CERTIFIED CROP ADVISER
A program of the American
Society of Agronomy
https://www.certifiedcropadviser.org/

Michigan
Performance Objectives

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Contents

INTRODUCTION

The Certified Crop Adviser (CCA) program recognizes a base of agronomic knowledge that is required of those who provide agronomic knowledge to farmers. The American Society of Agronomy has taken the lead in developing the International Certified Crop Advisor Performance Objectives, last published in 2017. Subsequently each state is required to develop Performance Objectives that deal with the specific needs of agriculture in their state. This is particularly important for Michigan because of the wide variation of climate, soils and crops compared to other Midwestern states.

Just as with the International Performance objectives, Michigan's objectives are divided into four main sections: 1) Nutrient Management, 2) Soil and Water Management, 3) Pest Management; and 4) Crop Management. For those agronomic concepts considered to be universal and not unique to Michigan, this document borrows largely from the International Objectives. Each of these four sections has specific competency areas defined by Performance Objectives. All questions on the Michigan exam will be based on the Michigan Performance Objectives.

These Performance Objectives should also serve as a guide for crop advisers to design a continuing education program that maintains and improves their competence over time.

The Michigan Performance Objectives were last updated in 2024 by the Michigan CCA Exam Committee.

PURPOSE OF EXAM

The stated purpose of the exam based on these Performance Objectives is to demonstrate that the Certified Crop Adviser possesses the knowledge that the agricultural industry has deemed important reflecting Michigan crops and conditions.

The Michigan State Crop List				
Corn	Cover Crops	Forages	Fruit Crops *(orchard and berries)*	Potatoes
Wheat and Cereal Grains	Soybeans	Vegetable Crops	Sugarbeets	Dry Beans
Vine crops: Hops and Grapes				

Nutrient Management

COMPETENCY AREA 1. Basic Concepts of Plant Nutrition

1. List the 18 elements essential for plant nutrition.
    a. Structural nutrients: C, H, O
    b. Primary nutrients: N, P, K
    c. Macronutrients: Ca, Mg, S
    d. Micronutrients: B, Cl, Cu, Fe, Mn, Mo, Ni, Zn
    e. Beneficial nutrients: Co, Na, Se, Si
2. Define each element as macro-, secondary- or micro-nutrient.
3. Describe basic functions of N, P and K in plants.
4. Classify each macronutrient as mobile or immobile in the plant.
5. List chemical uptake forms of each macronutrient.
6. Describe how nutrient needs change from germination to maturity.

COMPETENCY AREA 2. Basic Concepts of Soil Fertility

1. Describe nutrient mineralization, immobilization and uptake antagonism.
2. Describe mass flow, diffusion and root interception of nutrients.
3. Describe the role of the following in supplying nutrients from the soil:
    a. soil solution,
    b. cation exchange sites,
    c. organic matter,
    d. soil microbes,
    e. plant residues.
4. Describe how cation exchange capacity (CEC) influences nutrient mobility of the following:
    a. calcium,
    b. magnesium,
    c. potassium.
5. Classify the following as mobile or immobile in the soil:
    a. ammonium,
    b. nitrate,
    c. phosphate,
    d. sulfate.
6. Name the 4Rs of Nutrient Management and list them in the correct order.
7. Explain how a cropping system influences the following:
    a. soil fertility levels,
    b. method of applying nutrients,
    c. timing of nutrient application.
8. Describe how crop selection influences the following:
    a. soil fertility levels,

b. nutrient application method,
c. application timing.

9. Explain how the following soil factors affect symbiotic nitrogen fixation:
    a. pH,
    b. moisture,
    c. nitrogen level,
    d. presence of correct Rhizobia species.
10. Describe the N cycle and how the following affect the fate of N in the soil:
    a. fixation by clay,
    b. ammonification/mineralization,
    c. nitrification,
    d. volatilization,
    e. denitrification,
    f. leaching,
    g. immobilization,
    h. symbiotic fixation,
    i. plant uptake.
11. Describe how the following soil characteristics affect nutrient uptake:
    a. texture,
    b. structure,
    c. moisture,
    d. drainage,
    e. pH,
    f. temperature.

COMPETENCY AREA 3. Soil Testing and Plant Tissue Analysis

1. Describe how the following affect soil sampling methods:
    a. method of previous fertilizer application,
    b. nutrient stratification,
    c. within-field soil and crop variability,
    d. nutrient tested,
    e. predictive vs. diagnostic sampling,
    f. field vs. grid sampling.
2. Identify how the following may cause variability in soil test results:
    a. time of sampling,
    b. depth of sampling,
    c. type of extraction method used,
    d. number of acres per sample,
    e. number of sub-samples per sample,
    f. tools used to collect samples.

3. Describe how to use soil analysis for:
    a. problem solving and diagnosis,
    b. nutrient program monitoring,
    c. in-season nutrient management,
    d. pre-season nutrient planning.
4. Compare and contrast the following approaches for making fertilizer recommendations:
    a. sufficiency level,
    b. soil build-up and maintenance,
    c. base saturation.
5. Recognize how the following affect soil test interpretation:
    a. probability of crop response to added nutrients,
    b. reported nutrient sufficiency level,
    c. results reported as ppm or lb/a,
    d. within field-variability,
    e. environmental risk.
6. Recognize how the following affect plant tissue analysis results:
    a. crop species,
    b. growth stage,
    c. plant part sampled,
    d. crop stress level,
    e. time of day sampled,
    f. sample handling,
    g. method and timing of nutrient application.

COMPETENCY AREA 4 Nutrient Sources, Analyses and Application Rates

1. Describe the chemical composition and use of each of the following Ca/Mg sources:
    a. sugarbeet lime,
    b. calcite lime,
    c. dolomitic lime,
    d. gypsum,
    e. potassium magnesium sulfate.
2. Describe how the following serve as plant nutrient sources:
    a. organic matter,
    b. irrigation water,
    c. commercial fertilizer,
    d. soil minerals,
    e. animal manure/biosolids,
    f. urban/industrial reclaimed waste/water,
    g. plant residue,
    h. residual nutrients,

    i. airborne deposits,
    j. shallow ground water.
3. Describe characteristics of slow and controlled release fertilizers.
4. Recognize when to use urease and nitrification inhibitors.
5. Compare and contrast the physical form and analysis of each of the following nitrogen sources:
    a. anhydrous ammonia,
    b. urea,
    c. ammonium nitrate,
    d. urea/ammonium nitrate solution (UAN),
    e. ammonium sulfate,
    f. calcium nitrate.
6. Compare and contrast the physical form and analysis of each of the following phosphorus sources:
    a. triple superphosphate,
    b. monoammonium phosphate (MAP),
    c. diammonium phosphate (DAP),
    d. ammonium polyphosphate .
7. Compare and contrast the physical form and analysis of each of the following potassium sources:
    a. potassium chloride,
    b. potassium sulfate,
    c. potassium nitrate.
8. Convert fertilizer analysis of P and K from elemental to oxide, then oxide to elemental form.
9. Define the following commercial fertilizer terms:
    a. total availability,
    b. water solubility,
    c. guaranteed analysis.
10. Define the following terms:
    a. organic N,
    b. inorganic N,
    c. organic P,
    d. inorganic P.
11. Describe the use of total Kjeldahl nitrogen (TKN) and combustion N tests.
12. Calculate fertilizer rates based on fertilizer analysis and soil test information.
13. Calculate manure application rates based on manure analysis and soil test information.
14. Describe how the following affect nutrient availability from manure:
    a. physical form,
    b. animal source,

c. moisture content,
d. rate/stage of decomposition (C:N ratio),
e. incorporation.

