

**CERTIFIED CROP ADVISER**  
**Performance Objectives**  
**for**  
**NORTH DAKOTA**



**Prepared by the North Dakota Certified Crop Adviser Board**  
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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 and Canada) by the American Society of Agronomy ([www.certifiedcropadvisor.org](http://www.certifiedcropadvisor.org)). It is administered locally by a North Dakota state board composed of representatives from agri-business, agricultural consulting, NDSU 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.

These Performance Objectives provide guidance to individuals preparing for the North Dakota 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 North Dakota. Exam questions are based on these Performance Objectives and the International Performance Objectives as they apply to providing advice on crops grown in North Dakota.

The North Dakota Performance Objectives outline the knowledge and skill areas that Certified Crop Advisers in North Dakota 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 North Dakota.

<b>Key Crops of North Dakota</b>		
Alfalfa	Durum	Soybean
Barley	Flax	Sunflower
Canola	Field Pea	Sugar Beet
Corn	Oats	Wheat
Dry Bean	Potato	

Certified Crop Advisers in North Dakota should be familiar with the crops listed in the above table. Although there are other crops grown in the state that are important locally, these Performance Objectives and the corresponding Local Board Exam will focus on the crops indicated in the table above.

### **Conversions**

Examinees should be able to convert between metric and English units and vice versa, as well as understand SI units. Conversion factors will be provided for questions within the exam.

### **List of Acronyms**

- BMP – Best Management Practice
- CEC – Cation Exchange Capacity
- DAP – Diammonium Phosphate
- EC – Electrical Conductivity
- EPA – Environmental Protection Agency
- ET – Evapotranspiration
- FRAC – Fungicide Resistance Action Committee
- IPM – Integrated Pest Management
- MAP – Monoammonium Phosphate
- NRCS – Natural Resources Conservation Service
- PPE – Personal Protective Equipment
- RUSLE2 – Revised Universal Soil Loss Equation 2
- SAR – Sodium Adsorption Ratio
- WEPP – Water Erosion Prediction Project
- WUE – Water Use Efficiency

## NUTRIENT MANAGEMENT

### Nutrient Management Competency Areas:

1. Basic concepts of soil fertility
2. Nutrient movement in soil and water
3. Soil pH
4. Soluble salts
5. N, P, K
6. Secondary and micronutrients
7. Soil sampling, plant sampling, interpreting soil test reports and making fertilizer recommendations
8. Forms of fertilizer and application methods

## **Nutrient Management**

### **Competency Area 1. Basic Concepts of Soil Fertility**

1. Understand the relative frequency of deficiency of the 16 essential nutrients for plant growth: C, H, O, N, P, K, Ca, Mg, S, B, Cl, Cu, Fe, Mn, Mo, Zn.
2. Recognize or describe deficiency symptoms of the 13 mineral nutrients essential for plant growth as listed in the table of important crops in North Dakota.
3. Recognize which forms (compounds or ionic states) of the essential nutrients can satisfy plant nutrient requirements.
4. Understand factors affecting iron (i.e., iron chlorosis) in soybean.
5. Understand chelated nutrients, especially iron and zinc in corn, dry bean, soybean and alfalfa.
6. Understand the role of cation exchange in retaining and releasing nutrients for plants.
7. Understand the source of cation exchange capacity (CEC).
8. Understand the process of nutrient uptake and distribution in plants.
9. Understand the role of microorganisms in cycling nutrients needed for plants through organic matter and residue breakdown, immobilization and release.
10. Define and understand the differences between soil organic matter, soil organic carbon and humus.
11. Understand the effect of agronomic practices on soil organic matter levels.
  - a. Tillage practices.
  - b. Residue management.
  - c. Cover crops.
12. Understand how clay mineralogy can affect availability of potassium.

### **Competency Area 2. Nutrient movement in soil and water**

1. Understand how nitrogen moves or is retained in the soil:
  - a. climatic factors.
    - i. leaching.
    - ii. denitrification.
    - iii. immobilization.

- b. soil biological, chemical, and physical properties.
  - c. landscape position.
- 2. Understand how phosphorus moves or is retained in the soil:
  - a. soil biological, chemical, and physical properties.
  - b. soil erosion by wind and water.
- 3. Explain nutrient movement within the soil profile due to:
  - a. diffusion.
  - b. mass flow.
  - c. active transport.

