project (WEPP).
  - a. Understand what is meant by a soil k value (erodibility factor) and know the difference between  $k_f$  and  $k_w$  with regard to erosion potential and rock fragments.
5. Understand the following erosion control practices: residue management, contouring, strip cropping, terraces, grass waterways, crop rotation, vegetative filter strips, wind breaks, cover crops and drainage practices (i.e. drain tile).
6. Know advantages, disadvantages and relative effectiveness of common erosion control practices.
7. Recognize the components of an approved conservation plan and its relationship to crop management decisions.
8. Know how to estimate soil residue cover.

### Competency Area 7. Tillage

1. Define the following tillage systems and know their effect on residue: no-tillage, vertical tillage, clean tillage, strip tillage, mulch tillage, ridge tillage and stale seedbed.
2. Recognize how environment, soil properties, crop productivity, crop rotation and regulations influence tillage selection.
3. Understand how various tillage systems and no-till can impact weed control.
4. Explain how different tillage systems affect soil physical and biological properties.

### Competency Area 8. Water and Air Quality

1. Define point and non-point sources of pollution.
2. Understand the effects of agricultural pollutants (nutrients, pesticides and sediment) on water quality for different types of surface and groundwater resources and their importance relative to other pollutants (metals, organics and pathogens).
3. Understand the mechanisms and pathways that allow agricultural pollutants to move to surface water and to groundwater.
4. Know best management practices (BMPs) to minimize movement of agricultural pollutants to water and air resources.
5. Understand differences in regulatory requirements for water resources that have regulatory restrictions/requirements such as Total Maximum Daily Loads (TMDLs).
6. Understand there are legal limits for agricultural pollutants in different types of water bodies.
7. Understand there are regulatory requirements regarding odor/particulates with respect to large animal operations.

### Competency Area 9. Federal Regulations and Policy

1. Recognize the intended environmental benefits of:
  - a. conservation compliance
  - b. sodbuster
  - c. swampbuster
  - d. conservation reserve program
  - e. wetlands reserve program
2. Understand what is meant by Waters of the U.S. (WOTUS) and implications for agricultural operations.
3. Understand the uses of a NRCS electronic Field office technical guide and where to find the most recent information.

### Competency Area 10. Soil Quality

1. Relate soil quality to basic soil chemical, physical and biological characteristics.
2. Define concepts regarding maintaining soil sustainability including conservation practices listed in the Soil and Water Management Section of this document.
3. Understand how fertilizer and pesticide applications can impact soil health.

## **Pest Management**

### **Competency Area 1. Principles of Integrated Pest Management**

1. Understand the basic principles of integrated pest management:
  - a. prevention
  - b. avoidance
  - c. monitoring
  - d. suppression and control
2. Describe the components of an integrated pest management program including:
  - a. sampling and monitoring
  - b. identification
  - c. decision making
  - d. method evaluation
  - e. implementation
  - f. evaluation
  - g. record-keeping
3. Know the definitions of economic threshold and economic injury level and how they are used in decision making for pest control.
4. Describe standard scouting procedures for major pests.
5. Understand how resistance to control methods develops and describe management practices to prevent or delay development of pesticide resistance in insects, weeds or pathogens.
  - a. cultural
  - b. chemical
  - c. biological
6. Understand how the following can be used in pest management:
  - a. site-specific management
  - b. geographic information system (GIS)
  - c. global positioning system (GPS)
  - d. soil mapping (e.g., soil survey, EC data)
  - e. zone management system
  - f. yield mapping
  - g. variable rate technology (VRT)
  - h. remote sensing
7. Understand the herbicide (HRAC), insecticide (IRAC) and fungicide (FRAC) charts and how to use to manage resistance and effectiveness of pesticides.
8. Understand the differences between mode of action, mechanism of action and site of action.