15. Describe advantages and limitations of the following fertilizer placement methods:
    a. injection,
    b. surface broadcast,
    c. broadcast incorporated,
    d. band,
    e. fertigation,
    f. foliar,
    g. sidedress,
    h. topdress,
    i. seed placed.
16. Explain why it important to use chelated forms of micronutrients.

COMPETENCY AREA 5. Soil pH and Liming

1. Define the following as they pertain to Michigan soils:
    a. soil pH,
    b. buffer pH,
    c. acidity,
    d. alkalinity,
    e. lime requirement.
2. Understand liming material sources for Michigan and be able to calculate lime application rates to meet liming requirements.
3. Illustrate the effect of the following on soil pH:
    a. elemental sulfur,
    b. ammonium sulfate,
    c. gypsum,
    d. sugarbeet lime,
    e. calcite lime,
    f. dolomitic lime.
4. Describe how purity, fineness and Calcium Carbonate Equivalent (CCE) affect neutralizing ability of liming materials and be able to calculate CCE given the appropriate information.
5. Explain how nitrogen fertilizers affect long-term changes in soil pH.
6. Describe how CEC, soil texture and soil organic matter affect lime requirement.
7. Identify how the availability of essential plant nutrients and heavy metals are affected by soil pH.

COMPETENCY AREA 6. Nutrient Management Planning

1. Understand what is meant by environmentally sensitive area and how it relates to Nutrient Management Planning.
2. Use crop nutrient requirement, crop rotation and soil test information to determine crop nutrient needs.
3. Set a realistic yield goal by using information about:
    a. production history,
    b. soil productivity,
    c. management level,
    d. most limiting nutrient.
4. Compare P-based vs. N-based manure application recommendations and when to use each.
5. Given soil test recommendations and manure analysis, use manure and commercial fertilizer sources to construct a P-based and N-based nutrient application program.
6. Describe the importance of the following components of an economically and environmentally sound nutrient management plan:
    a. maps of facilities, field and soils,
    b. cropping system,
    c. recording expected yields,
    d. reports of test and analyses,
    e. nutrient budgets,
    f. nutrient recommendations,
    g. review/update the plan.
7. Describe potential environmental effects of N and P loss by:
    a. erosion,
    b. runoff,
    c. volatilization,
    d. leaching,
    e. denitrification.
8. List the basic requirements of a comprehensive nutrient management plan (CNMP).
9. Explain how to take a representative sample of manure or effluent.
10. Discuss the role of animal units in developing a CNMP.
11. Discuss nutrient management practices provided in the Michigan Right to Farm Act.
12. Explain why Watershed management and downstream water quality are important considerations, ie. Saginaw Bay Watershed, Lake Erie Watershed.
13. Explain how the 4R Nutrient Management concepts apply to nutrient management planning:
    a. source, timing, placement, rate,

b. CCA responsibilities with the producer.

Soil and Water Management

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. Understand, calculate, and interpret base saturation.
5. Differentiate saline, calcareous, acidic and alkaline soils.
6. Describe soil properties can affect nutrients and their plant availability.
7. Define soil textures commonly found in Michigan and geographical areas where they may occur.
8. Describe how soil particle size affects surface area and reactivity of soils.
9. Characterize soil structure types typically found in Michigan soils and differentiate the following types of soil structure:
   a. blocky,
   b. single grain,
   c. granular,
   d. platy,
   e. massive,
   f. prismatic/columnar.
10. Describe how soil structure affects the following:
    a. permeability,
    b. root development,
    c. water infiltration,
    d. aeration.
11. Describe how soil texture affects the water holding capacity, available water, field capacity and wilting point of soils.
12. Describe how to determine when soil moisture conditions are favorable for field operations,
13. Define and be able to calculate bulk density.
14. Describe how soil organic matter affects soil structure.
15. List the sources and beneficial effects of soil organic matter.
16. Describe physical and chemical properties of soil organic matter.
17. Describe how crop rotation, compaction, and tillage affect the amount of carbon stored or sequestered in the soil.
18. Explain how the following factors influence soil microbial activity:
    a. temperature,
    b. moisture,

c. soil pH,
d. organic matter,
e. salinity,
f. nitrogen application,
g. tillage,
h. soil compaction.

19. Explain how the C:N ratio affects organic material decomposition
20. Describe how soil management groups are useful for nutrient recommendations.

https://www.canr.msu.edu/resources/understanding_the_msu_soil_test_report_e0015

COMPETENCY AREA 2. Site Characterization

1. Define O, A, B and C soil horizons.
2. Define parent material.
3. Calculate the area of a field.
4. Calculate the slope of a field.
5. Identify characteristics of well-drained and poorly drained soils.
6. Use a soil survey to locate soil types on a tract of land.
   See: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
7. Use a soil survey to determine soil characteristics within a field
8. Explain how the following limit land use: a) leaching potential, b) erosion potential, c) wetlands classification, d) proximity to sensitive areas, e) runoff potential.

COMPETENCY AREA 3. Soil Erosion

1. Study and learn how to use the technical guides at the Michigan NRCS eFOTG website: See: https://efotg.sc.egov.usda.gov/#/
2. Compare and contrast water and wind erosion processes of detachment, transport and deposition.
3. Differentiate the following types of erosion:
   a. sheet,
   b. rill,
   c. gully,
   d. surface creep,
   e. saltation,
   f. suspension,
   g. tillage erosion.
4. Explain how the following affect the rate of erosion by water:
   a. duration and intensity of rainfall,
   b. soil texture and structure,

c. slope length,
d. slope percentage,
e. vegetative/residue cover.