### **Competency Area 3. Soil pH**

- 1. Understand the difference between active and reserve acidity.
- 2. Know how soil pH influences nutrient availability.
- 3. Understand why high soil pH (greater than 7.3) increases risk of iron deficiency chlorosis.
- 4. Know processes and materials that would lower pH.
- 5. Explain processes involved in raising pH.
- 6. Describe causes of stratified pH in no-till or reduced till situations.

### **Competency Area 4. Soluble salts**

- 1. Know the difference between saline, sodic and saline-sodic soils.
- 2. Know how the different levels of electrical conductivity (EC) and sodium adsorption ratio (SAR) affect management strategies.
- 3. Know the source of soluble salts.
- 4. Understand the term EC as it relates to soil salts and methods used to measure EC.
  - a. Know difference between routine 1:1 soil salinity and saturated paste test values.
- 5. Understand plant tolerances to salinity in crops and forages.
- 6. Explain leaching requirements for salinity management under irrigation.
- 7. Understand crop water use in relation to long-term management of salinity.
- 8. Understand tillage influence on ET and long term salinity management.

9. Know how tile drainage can affect long term salinity.
10. Understand gypsum and other calcium sources as an amendment for sodic soils.

### **Competency Area 5. N, P, and K**

1. Understand how soil properties and nutrient cycling processes affect P and K availability.
2. Understand the N cycle in soils and know the effect of the following processes:
  - a. ammonification.
  - b. crop removal.
  - c. denitrification.
  - d. erosion.
  - e. fallow.
  - f. immobilization.
  - g. leaching.
  - h. mineralization.
  - i. nitrification.
  - j. volatilization.
3. Understand the process of symbiotic N fixation.
4. Understand the sources of N contribution from previous crops.
5. Know why water status of the soil affects K availability.
6. Understand why soils with carbonates have lower P availability.

### **Competency Area 6. Secondary and micronutrients**

1. Understand which crops listed in the Key Crops of North Dakota are more sensitive to specific secondary and/or micronutrients.
2. Understand the relationship between soil minerals/organic matter, and secondary and micronutrient availability.
3. Understand why sulfur deficiency is more common early in the growing season.
4. Know why coarse textured, low organic matter soils are more prone to sulfur deficiencies.
5. Understand why Ca and Mg are rarely deficient in a soil with a pH over 6.5.
6. Know why soil test levels for Ca, Mg, and K are more important than % Ca, % Mg and % K.



## **Competency Area 7. Soil sampling, plant sampling, interpreting soil test reports and making fertilizer recommendations**

1. Understand how to obtain a composite field soil sample and why taking many soil cores is important.
2. Understand the difference between grid and zone sampling and the strengths and weaknesses of each approach.
3. Know what soil and man-made factors can cause nutrient levels to vary across a large field.
  - a. Know reasons why two areas of a field can be low yielding for different reasons and why those areas should not be grouped together for zone soil testing.
4. Understand how the plant part sampled and stage of crop growth influence the interpretation of plant tissue analysis.
  - a. Know why it is critical to have diagnostic tissue and soil samples.
  - b. Understand how to handle plant and soil samples before they arrive at the laboratory for testing.
5. Understand what nutrients and soil properties should be tested on each sample depth.
6. Interpret a soil test report.
7. Understand what a previous crop nitrogen credit is and why it should be accounted for when making fertilizer recommendations.
8. Know why fall soil nitrate testing is a valuable tool in North Dakota.
9. Know that soil test values for P and K, are indexes which tell you the probability of getting a crop response to fertilizer, but do not measure available nutrient for the crop.
10. Given a soil test report and calibration information, make an economically and environmentally correct fertilizer recommendation.
11. Know what environmental conditions can influence nutrient level in plants.