## Competency Area 2. Weeds

1. Be familiar with the methods of identification, life cycle, anatomy, biology, method of reproduction and control of common Missouri weeds listed in Appendix A.
2. Recognize plant parts that are used to identify weeds at all growth stages.
3. Recognize the importance of each of the following factors affecting weed problems and weed-crop interference:
  - a. light
  - b. water and nutrient competition
  - c. crop and weed growth rates
  - d. crop and weed germination patterns
  - e. duration and timing of competition
  - f. weed seed dormancy
  - g. vegetative reproduction
  - h. allelopathy
  - i. shade tolerance
  - j. weed species
  - k. weed life cycle
  - l. contamination of grain and forages
4. Understand the use of cultural practices
  - a. mechanical weed control practices (tillage and hand roguing)
  - b. cover crops
  - c. crop rotation
  - d. planting date
  - e. mowing
  - f. early harvest
  - g. stand density and row spacing
  - h. allelopathy
  - i. variety selection for specific traits (e.g., Roundup Ready)
5. Understand the use of biological practices
  - a. managing beneficial insects
  - b. managing livestock
6. Herbicide management and chemical control
  - a. Describe advantages and disadvantages to pre-plant incorporated, pre-emergence, post-emergence and burndown herbicide application and their adaptation to different tillage systems.
  - b. Recognize the soil, climatic and agronomic factors that affect herbicide performance and herbicide recommendations.
  - c. Understand how herbicide persistence affects soil residual herbicide performance.
  - d. Recognize the soil, climatic and agronomic factors that affect herbicide carryover.



- e. Know where to find WSSA herbicide mechanism/site of action listing and how to use it. ([www.hracglobal.com](http://www.hracglobal.com) and <http://wssa.net/wssa/weed/herbicides/>).
- f. Understand the relationship among mode/mechanism/site of action, chemical family symptomology and weed control.
- g. Recognize general plant symptoms (weed and crop) caused by the following site of action groups:
  - i. photosynthetic inhibitors
  - ii. cell membrane disrupters
  - iii. pigment inhibitors
  - iv. growth regulators
  - v. seedling root growth inhibitors
  - vi. seedling shoot growth inhibitors
  - vii. lipid synthesis inhibitors
  - viii. amino acid inhibitors
  - ix. nitrogen metabolism inhibitors
- h. Understand how the following impact herbicide effectiveness:
  - i. soil moisture and pH
  - ii. temperature
  - iii. precipitation
  - iv. growth stage/weed height
  - v. herbicide application time of day
- i. Understand how the following impact crop susceptibility to herbicide damage:
  - i. soil pH
  - ii. variety tolerance
  - iii. growth stage of the crop
  - iv. stress conditions of the crop (moisture, temperature, physical, etc.)
- j. Describe types, purposes and advantages of herbicide adjuvants.
- k. Understand various biotech herbicide tolerant traits and their impact on herbicide recommendations.
- l. Understand regulatory requirements on herbicide recommendations.

### Competency Area 3. Diseases

1. Distinguish between abiotic and biotic plant diseases.
2. Compare and contrast viruses, bacteria, fungi and nematodes with respect to:
  - a. physical characteristics
  - b. inoculum sources
  - c. means of dissemination
  - d. means of survival
  - e. characteristic symptoms
3. Be familiar with the methods of identification, type of pathogen, source of inoculum and management of common Missouri field crop diseases listed in Appendix B.

4. Understand how the disease triangle influences (environment, the host plant and the pathogen) the development of crop diseases.
5. Understand how crop management practices and environmental conditions affect crop disease incidence and severity.
6. Describe the advantages and disadvantages of genetic, cultural, biological and chemical control of plant diseases.
7. Know the definitions of resistant, immune, susceptible, tolerant and race.
8. Understand what the FRAC table is, where to find it and how to use it.  
([www.frac.info/](http://www.frac.info/))
9. Understand the differences between the groups of fungicides and their modes of action.
  - a. Know the difference between and why they are classified this way:
    - i. systemic fungicides
    - ii. contact
    - iii. protectant fungicides
    - iv. eradicant fungicides
  - b. Understand the difference between broad spectrum and narrow spectrum (or selective) fungicides.
  - c. Understand the differences among fungicides, nematocides and bactericides.
  - d. Describe factors that may influence fungicide use and efficacy.
10. Know the definition of mycotoxin and understand factors that influence the production of mycotoxins and management practices to minimize their impact.
11. Know the fungi and the crops they affect which produce the following mycotoxins:
  - a. vomitoxin
  - b. aflatoxin
  - c. zearalenone
  - d. fumonisin
  - e. ergot alkaloids