5. Understand the information that is available from RUSLE2 and WEPP and how it can be used. (See RUSLE2 universal-soil-loss-equation-2-how-rusle2-computes-rill-and-interrill-erosion/ WEPP https://milford.nserl.purdue.edu/wepp/weppV1.html)
6. Explain how the following affect the rate of erosion by wind:
   a. wind velocity,
   b. unsheltered distance,
   c. soil surface roughness,
   d. vegetative/residue cover.
7. Define the concept of soil loss tolerance.
8. 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.
9. Explain how the following Best Management Practices (BMPs) decrease erosion:
   a. strip cropping,
   b. tillage systems,
   c. contouring,
   d. terraces,
   e. grassed waterways,
   f. surface residue,
   g. cover crops,
   h. row spacing and direction,
   i. buffer/filter strips,
   j. surface roughness,
   k. windbreaks,
   l. riparian areas.

COMPETENCY AREA 4. Residue Management

1. Recognize how the following soil characteristics differ between clean-till and high surface residue management systems:
   a. temperature,
   b. erosion potential,
   c. moisture,

d. organic matter.

2. Compare and contrast how residue cover and erosion potential differ among the following tillage systems:
   a. clean-till,
   b. mulch-till/reduced-till,
   c. direct seeding,
   d. no-till/zero-till,
   e. vertical tillage.
3. Explain how to measure percent crop residue cover using the line transect method.
4. Describe how residue breaks down: microbial activity and C:N ratio.

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

COMPETENCY AREA 6. Air, Water and Solute Movement

1. Explain how the following components interact to influence the soil water cycle:
   a. precipitation,
   b. irrigation,
   c. runoff,
   d. soil water storage,
   e. evapotranspiration,
   f. deep percolation.
2. Identify how soil texture, soil structure and soil organic matter affect infiltration
3. Describe how the following factors influence surface runoff:
   a. infiltration,
   b. permeability,
   c. landscape position,
   d. surface residue cover,
   e. surface roughness,
   f. cover crops.
4. Evaluate how the following factors influence surface leaching:
   a. infiltration,
   b. permeability,
   c. depth,

d. water holding capacity,
e. texture.

5. Define preferential flow.
6. Distinguish how the following affect N, P, K, or S movement:
   a. soil pH,
   b. organic matter,
   c. CEC,
   d. soil texture,
   e. nutrient solubility.
7. Explain how the following management practices affect the potential for solute movement:
   a. timing of application,
   b. rate of application,
   c. erosion and runoff control (BMPs),
   d. irrigation,
   e. type of tillage operation.
8. List management practices that reduce phosphorus or nitrogen transport from a field.
9. Describe how lateral flow contributes to surface water contamination.
10. Describe how soil management practices affect:
    a. odor from manure and biosolids applications,
    b. ammonia emissions,
    c. particulates,
    d. carbon sequestration

COMPETENCY AREA 7. Soil-Plant/Water Relations

1. Define and understand how to apply 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. soil water status,
   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 8. Irrigation and Drainage

1. Describe the following irrigation methods:
   a. furrow,
   b. sprinkler,
   c. drip/trickle,
   d. flood,
   e. subsurface.
2. Describe the following drainage methods:
   a. tile,
   b. open ditch,
   c. beds.
3. Define Water Use Efficiency (WUE) and explain how to use field soil moisture monitoring to schedule irrigation.
4. Describe how soil texture affects tile drainage spacing and depth.
5. Identify methods to reduce irrigation runoff.
6. Understand Biochemical Oxygen Demand (BOD) and other contaminants in irrigation water as it relates to nutrient availability and plant health.

COMPETENCY AREA 9. Surface and Groundwater Quality

1. Describe how nutrients, pesticides and sediments move to off-site areas.
2. Explain Total Maximum Daily Loads (TMDLs) of nutrients and how they are related to water quality.
3. Explain how high sediment levels affect surface water quality.
4. Describe how the following components of animal products, manures and other biosolids affect surface water quality:
   a. nutrients,
   b. pathogens,
   c. heavy metals.
5. Explain the benefits of filter/buffer strips and riparian zones/tree plantings on water quality.
6. Explain how different forms of nitrogen and phosphorus can affect ground and surface water quality.
7. Define biochemical oxygen demand (BOD).
8. Describe how BOD affects water quality.
9. Identify the health effects of groundwater containing nitrate-nitrogen above the drinking water standard.
10. Explain the purpose of anti-backsiphoning devices.
11. Describe how water contamination occurs at a wellhead and explain methods of preventing wellhead contamination.

Pest Management

COMPETENCY AREA 1. Basic Concepts of Pest Management and Decision Making

1. Define IPM.
2. Describe how to use the following strategies to construct an effective IPM program:
    a. prevention,
    b. avoidance,
    c. monitoring,
    d. suppression.
3. Describe how to use each of the following steps of an IPM program:
    a. sampling and monitoring,
    b. identification,
    c. determining need for control,
    d. evaluating control options,
    e. implementation,
    f. evaluation and record keeping.
4. List the pros and cons of using IPM.
5. Define economic threshold and economic injury level.
6. Describe how natural enemies impact pest population projections.
7. Explain how to use the following information to help identify a pest:
    a. host,
    b. time of year,
    c. symptoms and patterns of damage,
    d. distinguishing characteristics of pest,
    e. distribution in field.
8. 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 production.
9. Use information about cost of control, potential pest damage and crop value to decide if pest control is necessary.

COMPETENCY AREA 2. Weeds

1. Identify characteristics of the following weeds and identify them as annual, biennial, or perennial weeds:

Grasses and Sedges	Broadleaves	Broadleaves con't
Annual bluegrass	Biennial wormwood	Mayweed
Barnyardgrass	Bull thistle	Palmer amaranth
Crabgrasses	Canada thistle	Pennsylvania smartweed
Downy brome	Cocklebur	Perennial sowthistle
Fall panicum	Common chickweed	Redroot pigweed
Foxtail barley	Common lambsquarters	Roughstalk bluegrass
Giant foxtail	Common milkweed	Russian thistle
Green foxtail	Common ragweed	Sheperd's purse
Johnsongrass	Curly dock	Velvetleaf
Quackgrass	Dandelion	Venice mallow
Sandbur	Eastern nightshade	Waterhemp
Wild oats	Field bindweed	Wild buckwheat
Wild proso millet	Field pennycress	Wild mustard
Windgrass	Giant ragweed	
Witchgrass	Henbit	
Woolly cupgrass	Jimsonweed	
Yellow foxtail	Kochia	
Yellow nutsedge	Leafy spurge	

2. Describe the life cycle, reproductive capacity, viability and dispersal of seed for the weeds listed in Table 1.
3. 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 or seed,
    g. stem shape,
    h. root system.
4. Describe how the following weed factors affect their ability to survive and be competitive:
    a. growth rate,
    b. seed production,

c. seed dormancy,
d. reproduction method,
e. light, temperature, moisture and humidity,
f. life cycle,
g. physical characteristics of the plant.