## Competency Area 8. Forms of fertilizer and application methods

1. Recognize the physical form and % nutrient content of the following common fertilizers in North Dakota:
  - a. anhydrous ammonia.
  - b. urea.
  - c. ammonium nitrate.
  - d. ammonium sulfate.
  - e. monoammonium phosphate (MAP).
  - f. diammonium phosphate (DAP).
  - g. muriate of potash.
  - h. elemental sulfur.
2. Define how chelated fertilizer materials help keep nutrients in an available plant form.
3. Considering plant uptake, know which fertilizer materials are best applied below the soil surface and which materials can also be applied as a topdress application.
4. Describe the effects of proper timing, placement method, and rate of N, P, and K for North Dakota crops and soils.
5. Know the factors that determine the safe rate of fertilizer placed directly with the seed.
6. Given the price per ton and fertilizer analysis, calculate the price per pound of nutrient.
7. Know how to calculate application rate of fertilizer product per acre to meet crop nutrient requirements.
8. Identify the advantages and disadvantages of broadcast and banded fertilizer application and when it is appropriate to use fertilizer stabilizers.
9. Understand why there is a benefit to banding P fertilizer on high pH soils (> 7.3).
10. Define a variable-rate fertilizer application.
11. Understand why elemental sulfur is not available as quickly for plant uptake as sulfate sulfur.

12. Understand the common uses and value of the following nutrient sources:

- a. fresh manure.
- b. sludges.
- c. legumes.
- d. broadleaf crops rich in N.
- e. soil organic matter.
- f. cover crops.
- g. composted manure

## SOIL AND WATER MANAGEMENT

### Soil and Water Management Competency Areas:

1. Basic soil properties
2. Soil erosion
3. Residue management
4. Soil survey
5. Water quality management
6. Plant/water relationships
7. Irrigation and drainage

## Soil and Water Management

### Competency Area 1. Basic Soil Properties

1. Understand the meaning of the following soil physical properties:
  - a. texture.
  - b. bulk density.
  - c. structure.
  - d. available soil water.
  - e. field capacity.
  - f. wilting point.
  - g. compaction.
  - h. drainage.
  - i. soil aggregate.
  - j. infiltration.
  - k. hydraulic conductivity (percolation).
2. Understand the meaning of the following soil biological properties:
  - a. soil organic matter.
  - b. nutrient cycling.
  - c. soil organisms (macro and micro).
  - d. soil/organism interactions (e.g., mycorrhizal associations).
  - e. soil/plant interactions.
3. Understand the meaning of the following soil chemical properties:
  - a. CEC.
  - b. pH.
  - c. salinity/sodicity.
  - d. phosphorus chemistry.
  - e. carbonates.
4. Understand how soil texture affects field capacity, wilting point, available water, infiltration, and hydraulic conductivity.
5. Understand soil/organism interactions (e.g., mycorrhizal associations) and soil/plant interactions.
6. Understand pH interactions with nutrient availability.
7. Understand how basic soil properties relate to soil health/soil quality.

## **Competency Area 2. Soil Erosion**

1. Understand the forms of erosion by water:
  - a. rill.
  - b. inter-rill.
  - c. sheet.
  - d. gully.
  
2. Understand the components of the Revised Universal Soil Loss Equation 2 (RUSLE2) or the Water Erosion Prediction Project (WEPP) when it becomes available.
  
3. Understand and be able to describe the use of Best Management Practices (BMPs) to reduce erosion by water.
  - a. reduced tillage.
  - b. cover crops.
  - c. continuous cropping.
  - d. soil conservation practices (grassed waterways, residue management).
  
4. Understand the forms of erosion by wind:
  - a. creep.
  - b. saltation.
  - c. suspension.
  
5. Understand and be able to describe the use of BMPs to reduce erosion by wind.
  - a. shelter belts/tree planting.
  - b. reduced tillage.
  - c. cover crops.
  - d. continuous cropping.
  - e. residue management.
  - f. tillage timing.

## **Competency Area 3. Residue Management**

1. Know how to estimate percent residue cover:
  - a. using the line transect method.
  - b. visual observation.
  - c. effects of crop rotation.
  - d. effects of C:N ratios.

2. Understand how the following tillage practices affect percent residue cover and soil susceptibility to erosion:
  - a. no-till, zero-till.
  - b. moldboard plow.
  - c. chisel-plow.
  - d. field cultivator.
  - e. disk.
  - f. strip-till.
  - g. vertical tillage.
  - h. harrowing.

#### **Competency Area 4. Soil Survey**

1. Understand and be able to utilize NRCS soil surveys as a resource inventory for North Dakota soils in regard to:
  - a. natural drainage class.
  - b. soil depth.
  - c. soil slope.
  - d. parent material.
  - e. influence of natural vegetation.
  - f. erosion susceptibility.
  - g. best land uses.
  - h. crop suitability.
  - i. physical and chemical soil properties.
2. Understand the following NRCS soil survey terms
  - a. soil series
  - b. soil map unit.
  - c. land suitability.
3. Understand the limitations of soil surveys with regard to resolution, map accuracy, and utility.