#### Competency Area 4. Insects and Mites

1. Be familiar with methods of identification, crop injury symptoms and management of insects and mites common in Missouri (Appendix C).
2. Describe how mouthpart type and feeding habit affect plant injury.
3. Recognize how the following characteristics of insects influence their ability to survive and cause damage:
  - a. development time and period of activity
  - b. reproduction method, rate and number of generations
  - c. overwintering and over-summering strategies
  - d. dispersal and movement strategies

- e. behavioral characteristics
  - f. types of metamorphosis
4. Recognize how insect life stage, timing of pest occurrence and plant development status affect management decisions.
  5. Describe the control methods for insects and mites:
    - a. genetic
    - b. cultural
    - c. biological (beneficial insects, pathogens, etc.)
    - d. chemical
    - e. genetic and biological control contributions of transgenic traits
  6. Be able to identify common insect predators and parasitoids and their potential impact on pest insects (Appendix D).
  7. Understand how crop rotation, cropping sequence, planting date and other cultural practices influence insect and mite populations.
  8. Understand the use of insect resistance management techniques.
  9. Understand refuge requirements for transgenic crops.
  10. Understand how weather and climate affects insect development and damage potential including the degree day concept of insect development.
  11. Insecticides and insecticides management ([www.irac-online.org](http://www.irac-online.org))
    - a. Recognize the effects of insecticides on non-target organisms:
      - i. pollinators, such as bees
      - ii. birds
      - iii. fish
    - b. Understand factors that influence the development of pesticide resistance in target organisms.
    - c. Describe management practices that reduce the probability of developing insect resistance to insecticides.
    - d. Relate timing of insecticide application to pest stage of development
    - e. Distinguish among contact insecticides, stomach poisons and systemic insecticides.

#### Competency Area 5. Pesticides and Their Application

1. Recognize physical characteristics of the following pesticide formulations: water soluble powders, water soluble liquids, wettable powders, emulsifiable concentrates, water dispersible granules, dusts, pellets and granules.
2. Know how to calibrate granular applicators.
3. Know how to calibrate pesticide sprayers and describe pattern relative droplet size, pattern overlap and primary uses for the following nozzle types: standard flat fan, even flat fan, hollow cone and flood tip.

4. Recognize how spray pressure, application speed, nozzle type, nozzle spacing and weather conditions affect spray delivery, spray coverage and spray drift.
5. Pesticide Behavior in the Environment
  - a. Understand how movement of pesticides in soil, surface water and ground water may be affected by: soil texture, soil pH, CEC, leaching, erosion, depth to water table, precipitation and runoff, pesticide adsorption and solubility, pesticide degradation rate, pesticide application rate and timing.
  - b. Define pesticide persistence and describe the influence of soil moisture, soil temperature, soil pH, permeability of soil, application rate and weather on pesticide persistence and fate.
  - c. Describe the degradation and transfer process that affects the performance of all pesticides, especially herbicides.
6. Be aware of the effects of pesticides on non-target organisms:
  - a. non-target crops
  - b. native vegetation
  - c. soil microorganisms
  - d. pollinators
  - e. aquatic organisms
  - f. birds, mammals, reptiles and amphibians

#### Competency Area 6. Laws and Regulations Related to Agricultural Pesticides

1. Know the information that must be printed on pesticide labels and how to use that information for safe, effective and environmentally sound pesticide recommendations.
2. Know where to find up to date label requirements on manufacturers websites and how often these websites should be referenced. Example websites include:
  - a. [xtendimaxapplicationrequirements.com](http://xtendimaxapplicationrequirements.com)
  - b. [engeniataankmix.com](http://engeniataankmix.com)
  - c. [enlist.com](http://enlist.com)
3. Understand training requirements for specific pesticide applications e.g., paraquat training.
4. Define: dermal toxicity, oral toxicity, LD<sub>50</sub>.
5. Relate pesticide reentry times and harvest restrictions to human exposure.
6. Describe proper procedures for disposal of pesticides and their containers.
7. Describe safe storage procedures for pesticides.
8. Know proper reporting and cleanup procedures for pesticide spills.
9. Know modes of pesticide entry into human bodies.
10. Know state and federal rules for record keeping.