5. Describe competitive interactions of:
   a. crop on weeds,
   b. weeds on crops.

Competency Area 3. Insects

1. Identify the following pests and classify each by feeding habits, crops attacked, type of metamorphosis, and symptoms of damage on plants:

Important Insects in Michigan Crops – General List	
Alfalfa weevil larva and adult	Japanese beetle adult and larva
Aphids	Lygus bug
Fall Armyworm	Northern corn rootworm adult and larva
True Armyworm	Potato Leafhopper
Aster leafhopper	Seedcorn maggot
Bean leaf beetle adult	Soybean aphid
Black cutworm	Spider mites
Blister beetle	Spinach leafminer
Cabbage loopers	Spotted Wing Drosophila (lanternfly)
	Springtails
Cereal leaf beetle	Stink bugs (brown and green)
Corn blotch leafminer	Thistle caterpillar
Corn earworm larva	Thrips
Corn leaf aphid	Two-spotted spider mite
Diamond back moths	Western bean cutworm
European chafer grub	Western corn rootworm adult and larva
European corn borer	Wheat stem maggot
Flea beetle	Wheat stem sawfly
Grasshopper	White grub
Grass sawfly	Whiteflies
Hessian fly	Wireworm
Imported cabbage worms	
Beneficial Insects	**Other Pests**
Green lacewing	Nematodes
Ladybug	Slugs
Minute pirate bugs	
Parasitic wasps	
Syrphid fly	

Important Insects Listed by Crop	
Corn	**Soybeans**
Western/Northern corn rootworm	Soybean aphid
European Corn Borer	Spider mites
Armyworm	Slugs/snails
Seedcorn maggot	
Fall armyworm	**Alfalfa**
Western Bean cutworm	Alfalfa snout beetle
Black cutworm	Alfalfa weevil
White grub	Clover root curculio
Wireworm	Pea aphid
Corn leaf aphid	Potato leafhopper
Slugs/snails	
Corn earworm	**Small Grains** (wheat, barley, oats, rye)
	Cereal leaf beetle
Perennial Grasses and Clover	Wireworm
Armyworm	Thrips
Slugs/snails	Armyworm
White grubs	
	Cucurbits (Pumpkin, Squash, Cucumbers)
Potatoes	Aphids
Aphids	Cucumber beetle
Colorado potato beetle	Squash bug
European corn borer	Squash vine borer
Flea beetles	
Potato leafhopper	**Tomatoes**
Spider mites	Aphids
Tarnished plan bugs	Hornworms
Wireworms	Spider mites
Brassicas (Cabbage and Broccoli)	**Apples**
Aphids	Apple maggot
Cabbage looper	Borers
Cabbage maggot	Codling moth
Diamondback moth	Leafhoppers
Flea beetle	Leafminers
Imported cabbageworm	Mites
	Obliquebanded leafroller
Grapes	Oriental fruit moth
Brown marmorated stink bug	Plant bugs
Leafhoppers and treehoppers	Plum curculio
Mites	Rosy apple aphid
Phyllocera	San Jose scale
Spotted lantern fly	Stink Bug
Thrips	Woolly apple aphid

Grape Berry Moth	**Sugarbeets**
Grape Leaf Hopper	Aphids
Phylloxera	Army Worm
	Web Worm
Dry Beans	Cut Worm
Aphids	Flea Beetle
European Corn Borer	Grasshopper
Bean Leafe Beetle	Leafhopper
Bean Leaf Beetle	Lygus Bug
Western Bean Cutworm	Spinach Leafminer
Stink Bugs (Green, One Spotted, and Brown)	White Grubs
Grasshopper	Springtail
Cloverworm	Wireworms
Mexican Bean Beetle	Woolly Bear
Two-spotted spider mite	
Lygus Bug	**Blueberries**
Potato Leafhopper	Cranberry Fruit Worm
Seedcorn Maggot	Blueberry Maggot
Slugs	
Thrips	**Asparagus**
White Grubs	Common asparagus beetle
	Spotted asparagus beetle
	Cutworm
	Japanese beetle
	Tarnished plant bug
	Asparagus aphid
	Rose Chafer
	Armyworm

2. Use the following to identify mites and types of insects:
    a. type and number of legs,
    b. type of mouth parts,
    c. wing characteristics,
    d. life cycle.
3. Explain how the following factors affect insect pest population development:
    a. pathogens, predators, parasites, and parasitoids,
    b. host plants and habitat,
    c. initial pest population,
    d. temperature,
    e. moisture,
    f. soil characteristics and conditions,
    g. wind.
4. 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. over-wintering and over-summering characteristics,
    d. feeding habits,
    e. type of metamorphosis,
    f. dispersal and movement characteristics.
5. Identify plant damage caused by the following non-pest factors:
    a. wind,
    b. temperatures,
    c. rail, hail and ice,
    d. moisture extremes,
    e. sunlight,
    f. pesticide phytotoxicity,
    g. nutrient deficiency and toxicity,
    h. soil compaction,
    i. mechanical or animal.
6. Describe how nematodes survive and disperse
7. List the advantages and limitations of using the following diagnostic tools:
    a. hand lens,
    b. camera,
    c. picture references,
    d. dichotomous keys,
    e. pest ID applications.

COMPETENCY AREA 4. Diseases

Diseases - General

1. Identify each of the following agronomic diseases by host plant symptoms, and classify each by crops infected and type of causal organism for each of the important crops in Michigan:

apple scab	Leaf, stem, stripe, and crown rust
bacterial canker	Loose smut
bacterial speck	Mycotoxins
bacterial spot	Northern corn leaf blight
Bacterial wilt	Phytophthora root rot
Barley yellow dwarf	powdery mildew
Bean pod mottle virus	purple spot
Brown stem canker	Pythium seeding rot
cherry leaf spot	Rhizoctonia root/crown rot
Common leafspot	Sclerotinia diseases
Downy mildew	Septoria leaf and glume blotch
early blight	Soybean rust
Ear rots/mold	Stalk, stem, and root rots
Ergot	Sudden death syndrome
fire blight	Brown rot
Goss's wilt	tar spot
Head scab	Wheat streak mosaic
late blight	

Diseases – By Crop

Alfalfa	**Corn**
Anthracnose	Anthracnose leaf blight and stalk rot
Brown root rot	Common rust
Pythium damping-off	Common smut
Leaf and stem blight complex including:	Eyespot
Spring black stem and leaf spot	Gibberella stalk and (red) ear rot
Lepto leaf spot	Goss's wilt
Common leaf spot	Gray leaf spot
Fusarium crown and root rot	Northern corn leaf blight
Verticillium wilt	Northern corn leaf spot
	Seed decay/seedling blights
	Stewart's bacterial leaf blight and wilt
	Tar spot