#### **Competency Area 5. Water Quality Management**

1. Understand how water and solutes move through soil:
  - a. different physical properties (i.e., texture, aggregation, density, capillary rise, etc.).
  - b. different chemicals (i.e., solubility, pesticides, fertilizer, etc.).
  - c. salts.
  - d. preferential flow.
2. Understand the principles and consequences of point and non-point source pollution and be prepared to recognize examples of each.

3. Know management strategies and BMPs to reduce non-point source pollution.
4. Understand the importance of water movement within watersheds.
5. Know the two most important nutrients (N and P) in terms of surface water pollution and understand how they affect water quality.

#### **Competency Area 6. Plant/Water Relationships**

1. Understand the factors influencing evapotranspiration.
2. Understand the effects of soil dryness and soil wetness on plant growth and how soil water influences nutrient uptake.
3. Understand how soil characteristics influence plant available water.
4. Understand the concept of crop rotation intensity and diversity and its relation to crop available water and nutrients.

#### **Competency Area 7. Irrigation and Drainage**

1. Understand the components needed to facilitate successful surface and subsurface drainage.
2. Understand the relationship between irrigation and drainage.
3. Understand the concept of Water Use Efficiency (WUE).
4. Understand the consequences of over-watering/under-watering.
5. Understand the importance of compatible soils and irrigation water in sustaining successful irrigation.
6. Understand the benefits and disadvantages of surface and tile drainage systems.
7. Understand the type of soil water (at saturation, field capacity, etc.) is able to be drained by tile drainage systems.
8. Generally, understand the relationship between drainage regulation, wetlands and how it may affect surface and subsurface drainage.



## **PEST MANAGEMENT**

### **Pest Management Competency Areas:**

#### Weed Management

1. Weed Identification and Biology
2. Integrated Weed Management Principles and Practices

#### Insect Management

3. Insect Identification and Biology
4. Integrated Insect Management Principles and Practices

#### Disease Management

5. Plant Disease Identification
6. Integrated Disease Management Principles and Practices

#### Laws and Regulations Affecting Pesticides, Fertilizers, and Noxious Weeds

7. North Dakota Pesticide Act
8. Label Knowledge and Comprehension
9. North Dakota Noxious Weed Law and Regulations
10. North Dakota Seed Law

## Pest Management

### Weed Management

#### Competency Area 1. Weed Identification and Biology

1. Identify characteristics of the following annual and perennial weeds:

Absinth wormwood	Giant ragweed	Purple loosestrife
Barnyardgrass	Green foxtail	Quackgrass
Biennial wormwood	Knapweed:	Redroot pigweed
Canada thistle	--Diffuse knapweed	Russian thistle
Common cocklebur	--Russian knapweed	Saltcedar
Common lambsquarters	--Spotted knapweed	Waterhemp
Common mallow	Kochia	Wild buckwheat
Common ragweed	Ladysthumb/smartweed	Wild mustard
Dalmation toadflax	Lanceleaf sage	Wild oats
Downy brome	Leafy spurge	Wild sunflower
Eastern black nightshade	Marestail/horseweed	Yellow foxtail
Foxtail barley	Marshelder	Yellow starthistle
Field bindweed	Musk thistle	Yellow toadflax
Field sandbur	Palmer amaranth	

2. Describe the life cycle, reproductive capacity, viability and dispersal of seed for the weeds listed in 1.1 above.

#### Competency Area 2. Integrated Weed Management Principles and Practices

1. Know and understand cultural, mechanical and biological and chemical methods of weed control and how they can influence the use and effectiveness of methods of control including management strategies for herbicide-resistant weeds.
2. Describe how the following factors affect soil and post-emergence applied herbicide efficacy, persistence, and drift.
  - a. Rainfall and soil moisture.
  - b. Soil characteristics (pH, organic matter, fertility, clay content, and CEC).
  - c. Soil temperature, air temperature, humidity and temperature inversions.
  - d. Herbicide volatility.
  - e. Rate and method of herbicide degradation.
  - f. Herbicide uptake, translocation and fate in plants.
  - g. Adjuvant function and specificity.
  - h. Mechanisms of herbicide selectivity.
  - i. Application technique and incorporation.
  - j. Optimum crop and weed growth stage for herbicide application.
  - k. Application equipment used.