11. Describe protective gear used during mixing and application of pesticides including those stated in Workers Protection Safety Standards.
12. Recognize the responsibilities of and assistance available through the following State and Federal agencies:
  - a. University of Missouri
  - b. University Extension
  - c. Missouri Department of Agriculture
  - d. Missouri Department of Natural Resources
  - e. Missouri Department of Conservation
  - f. U.S. Environmental Protection Agency
  - g. U.S. Fish and Wildlife Service
  - h. Natural Resources Conservation Service
  - i. Farm Service Agency
  - j. [fieldwatch.com](http://fieldwatch.com)
  - k. [driftwatch.org](http://driftwatch.org)

## **Crop Management**

### Competency Area 1. Crop Adaptation

1. Understand how climate (temperature and precipitation), soil properties and land capability class influences cropping system options.
2. Understand how day length and climate affect hybrid and variety selection.
3. Know the minimum, optimum and maximum temperatures for seed germination and growth for the crops shown in the Table of Important Missouri Crops.

### Competency Area 2. Crop Growth and Development

1. Be able to identify the key plant structures at all stages of growth of major crops in Missouri.
  - a. Identify seed parts, vegetative anatomy and reproductive organs
  - b. Identify anatomical differences between monocots and dicots.
2. Know the important growth stages for the crops shown in the Table of Important Missouri Crops.
3. Understand how water and nutrient requirements change during growth and development and which stages are most sensitive to stress.
4. Distinguish between determinate and indeterminate growth habits.
5. Relate the growing degree day (GDD) concept to crop development and be able to calculate GDD for corn, cotton, rice and wheat.
6. Understand the effects of temperature extremes on plant growth, crop development and crop quality.
7. Understand photoperiod impacts on crop maturation such as soybeans.

### Competency Area 3. Crop Damage, Mortality and Replant Decisions

1. Understand the consequences of damage from hail, frost, drought, wind, flooding and pest defoliation to plant growth and crop yield and the relationship between the magnitude of crop damage and stage of development.
2. Recognize weather factors and plant characteristics that influence the ability of plants to resume growth or recover from damage.
3. Be able to determine if replanting is warranted of the Important Missouri Crops
  - a. Know how to calculate stand counts.
  - b. Determine economic viability of current stand compared to crop destruction and replanting costs as well as new stand potential yield.
4. Be able to identify crop responses to different stresses by evaluating plant symptomology, field patterns and field history.

#### Competency Area 4. Variety (Hybrid) Development and Selection

1. Know the differences between hybrids and varieties (cultivars) and how these differences influence management decisions.
2. Know characteristics used for selecting hybrids and varieties.
3. Distinguish between transgenic and non-transgenic traits.
4. Know how to use least significant difference (LSD) to compare hybrids and/or varieties.
5. Understand common identity preserved traits and value-added traits in Missouri crops.

#### Competency Area 5. Cultural Practices

1. Tillage Systems and Residue Management
  - a. Know the effect of residue cover on crop growth through changes in soil temperature, soil moisture, gas exchange and compaction.
  - b. Know tillage implements commonly used for the following tillage systems: no-tillage, clean tillage, strip tillage, mulch tillage and ridge tillage.
  - c. Describe the effect of tillage system choice on other crop management practices.
2. Understand the use of crop rotation in crop management.
3. Understand the impacts of planting date on crop management.
4. Explain how cultural practices are associated with soil health:
  - a. organic matter
  - b. compaction
  - c. pH
  - d. soil-water relations
  - e. soil temperature

#### Competency Area 6. Seeds and Seeding

1. Understand characteristics used to measure seed quality.
2. Know how to calculate purity, germination percentage, pure live seed percentage and true seed cost.
3. Know how to measure and calculate seeding rates and how to adjust for pure live seed percentage.
4. Describe crop responses to planting patterns and densities.
5. Understand how planting date affects crop establishment, growth, yield and quality.
6. Know how crop type, seed size, emergence type, soil conditions, planting date and weather may influence seeding depth.

7. Explain the impact of proper seed placement on uniformity of emergence, crop growth and yield.
8. Know common row widths for Important Missouri Crops.
9. Know the different seeding methods for Important Missouri Crops and how it impacts distribution, singulation and planting depth:
  - a. broadcast
  - b. drill
  - c. planted
  - d. transplant
  - e. overseeding
10. Explain the challenges and practices associated with planting into different residue management systems.