Small Grains (wheat, barley, oats, rye)	
Crown rust	**Soybean**
Fusarium head blight (scab)	Bacterial blight
Leaf rust	Bacterial pustule
Loose smut	Brown stem rot
Powdery mildew	Downy mildew
Stripe rust	Pod and stem blight
Leaf and glume blotch complex including:	Sclerotinia stem rot (white mold)
Septoria	Septoria brown spot
Stagonospora	Soybean cyst nematode
Tan spot	Soybean mosaic
Soil-bore wheat mosaic virus	Stem canker
Wheat spindle streak mosaic virus	Sudden death syndrome
Yellow dwarf virus	Frogeye leaf spot
	Anthracnose
	Grapes
Perennial Grasses and Clover	Botrytis bunch rot
Leaf rust	Bitter rot
Leaf spot	Black rot
Powdery mildew	Botrytis
	Downy mildew
	Powdery mildew
	Sour rot

Potatoes	**Brassicas** (cabbage and broccoli)
Brown spot	Alternaria
Early Blight	Anthracnose
Grey mold/Botrytis	Bacterial leaf spot
Late blight	Black rot/ Xanthomonas
Pink rot	Clubroot
Pythium leak	Downy mildew
Rhizoctonia stolon canker/black scruf	Powdery mildew
Silver scruf	Sclerotinia white mold
White mold/Sclerotinia	
	Tomatoes/Peppers
Cucurbits (pumpkin, Squash, Cucumbers)	Bacterial canker
Alternaria leaf blight	Bacterial leaf spot
Angular leaf spot	Early blight
Anthracnose	Gray leaf spot (Stemphylium)
Bacterial wilt	Gray mold/Botrytis
Downy mildew	Late blight
Gummy stem blight	Phytophthora capsici
Phytophthora crown and root rot	Septoria leaf spot
Plectosporium/Michrodochium blight	
Powdery mildew	

Apples	
Bitter rot	
Fire blight	
Fly speck and sooty blotch	
Powdery mildew	
Scab	
White Rot	

Dry Beans	**Sugarbeets**
Rhizoctonia	Aphanomyces
Pythium	Rhizoctonia
Halo Blight	Pythium
Anthracnose	Phytophthora
White Mold	Crown Rot
Bean Mosaic Virus	Cercospora Leafspot
Bacterial Blight	Powdery Mildew
Ozone Injury	Rhizomania
Rust	Alternaria Leafspot
Fusarium	Bacterial Leaf Spot
Angular Leaf Spot	
Bacterial Wilt	**Blueberry**
Bacterial Brown Spot	Mummy berry
	Botrytis blossom blight
Cherry	Anthracnose fruit rot
Bacterial Canker	Alternaria fruit rot
Brown Rot	Leaf Rust
Cherry Leaf Spot	
	Pepper
Asparagus	Bacterial leaf spot
Rust	Phytophthora crown and root rot
Purple spot	
Phytophthora Crown and spear rot	**Celery**
Fusarium decline	Fusarium yellows
	Septoria leaf spot (late blight)
Onion	Cercospera early blight
Stemphylium leaf spot/blight	
Pink root	
Downey Mildew	
Anthracnose	

2. Describe how the environment, host plant and pathogen interact to result in plant disease.
3. Describe how the following plant pathogens survive and disperse:
   a. fungi,

b. bacteria,
c. viruses.

4. 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.
5. Describe how the following pathogens infect plant tissue:
   a. fungi,
   b. bacteria,
   c. viruses.

COMPETENCY AREA 5. Pest Management Strategies

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

2. Describe methods to minimize introducing pests into fields
3. Describe the concept of critical weed free period
4. Explain advantages and limitations of using biological control agents in crop production
5. Explain how the following pesticide characteristics affect pesticide selection:
   a. mode of action,
   b. chemical and physical properties,
   c. toxicity to non-target organisms,
   d. environmental hazard,
   e. persistence,
   f. selectivity,
   g. phytotoxicity to crop.

6. 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.
7. Distinguish between contact and systemic pesticides
    a. contact vs. locally systemic vs. systemic,
    b. pre vs. post infection timing,
    c. seed vs. soil vs. narrow spectrum,
    d. mode of action.
8. List factors that increase the risk of crop injury from pesticides.
9. Explain how the following affect pesticide coverage:
    a. wind speed,
    b. nozzle characteristics,
    c. boom height and configuration,
    d. evaporation rate,
    e. spray viscosity,
    f. spray pressure,
    g. ground speed,
    h. spray adjuvants.
10. List advantages and limitations of ground vs. aerial application methods.
11. Identify plant injury symptoms caused by the following herbicide mode-of-action groups:
    a. photosynthesis inhibitors,
    b. cell membrane disruptors,
    c. growth regulators,
    d. pigment inhibitors,
    e. root/shoot growth inhibitors,
    f. amino acid inhibitors,
    g. ALS inhibitors.
12. 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.
13. Describe the toxicity and persistence of the following insecticide families:
    a. organophosphates,
    b. carbamates,
    c. synthetic pyrethroids,
    d. neonicotinoids,

e. DMI.

14. Recommend insecticide timing and placement based on the following types of insecticide activity:
    a. contact,
    b. ingestion poison,
    c. systemic,
    d. ovicidal,
    e. juvenile hormone.
15. Describe how the following affect pest resistance:
    a. selection pressure,
    b. resistance mechanisms,
    c. pest reproduction methods.
16. Describe strategies for managing a pest population that develops resistance to pesticides.
17. Explain how pests overcome host resistance.
18. Explain the role of susceptible refuge host populations in managing insect resistance.
19. List the advantages and limitations of incorporating multiple traits into crops through transgenic techniques.

COMPETENCY AREA 6. Sampling and Monitoring

1. List advantages and limitations of the following insect sampling methods:
    a. presence/absence sampling,
    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 year,
    d. crop growth stage,
    e. pest development stage
    f. NDVI, drone technology/remote sensing ,
    g. forecasting models.
3. Describe how to obtain a representative sample from the following pest distribution patterns:
    a. clumped,
    b. uniform,
    c. border effect,
    d. random.
4. Describe how to prepare and ship samples of the following to a laboratory for evaluation:

a. weeds,
b. insects,
c. diseased plants,
d. soil for nematode analysis.