- Herbicide classification: know chemical family, site of action and corresponding group number, symptomology and selectivity of herbicides used in North Dakota

## **Insect Management**

### **Competency Area 3. Insect Identification and Biology**

- Identify the following economically important insect pests in North Dakota

<b>General insects:</b>	<b>Corn insects:</b>	<b>Potato insects:</b>
cutworms	corn rootworms	Colorado potato beetle
grasshoppers	European corn borer	green peach aphid
thistle caterpillar	white grubs	leafhoppers
wireworms		
<b>Small grain insects:</b>	<b>Sunflower insects:</b>	<b>Canola insects:</b>
armyworms	banded sunflower moth	Bertha armyworm
cereal aphids	grey seed weevil	diamond back moth
barley thrips	red seed weevil	flea beetles
Hessian fly	spotted stem weevil	
orange wheat blossom midge	sunflower midge	<b>Beneficial insects:</b>
wheat stem sawfly	sunflower beetle	green lacewing
wheat stem maggot		ladybird beetles
wheat curl mite		minute pirate bug
		syrphid fly
<b>Forage insects:</b>	<b>Sugarbeet insects:</b>	
blister beetles	lygus bug	<b>Soybean insects:</b>
green cloverworm	sugarbeet root maggot	aphid
weevils		bean leaf beetle
		spider mites

- Understand insect life cycles; recognize gradual and complete metamorphosis, and be familiar with life cycle events throughout the growing season for the insects listed above.
- Understand insect reproductive habits: egg-laying, live bearing insects, and the role of pheromones and their use in monitoring population activity.
- Be familiar with insect morphology and feeding injury; recognize the relationship between types of insect mouthparts and the types of feeding injury that can be inflicted.

### **Competency Area 4. Integrated Insect Management Principles and Practices**

- Understand types of control and the advantages and disadvantages of cultural, natural, biological, and chemical control.

2. Understand the concept and use of economic thresholds.
3. Understand insect scouting procedures; random vs. sequential sampling, sample size, pheromone trap monitoring.
4. Describe how the following factors affect soil and post-emergence insecticide efficacy, persistence and drift:
  - a. rainfall and soil moisture.
  - b. air temperature, humidity and temperature inversions.
  - c. rate and method of insecticide degradation.
  - d. insecticide uptake and fate in insects.
  - e. adjuvant function and specificity.
  - f. mechanisms of insecticide selectivity.
  - g. application technique and incorporation.
  - h. optimum crop and insect growth stage for insecticide application.
  - i. application equipment used.
4. Describe how insect resistance to insecticides develops; understand modes of action.
5. Recognize and know management strategies associated with beneficial insects including pollinators.
  - a. Be familiar with the North Dakota Pollinator Plan.

## **Disease Management**

### **Competency Area 5. Plant Disease Identification**

1. Recognize the signs and symptoms of the following major crop diseases in North Dakota, and understand how each disease develops and how it is managed.

Ascochyta of pulse crops	Fusarium head scab of small grains
black leg and soft rot of potato	Goss's wilt
canola blackleg	leaf and stem rust of small grains
canola clubroot	powdery mildew of field pea
Cercospora leafspot of sugarbeet	Sclerotinia (white mold) of broadleaf crops
common and halo blight of dry bean	soybean cyst nematode
common root rots	soybean rust
downy mildew	sudden death syndrome
dry rot of potato	sunflower and dry bean rust
early and late blight of potato	wheat Septoria leaf and glume blotch
ergot of small grains	wheat streak mosaic virus
flax pasmo	wheat tan spot

2. Know the disease triangle, and how pathogens infect, are disseminated and survive.
3. Understand factors that influence/favor disease development.

### **Competency Area 6. Integrated Disease Management Principles and Practices**

1. Differentiate infectious and non-infectious diseases.
2. Understand the principles of Integrated Pest Management (IPM) with respect to disease management.
3. Know which seed treatments and foliar fungicides are used in North Dakota for the diseases listed in 1.1; understand whether they are systemic or non-systemic.
4. Know principles of fungicide application:
  - a. spray volume.
  - b. timing.
  - c. nozzle selection.
  - d. tank mix concerns.
5. Understand how to manage fungicide resistance.
6. Understand modes of action and the FRAC Code List.