### Competency Area 7. Forage Management, Harvest and Storage

1. Match forage species in the following categories to climate, soil properties and expected use:
  - a. cool season grasses
  - b. warm season grasses
  - c. legumes
  - d. grains used for silage
2. Grazing Systems
  - a. Define the following terms:
    - i. stocking rate
    - ii. stock density
    - iii. carrying capacity
    - iv. animal unit
    - v. grazing pressure
    - vi. paddock
    - vii. continuous grazing
    - viii. management intensive grazing
      - a. mob grazing
      - b. rotational grazing
  - b. Understand the principles involved in dividing pastures into multiple paddocks.
  - c. Explain species and variety selection importance in grazing tolerance.
3. Hay
  - a. Know appropriate stages of development for harvesting legumes and grasses as hay.
  - b. Know proper moisture content for hay preservation.
  - c. Know limitations of chemical desiccants and hay preservatives.



- d. Understand the effect of frequency and timing of harvest on stand persistence and forage quality.

#### 4. Silage and Haylage

- a. Know appropriate stages of development for harvesting legumes, grasses and grains as silage and haylage.
- b. Understand conditions and storage methods necessary for proper fermentation and silage/haylage preservation.
- c. Understand advantages and disadvantages of silage additives including acids, inoculum, ground grain, sugars and water.
- d. Understand the importance of fine chopping and wilting of forage grasses and legumes to silage preservation.

#### 5. Anti-quality (undesirable) components in forage quality

- a. Know the major toxic factors that may be found in forages:
  - i. Nitrates
  - ii. prussic acid
  - iii. fescue toxicosis
  - iv. coumarin in sweetclover
- b. Understand how mineral deficiencies affect forage quality with issues such as grass tetany.
- c. Understand forage management procedures to decrease occurrence or counteract toxic factors.
- d. Know weeds that decrease forage quality and palatability.

### Competency Area 8. Grain and Fiber Crop Harvest, Drying and Quality

1. Define physiological maturity and harvest maturity.
2. Understand the use of defoliant and desiccants.
3. Know recommended harvest moisture percentages for corn, soybean, wheat and grain sorghum.
4. Know the bushel weight of grain crops important to Missouri.
5. Understand the effect of grain temperature and moisture on safe storage time.
6. Understand the advantages and disadvantages of aeration, artificial (heat) drying and high moisture storage of grains.
7. Understand the importance of seedcoat integrity to grain storage and effects of grain characteristics, harvest and handling on seedcoat breakage.
8. Understand characteristics used to assess grain quality and what factors account for dockage at point of sale.
9. Know factors that can impact harvest loss.
  - a. lodging

- b. head shatter
- c. environmental and weather losses due to delayed harvest

#### Competency Area 9. Cropping Systems

1. Compare and contrast continuous and crop rotation systems.
2. Define double-cropping, relay cropping, inter-cropping, green manure crops, cover crops and companion crops.
3. Know limitations to double-cropping and know wheat and soybean management recommendations in a double-cropped system.

#### Competency Area 10. Calibration Procedures for Application Equipment

1. Know calibration procedures for nutrient application equipment that will result in accurate and uniform applications of nutrients.
2. Know calibration procedures for pesticide application equipment that will result in accurate and uniform applications of pesticides.
3. Know calibration procedures for seeding equipment that will result in accurate and uniform applications for seeding.

#### Competency Area 11. Precision Agriculture

1. Understand how the following are used in crop management:
  - a. site-specific management
  - b. geographic information system (GIS)
  - c. global positioning system (GPS)
  - d. grid and zone soil sampling
  - e. yield mapping
  - f. variable rate technology (VRT)
  - g. multiple hybrid placement
  - h. UAVs (unmanned aerial vehicles)
  - i. remote sensing
  - j. imagery (aerial and satellite)
  - k. robotics
  - l. autonomy
  - m. telecommunications
  - n. computer modeling
2. Know and understand the different regulation that affect the use of precision ag practices, i.e., UAV regs, data transfer.
3. Understand data security, data privacy and data transfer.