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

COMPETENCY AREA 7. Environmental Stewardship

1. Review and follow 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. 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.
5. Define the following terms associated with pesticide use:
    a. point source pollution,
    b. non-point source pollution,
    c. parts per million (ppm) and parts per billion (ppb),
    d. pesticide residue tolerance in the crop,
    e. best management practices.
6. 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. application speed,
    h. temperature inversion,
    i. humidity.
7. Describe how the following affect potential for pesticide loss from a field:
    a. residue management,
    b. buffer strips,
    c. contour of strip farming,
    d. subsurface drainage.
8. Explain how the presence of beneficials, endangered species, species at risk, or nearby sensitive crops affect pesticide selection and application.

9. View and understand Michigan regulations. See https://www.michigan.gov/mdard/plant-pest/pesticides/pesticide-laws-regs.

COMPETENCY AREA 8. Health and Safety

1. List modes of pesticide exposure into humans.
2. Define chronic and acute pesticide poisoning.
3. Recognize symptoms of acute poisoning.
4. List possible chronic effects of chronic poisoning.
5. Describe procedures to follow if a pesticide gets on skin, in eyes, mouth or stomach, or is inhaled.
6. Describe PPE (personal protective equipment) to use while mixing and applying pesticides.
7. Describe proper clean-up procedures for application equipment and PPE.
8. Demonstrate knowledge and use of a SDS.

Crop Management

COMPETENCY AREA 1. Cropping Systems

1. List the advantages and limitations of monoculture crop and crop rotation systems.
2. Describe the role of the following in a cropping system:
   a. fallow,
   b. green manure crops,
   c. cover crops,
   d. companion crops.
3. Describe how cropping sequence in a rotation influences:
   a. tillage options,
   b. residue management,
   c. moisture availability,
   d. pest management,
   e. yield potential,
   f. soil carbon.
   g. resistance 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.
5. Describe how the following affect the conversion of non-cropland to cropland:
   a. existing vegetation,
   b. pest management,
   c. nutrient availability,
   d. yield potential,
   e. erosion potential,
   f. other environmental impacts.
6. Define allelopathy.
7. Identify sources of information on organic standards and production practices.

COMPETENCY AREA 2. Hybrid and Variety Selection

1. Define cultivar or variety and hybrid.
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 sensitivity,
   g. harvestability,

h. end use,
i. value added trait.

4. Define transgenic crop.
5. List advantages and limitations of growing transgenic crops.
6. Explain why randomization and replication are important in field trials.
7. Use least significant differences (LSD) values to interpret differences among varieties or hybrids.

COMPETENCY AREA 3. Crop Establishment

1. Understand the information provided on a seed tag or label.
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. manage germination timing,
   d. enhance nutrient uptake and use.
5. Describe advantages and limitations of bacterial inoculants (storage time, handling, storage conditions, etc.).
6. Describe uses and limitations of the standard germination test.
7. Describe Pure Live Seed (PLS).
8. Use purity and germination information to calculate a seeding rate
9. Describe how the following factors affect seed germination:
   a. soil temperature,
   b. soil moisture,
   c. seed-soil contact.
10. Describe how depth of planting affects crop emergence.
11. List conditions that alter recommended planting depth.
12. Identify consequences of seeding earlier or later than optimum.
13. Identify the factors that influence planting date.
14. Describe how the following factors affect seeding rates:
    a. planting practices,
    b. soil tilth,
    c. environmental conditions,
    d. crop residue,
    e. seed size,
    f. seed quality.
15. Describe advantages and limitations of applying fertilizer at seeding.
16. Calculate plant population in a field.
17. Differentiate seeding rate, plant population and harvest population.

COMPETENCY AREA 4. Crop Growth and Development

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:
    a. germination and emergence,
    b. vegetative,
    c. flowering,
    d. seed development,
    e. physiological maturity.
3. Define growing degree unit. See MSU website:http://www.agweather.geo.msu.edu/mawn/.
4. Use growing degree units to determine rate of crop development.
5. Describe how day length affects flowering on short day, long day, and day neutral plants.
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 growth:
    a. pH
    b. moisture and temperature,
    c. texture and structure,
    d. fertilizer placement,
    e. nutrient status,
    f. soil borne pests,
    g. compaction.
10. Describe the effect of tap and fibrous root systems on:
    a. nutrient uptake,
    b. water uptake,
    c. erosion control,
    d. soil aggregation.
11. Describe how the following affect the economics of replanting:
    a. expected date of replanting,
    b. population of surviving plants,
    c. pesticides applied,
    d. stand uniformity,
    e. pest pressure.

12. Use information about the following to diagnose a cropping problem:
    a. pattern of problem in the field,
    b. cropping history,
    c. field preparation,
    d. weather information,
    e. management practices,
    f. equipment function.

COMPETENCY AREA 5. Applied Information Technologies

1. Define the following precision agriculture terms:
    a. global positioning systems,
    b. remote sensing,
    c. geographic information systems (GIS),
    d. variable rate technology,
    e. crop management zone.
2. Describe how the following factors affect yield variability in a field:
    a. soil texture,
    b. soil organic matter,
    c. topography,
    d. pest distribution,
    e. previous management,
    f. salinity,
    g. nutrient status and pH,
    h. drainage.
3. Interpret a map legend to identify information on a GIS map.
4. Understand geographical coordinates to locate a tract of land.
5. Understand latitude and longitude coordinates to locate a point in a field.
6. List advantages and limitations of guidance and data logging systems.

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 crop quality in storage:
    a. temperature,
    b. moisture,
    c. aeration,
    d. stored product pests,
    e. crop condition and moisture at harvest,
    f. post-harvest handling,
    g. length of storage,
    h. amount of foreign material,
    i. sanitation of storage facilities.
3. List the consequences of not maintaining the purity of an identity preserved (IP) crop.

4. Describe how to maintain purity of an identity-preserved (IP) crop at planting, harvest, delivery and storage.
5. Recognize excessive crop loss or low quality factors in harvested product caused by improper harvesting procedures.

COMPETENCY AREA 7. Managing Production Risk

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.
2. Describe how the following affect crop management decisions:
    a. crop species,
    b. input costs,
    c. availability and skill of labor,
    d. equipment,
    e. weather,
    f. cash flow,
    g. crop insurance,
    h. farm programs,
    i. field proximity,
    j. time constraints,
    k. pest threat,
    l. global events.

Appendix A. Nutrient Management Glossary

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

Aerobic: A condition identified by the presence of oxygen.

Agronomic nutrient rate: Amount of nutrients required by a crop for an expected yield, after all soil, water, plant, and air credits are considered.

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

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

Ammonium nitrate solution: Water based solution of ammonium nitrate in water usually standardized to 20% nitrogen used for direct application or a ingredient in a multi-nutrient liquid fertilizer. Analysis is 20-0-0.

Ammonium Phosphate: A group of phosphorus fertilizers manufactured by the reaction of anhydrous ammonia and super-phosphoric acid to produce either solid or liquid fertilizer.