7. Understand the importance of crop rotation to break pest cycles.
8. Be familiar with the disease forecast models.

## **Laws and Regulations Affecting Pesticides, Fertilizers, and Noxious Weeds**

### **Competency Area 7. North Dakota Pesticide Act**

1. Understand the general provisions of the North Dakota Pesticide Act regulations.
2. Define the following terms:
  - a. general use pesticide.
  - b. restricted use pesticide.
  - c. certified applicator.
  - d. commercial applicator.
  - e. private applicator.
  - f. pesticide label and labeling.
  - g. bulk pesticide.
3. Know the regulations regarding pesticide application, posting, storage, transportation and disposal, and record keeping.
4. Know the requirements for chemigation.
5. Know the penalties and consequences of non-compliance with the North Dakota Pesticide Act and regulations.
6. Know the general provisions of the Environmental Protection Agency (EPA) Worker Protection Standards.
7. Be aware of the Certified Organic Program in ND and its certification.

### **Competency Area 8. Label Knowledge and Comprehension**

1. Know the format of a pesticide label and comprehend the meaning of the warnings, precautions, signal words, and symbols used.
2. Know how to identify Restricted Use Pesticides used for the major crops in North Dakota.

3. Define the following terms:
  - a. signal word.
  - b. pre-harvest interval.
  - c. restricted entry interval.
  - d. personal protective equipment (PPE).
  - e. statement of practical treatment.
  - f. precautionary statements.
  - g. environmental hazards.
  
4. Know the importance of using a pesticide only in a manner consistent with its labeling.

### **Competency Area 9. North Dakota Noxious Weed Law and Regulations**

1. Know the general provisions and requirements of this law and regulations.
2. Know the common names of the North Dakota noxious weeds and be able to identify them.

### **Competency Area 10. North Dakota Seed Law**

1. Know the general provisions and requirements of North Dakota Seed Law and regulations.
2. Know the requirements for labeling agricultural seed.
3. Know the prohibited noxious weed seeds and restricted noxious weed seeds.
4. Know about the seed certification system, and the terms breeder, foundation, registered, and certified seed.
5. Know the requirement for the sale of seeds covered by the Plant Variety Protection Act.

## **CROP PRODUCTION**

### **Crop Production Competency Areas:**

1. Role of Bioengineered Crops
2. Role of Bioengineered Crops in Insect Management
3. Establishment
4. Growth and Development
5. Harvest and Storage



## **Crop Production**

### **Competency Area 1. The Role of Bioengineered Crops**

1. Understand the meaning of transgenic crops.
2. Understand the advantages and disadvantages of genetically altered herbicide tolerant crops.

### **Competency Area 2. The Role of Bioengineered Crops in Insect Management**

1. Understand the types of genetically altered crops available and the types of insects they control.
2. Understand that components of crops or the entire crop may contain genetically incorporated insecticidal properties.

### **Competency in Area 3. Establishment**

1. Know the factors that influence the seeding practices of major crops in North Dakota.
2. Be familiar with recommended crop rotations.
3. List recommended planting rates and the factors that influence plant populations of major crops including date of planting, planting depth and row spacing.
4. Recognize how tillage systems impact crop production and management.
5. List the criteria for selection of a hybrid or cultivar for all major crops.
6. Understand how to assess crop establishment and determining minimal acceptable stand density and determine when reseeding is warranted.

### **Competency in Area 4. Growth and Development**

1. Describe plant growth and development stages of the major crops in North Dakota.
2. Define the term “growing degree day” and describe how it is used in crop production. Know how to calculate growing degree days for a given period if given the necessary background temperature information.
3. Describe how temperature extremes affect the growth and development of the crops in North Dakota.

4. Identify damage to crops from high temperatures, hail, frost, flooding, drought and wind.
5. Understand plant physiology and plant growth habits of crops in North Dakota and how these differences affect crop management.
6. Describe how the water and nutrient requirements of major North Dakota crops change during their growth and development.

#### **Competency Area 5. Harvest and Storage**

1. Know when the major crops in North Dakota physiologically mature and how it affects harvest.
2. Recognize how drying temperature, handling, storage time and storage conditions affect seed quality.
3. Know the best management practices for residue management, pest control, and soil water management following harvest of major crops in North Dakota.
4. Physiologically, know the best timing for harvest of the major crops in North Dakota for best grain, forage, storage characteristics, and processing quality.
5. Define forage quality and the management necessary to achieve top quality forages.