## Appendix A: Common Weeds in Missouri

Additional information can be found at [www.weedid.missouri.edu](http://www.weedid.missouri.edu)

### Summer annual

#### Broadleaf

Asiatic dayflower  
Burdock  
Common cocklebur  
Common  
    lambsquarters  
Common purslane  
Common ragweed  
Common sunflower  
Eastern black nightshade  
Giant ragweed  
Hophornbeam  
copperleaf  
Jimsonweed  
Ivyleaf morningglory  
Ladysthumb  
smartweed  
Palmer Amaranth  
Pennsylvania  
smartweed  
Pitted morningglory  
Prickly Sida  
Redroot pigweed  
Spiny amaranth  
(pigweed)  
Tall morningglory  
Velvetleaf  
Waterhemp species

#### Grass

Barnyardgrass  
Broadleaf signal grass  
Crabgrass species  
Fall panicum  
Giant foxtail  
Goosegrass  
Green foxtail  
Shattercane  
Yellow foxtail

### Winter annual

#### Broadleaf

Common chickweed  
Field pennycress  
Henbit  
Horseweed (Marestail)  
Mouse ear chickweed  
Mustard species  
Purple dead nettle  
Shepherds purse

#### Grass

Cheat grass  
Downy brome  
Japanese brome  
Poa (annual bluegrass)  
Wild oats

### Perennial / Biennial

#### Broadleaf

Blackberry  
Buckbrush  
Bull Thistle  
Carolina geranium  
Common milkweed  
Curly dock  
Dandelion  
Field bindweed  
Hemp dogbane  
Honey locust  
Horsenettle  
Ironweed species  
Multiflora rose  
Musk Thistle  
Osage orange  
Poison Hemlock  
Sericia Lespedeza  
Swamp smartweed  
Trumpet creeper  
Wild carrot

#### Grass

Johnsongrass  
Purpletop

#### **Sedges**

Broomsedge  
Purple nutsedge  
Yellow nutsedge

#### **Other**

Wild garlic  
Wild onion  
Star of Bethlehem

## Appendix B: Common and Emerging Field Crop Diseases in Missouri

<b>CORN</b>	<b>SOYBEAN</b>
<b>Seed and Seedling Diseases</b>	<b>Seed and Seedling Diseases</b>
Fusarium	Fusarium root rot
Pythium	Phomopsis
Rhizoctonia	Phytophthora root rot
<b>Foliage Diseases - Bacterial</b>	Pythium damping-off
Bacterial streak	Rhizoctonia root rot
Goss' wilt	Sudden death syndrome
Holcus spot	<b>Foliage Diseases</b>
Stewart's wilt	Asian soybean rust
<b>Foliage Diseases - Fungal</b>	Bacterial spot
Anthracnose	Bacterial blight
Common rust	Cercospora blight
Crazy top	Downy mildew
Eye spot	Frogeye leaf spot
Gray leaf spot	Septoria brown spot
Northern corn leaf blight	Target spot
Southern corn leaf blight	<b>Stem and Root Diseases</b>
Southern rust	Anthracnose
Tar spot	Brown stem rot
<b>Stalk and Root Rots</b>	Charcoal rot
Anthracnose stalk rot	Stem canker
Charcoal rot	Sudden death syndrome
Diplodia stalk rot	<b>Pod Diseases</b>
Fusarium stalk rot	Cercospora (purple seed stain)
Gibberella stalk rot	Phomopsis
Red root rot	Pod and stem blight
<b>Ear and Kernel Diseases</b>	<b>Nematodes</b>
Aspergillus flavus	Reniform nematode
Common smut	Root knot nematode
Diplodia ear rot	Soybean cyst nematode
Fusarium ear rot	<b>Virus</b>
Gibberella ear rot	Bean pod mottle virus
Penicillium rot	Soybean mosaic virus
<b>Nematodes</b>	Tobacco ringspot virus
Lesion nematode	
Root knot nematode	
Sting nematode	
<b>Virus</b>	
Maize dwarf mosaic virus	