Ammonium sulfate: A fertilizer with an analysis of 21-0-0 and 24% sulfur.

Anaerobic: A condition identified by the absence of oxygen.

Anhydrous ammonia (NH_3): Nitrogen fertilizer made by compressing air and natural gas under high temperature in the presence of a catalyst. Analysis is 82-0-0.

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

Anion: An ion that has a negative electrical charge. Common anions include sulfate, and nitrate.

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

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

Available nutrient: The form of a nutrient that the plant is able to use. Many nutrients are in forms the plant cannot use and must be converted to forms available to the plant to be useful.

Banded nutrients: Placing fertilizer nutrients in a band near the seed at planting. Also may include a separate surface or subsurface band application of either solid or liquid materials before or after planting.

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

Bioremediation: The use of biological agents to reclaim soil and/or water polluted by substances hazardous to human health or the environment.

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

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

Calcite lime: Limestone consisting of $CaCO_3$ based material with low magnesium levels.

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

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

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

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

Chelated molecule: A large water-soluble organic molecule that binds with a free metal ion to form a water soluble complex. Chelation improves the solubility and plant availability of the metal ion.

Comprehensive nutrient management plan: A group of conservation practices and management activities unique to animal feeding operations, which ensures efficient crop production as well as natural resource protection.

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

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

Crop removal rate: The amount of nutrients that are removed from the field in the plant harvest, including grain, fruit forage and residues that are removed form the field.

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

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

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

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

Diammonium Phosphate: A fertilizer containing both nitrogen and phosphorus with an analysis of 18-46-0.

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

Dolomitic Lime: A naturally occurring liming material mostly composed of carbonates of magnesium and calcium.

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

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

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

Fertigation: Applying fertilizer through an irrigation system.

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

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

Fertilizer suspension: A fluid fertilizer containing dissolved and un-dissolved plant nutrients. The un-dissolved nutrients are kept in suspension with an agent, usually by swelling type clays.

Field Capacity: The amount of water soil holds after free water has drained due to gravity.
Foliar fertilizer: Application of a dilute solution of fertilizer to plant foliage, usually made to supplement soil-applied nutrients.

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

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

Gypsum: Calcium sulfate ($CaSO_4 * 2H_2O$) used either to supply said nutrients or to improve sodic soils.

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

Immobilization: The conversion of an element from the inorganic to the organic form in microbial tissues resulting in that element not being readily available to other organisms or plants.
Impermeable layer: Soil layers, either natural of human-made, that resist penetration by fluids or roots.

Injection: Mechanical placement of materials below the surface of the soil.

Inorganic Nitrogen: Mineral forms of nitrogen.

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

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

Lime fineness: The particle size of limestone determined by the fineness of grind. Finer grind results in faster acid neutralization.

Lime material: A material capable of neutralizing soil acidity.

Lime purity: The measure of impurities in a given liming material to determine neutralizing value.

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

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

Macro-nutrient: Nutrients that plants need in relatively large amounts. Essential macronutrients include carbon (C), oxygen (O), Hydrogen (H) nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), Magnesium (Mg), and sulfur (S).

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

Micro-nutrient: Nutrients that plants need in relatively small or even trace amounts. Boron (B), chlorine (Cl), copper (Cu), iron (Fe), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), and zinc (Zn) are considered micronutrients.

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

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

Monoammonium phosphate (MAP): A fertilizer composed of ammonium phosphates, resulting from the ammoniation of phosphoric acid. Typical analysis is 11-52-0.

N-based nutrient application: Application of the fertilizer is base on the nitrogen content and the amount N desired, regardless of the amounts of the other nutrients being applied.

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

Nitrification: The process of converting ammonium to nitrate.

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

Nutrient build-up: An increase in soil test levels of a nutrient due to the application of that nutrient.

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

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

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

Orthophosphate: Inorganic form of plant available phosphorus.

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

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

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

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

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

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

Potassium: Generally referred to as potash, it is an essential plant nutrient involved in energy metabolism, starch synthesis and sugar degradation.

Recommended rate: Amount of nutrients recommended on a soil test report for a specific crop that meets but does not exceed the crop nutrient requirements. Recommended rates can also include nutrients used for soil test build-up.

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

Rhizobia: Bacteria capable of living symbiotically with higher plants, usually legumes, by receiving food and carbon and providing nitrogen to the plant.

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

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

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

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

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

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

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

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

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

Soil sampling: A process of obtaining a quantity of soil representative of an area of the soil or field.

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

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

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

Soil test interpretation: Using soil test report information to manage soil fertility and monitor environmental conditions.

Soil test level: The nutrient content of the soil, as measured by an analysis of a soil sample.

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

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

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

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

Sufficiency level: IN PLANTS, a nutrient concentration in the plant tissues above which the crop is amply supplied and below which the crop is deficient. IN SOILS, A soil test level above which economic responses to an applied fertilizer are unlikely to occur.

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

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

Symbiotic N fixation: Conversion of molecular nitrogen (N2) to ammonia and subsequently to organic nitrogen forms by organisms.

Topdress: Applying fertilizer, pesticides or soil amendments on the surface, usually after the crop has emerged.

Total Kjeldahl nitrogen (TKN): A laboratory procedure to measure organic and ammonia nitrogen on soils and plants.

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

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

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

Uptake antagonism: When the excess of one nutrient interferes with the uptake of another nutrient. Often the nutrients involved have a similar mechanism of uptake.

Urea: A nitrogen fertilizer that is white crystalline solid, very soluble in water, which has an analysis of 46-0-0.

Urea ammonium nitrate (UAN): A liquid nitrogen fertilizer containing urea and ammonium nitrate in approximately equal proportions dissolved in water. The nitrogen content ranges from 28 to 32%, with 28% most common in regions having cold winter temperatures.

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

Appendix B. Soil and Water Management Glossary

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

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

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

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

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

Anion: An ion with a negative charge.

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

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

Available nutrient: The form of a nutrient that the plant is able to use.

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

Bedrock: Solid or consolidated rock lying under the soil.

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

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

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

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

Buffering: The ability of a solution, like the soil solution or irrigation water, to resist

changes in pH when acid or alkaline substances are added. Often used when speaking of soil to describe its resistance to pH changes when limed or acidified.

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

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

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

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

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

Cation: An ion with a positive charge.

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

Clay: PARTICLE SIZE, The class of smallest soil particles, smaller than 0.002 millimeter in diameter. SOIL, the textural class (portion of texture triangle) with more than 40% clay and less than 45% sand and less than 40% silt.

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

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

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

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

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

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

Conservation tillage: A general term for tillage practices that leave crop

residues on the soil surface to reduce erosion.

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

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

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

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

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

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

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

Drainage: Rate and amount of water removal from a soil by surface or subsurface flow. **Ecosystem:** Community of animals and plants and the physical environment in which they live. **Effluent:** Discharge or emission of a liquid or gas.

Erosion: The movement of soil by water, wind or tillage.

Eutrophication: Enrichment of water by nutrients, primarily nitrogen (N) and phosphorus (P) that results in excessive plant or algal growth. Decomposition of this plant/algal material can result in the depletion of oxygen in water leading to death of aquatic animals.

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

Fallow: Soil left idle to accumulate water and/or mineral nutrients.

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

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

Fragipan: A dense and brittle subsurface layer of compacted soil.

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

Granular: Soil structure where the units are approximately spherical or polyhedral. **Gravitational water:** Water that moves through the soil under the influence of gravity. **Ground water:** Water in the saturated zone below the soil surface.

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

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

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

Heavy metals: Usually refers to lead, copper, zinc, mercury, arsenic, cadmium nickel and selenium.

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

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

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

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

Hygroscopic water: Water held tightly by adhesion to soil particles. It is unavailable for plants and remains in the soil after air-drying, but can be removed with oven drying.

Infiltration: Water entry into the soil from precipitation, irrigation or runoff.

Irrigation: Application of water to supplement natural rainfall.

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

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

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

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

Massive soil: A structure-less soil.

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

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

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

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

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

Mulch: Natural or synthetic layer of plant residue or other material covering the land surface which conserved soil moisture, hold plants in place, aids is establishing plant cover and minimizes temperature fluctuations.

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

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

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

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

Organic matter: The organic fraction of the soil exclusive of un-decayed plant and animal residues.

Organic soil: Soil containing more than 20 or 30% organic matter in the U.S. and Canada respectively.

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

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

Percolation: Downward movement of water through soil or rock.

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

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

pH: Numerical measure of (negative log of the) hydrogen ion concentration with a scale of 0-14. Neutral is 7.0 and values below 7 are acidic and values above 7 are alkaline.

Platy: Consisting of soil aggregates that are developed predominantly along the horizons and are laminated and flaky.

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

Potable: Water that is suitable for drinking.

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

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

Recharge: Downward movement of water through soil to ground water.

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

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

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

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

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

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

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

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

Saturated zone: Portion of the soil or rock profile in which all pores are filled with water. **Sediment:** Eroded soil and rock and/or plant debris transported and deposited by wind or water. **Single grain:** A structure-less soil in which each particle exists separately as in sand.

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

Soil loss tolerance (T value): Relative to CROPPING: the maximum average annual soil loss that will allow continuous cropping and maintain soil productivity without requiring additional management inputs. Relative to EROSION: the maximum soil erosion loss that is offset by the theoretical maximum rate of soil development that maintains equilibrium between soil losses and gains.

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

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

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

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

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

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

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

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

Tillage erosion: The down-slope displacement of soil through the action of tillage operations.

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

Tilth: Physical condition of the soil relative to how easily it can be tilled, how good the seedbed can be made, and how easily shoots and roots can penetrate.

Volatilization: The loss of a compound in gaseous form.

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

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

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

Wind Erosion Equation (WEQ): An equation for predicting the average annual soil loss from wind erosion in mass per unit area per year (E). The equation is E = f(IKCLV), where f indicates "a function of", I is the soil erodibility index, K is the soil roughness factor, C is the climate factor, L is the unsheltered distance and V is the vegetative factor.

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

Appendix C. Pest Management Glossary

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

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

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

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

Adjuvant: Substance that enhances the effectiveness of a pesticide.

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

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

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

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

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

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

Biotic: Pertaining to living organisms.

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

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

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

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

Common pesticide name: Name given to a specific pesticide active ingredient. A pesticide may be know by many trade names, but has only one common name.

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

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

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

Economic Threshold (Action Threshold): Pest density at which control measures should be taken to avoid crop value loss from reaching the EIL. Implementing a management strategy when Economic Threshold is reached keeps pest populations from reaching the EIL.

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

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

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

Good Farming Practices: See BMP

Growth regulator: A substance when applied to plants in small amounts either inhibits stimulates or otherwise modifies the growth process. Also may be defined as one of a class of herbicides that causes rapid growth distortions prior to plant death.

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

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

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

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

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

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

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

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

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

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

Parts per billion (ppb)/ Parts per million (ppm): A means of expressing concentration, one part of analyte per each billion/million parts of sample.

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

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

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

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

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

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

Phytotoxic: Injurious or toxic plants.

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

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

Point Source Pollution: Contamination from a specific identifiable source.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix D. Crop Management Glossary

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

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

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

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

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

Anthesis: The time of flowering in a plant.

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

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

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

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

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

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

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

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

Cover crop: A crop grown to protect the soil from erosion during periods when it would otherwise be bare, and/or scavenge excess nutrients from a previous crop to prevent nutrient loss.

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

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

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

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

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

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

Desiccation: The removal of moisture from a material.

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

DNA: Deoxyribonucleic acid, a relatively large molecule that contains genetic information. Each DNA molecule is composed of two complementary strands in the shape of a double helix. A gene is a piece of DNA.

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

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

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

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

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

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

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

Gene: A portion of a chromosome (piece of DNA) that contains the hereditary information for the production of a protein.

Genetic engineering: The technique of removing, moving or adding genes to a DNA molecule. Also called gene splicing or recombinant DNA technology.

Genetically modified organism (GMO/GM): See also transgenic plants. A living entity modified or transformed through recombinant DNA technology (genetic engineering).

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

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

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

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

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

Green manure: Green, live plant material incorporated into the soil for soil improvement.

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

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

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

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

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

Identity preserved (IP) crop: A crop with which specific traits are know to exist.

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

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

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

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

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

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

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

Long day crop: Crop in which flowering occurs when night length is less that the crops required critical length.

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

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

Monoculture: Growing the same crop over a wide area and/or continuously in the same field year after year.

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

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

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

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

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

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

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

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

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

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

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

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

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

Recombinant DNA technology: The technique of isolating DNA molecules and inserting them into the DNA of a cell. See also genetic engineering.

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

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

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

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

Rhizobium: Bacteria which fix atmospheric nitrogen in nodules on the roots of legume plants. **RNA:** Ribonucleic acid, a messenger molecule that contains instructions for protein synthesis.
Self pollinated: A plant pollinated by its own pollen.

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

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

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

Tilth: Physical condition of the soil relative to how easily it can be tilled, how good the seedbed can be made, and how easily shoots and roots can penetrate.

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

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

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

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

Vegetative: The non-reproductive stage of plants and/or the non-reproductive parts of plants

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

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

Yield map: The pattern of crop yield in a field based on data collected using a yield sensor on a harvester and geographic positioning of these yield values using a global position system.