<b>ALFALFA</b>	<b>GRAIN SORGHUM</b>
<b>Seed and Seedling Diseases</b>	<b>Seed and Seedling Diseases</b>
Aphanomyces seedling blight	Fusarium
Phytophthora seedling blight	Pythium
Phytophthora root rot	Rhizoctonia
Pythium seedling blight	<b>Foliage Diseases</b>
<b>Foliage Diseases</b>	Anthracnose
Anthracnose	Crazy top
Common leaf spot	Sorghum downy mildew
Downy mildew	Zonate leaf spot
Lepto leaf spot	<b>Stalk and Root Rots</b>
Rust	Charcoal rot
Spring black stem	<b>Virus</b>
Summer black stem	Maize dwarf mosaic virus
Yellow leaf blotch	<b>Head smut, blights, and molds</b>
<b>Root and Crown Rots</b>	
Crown rot	
Phytophthora root rot	<b>WINTER WHEAT</b>
Sclerotinia crown and stem rot	<b>Seedling Diseases</b>
<b>Wilt Diseases</b>	Pythium
Bacterial wilt	Fusarium
Fusarium wilt	Rhizoctonia
Verticillium wilt	<b>Foliage Diseases</b>
<b>Virus</b>	Bacterial stripe and black chaff
Alfalfa mosaic virus	Cephalosporium stripe
	Leaf rust
<b>COTTON</b>	Powdery mildew
Bacterial blight	Septoria leaf blotch
Cotton seedling disease complex	Stem rust
Fusarium wilt	Take-all
Root knot nematode	Tan spot
Verticillium wilt	Stripe rust
<b>RICE</b>	<b>Other</b>
Brown spot	Fusarium head blight (scab)
Rice blast	Loose smut
Sheath blight	<b>Virus</b>
<b>EMERGING OR POTENTIAL DISEASES</b>	Barley yellow dwarf mosaic
Karnal bunt of wheat	Soil-borne mosaic
Sclerotinia white mold of soybean	Wheat streak mosaic
Sorghum ergot	Spindle streak mosaic
Goss' wilt	
Bacterial streak	
Tar spot	

## Appendix C: Common and Emerging Insect and Mite Pests in Missouri

### Alfalfa

Alfalfa weevil  
Aphid species  
Armyworm  
Blister beetle  
Cutworm  
Grasshopper species  
Mormon cricket  
Potato leafhopper

Grasshopper species  
Green cloverworm  
Japanese beetle  
Spider mite  
Soybean aphid  
Soybean podworm  
Stinkbug species  
Thistle caterpillar  
Thrips  
Webworm

### Corn

Armyworm  
Billbugs  
Black cutworm  
Chinch bug  
Corn earworm  
Corn leaf aphid  
Corn leaf beetle  
Dingy cutworm  
European corn borer  
Flea beetles  
Fall armyworm  
Grasshopper species  
Grape colaspis  
Japanese beetle  
Northern corn rootworm  
Seed corn beetle  
Seed corn maggot  
Southwestern corn borer  
Southern corn rootworm  
Spider mite  
Stink bug species  
Western bean cutworm  
Western corn rootworm  
White grub species  
Wireworm species

### Wheat

Armyworm  
Bird oat-cherry aphid  
Cereal leaf beetle  
English grain aphid  
Grasshopper species  
Greenbug (aphid)  
Hessian fly  
Stink bug species

### Forages

Armyworms  
Fall armyworm  
Grasshoppers  
Japanese beetle

### Cotton

Boll weevil  
Boll worm  
Loopers  
Plant bugs  
Spider mites  
Thrips

### Rice

Rice stalk borers  
Rice water weevil  
Stinkbug species

### Soybean

Bean leaf beetle  
Blister beetle  
Cabbage looper  
Cutworm  
Dectes stem borer  
Grape colaspis

### Sorghum

Chinch bugs  
Grasshoppers  
Greenbugs (aphid)

**Sorghum continued**

Sugarcane aphid  
Sorghum headworm  
Sorghum midge

**Emerging Insect Problems**

Brown marmorated stink bug  
Red banded stink bug  
Spotted Japanese lantern bug  
Soybean gall midge

**Appendix D: Beneficial Insects****Predators**

Assassin bug  
Damsel bug  
Ground beetles  
Lacewings  
Hover flies  
Lady beetles of "ladybugs"  
Predaceous stinkbug  
Spiders

**Parasitoids**

Parasitic wasps  
Syrphid flies (Hover fly)  
Tachinid flies