

**Ontario
Certified Crop Advisor**

Performance Objectives

**Eleventh Edition
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Introduction

The purpose of this booklet is to be a guide to help you prepare for the Ontario Certified Crop Advisor examination. The performance objectives outline the knowledge and skills that are needed in order to provide sound advice to crop producers.

To become a Certified Crop Advisor (CCA) in Ontario, it is necessary to pass two exams. The first is the International exam; its performance objectives are set by the American Society of Agronomy and are available in a separate booklet. The second is the Ontario CCA examination; these performance objectives are described in this booklet. The Ontario exam consists of 100 multiple choice questions. The subject matter is divided into four sections. The percentage of exam questions under each section (weighting) will be as follows:

1.	Nutrient Management	27%
2.	Soil and Water Quality	20%
3.	Integrated Pest Management	25%
4.	Crop Management	28%

Each of the four sections is broken down into competency areas with specific performance objectives. In preparing for the exam, you can best allocate your time by focusing on areas where your knowledge is weakest relative to what is described in the performance objectives.

This tenth edition of the performance objectives were developed by the Ontario Certified Crop Advisor Exam Committee.

We invite and encourage you to show your professionalism, integrity and pride. Agriculture, like medicine and law, relies on expertise, information and skill. The CCA designation identifies people who care about their profession and the success of their customers.

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Section 1: Nutrient Management

Competency Area NM-1. Basic Soil Fertility Concepts

1. Describe the roles of nitrogen, phosphorus, potassium, magnesium, sulphur, calcium and micronutrients in plants.
2. Define base saturation.
3. Describe the influence of soil pH, clay content and organic matter content on cation exchange capacity and base saturation.
4. Describe the difference between an estimated value for cation exchange capacity and an actual determination.
5. Define guaranteed analysis as outlined in the *Fertilizers Act* of Canada.

Competency Area NM-2. Soil Testing, Plant and Manure Analysis

6. Describe the soil sampling procedures recommended in the Agronomy Guide for Field Crops, OMAFRA Publication 811.
7. Describe methods used for site specific/intensive soil sampling and list their advantages and disadvantages.
8. Describe the tissue sampling procedures recommended in OMAFRA Publication 811 for corn, soybeans, winter wheat and alfalfa.
9. List advantages and disadvantages of the following three fertilizer recommendation approaches:
 - a. cation saturation ratio
 - b. nutrient build-up and maintenance
 - c. nutrient sufficiency
10. Identify the approach used in the fertilizer recommendations in OMAFRA Publication 811.
11. Distinguish between extractable amount and total amount of a nutrient in a soil.
12. List nutrients for which there are accredited Ontario soil tests as stated in OMAFRA Publication 811.
13. Identify accredited soil test extractants for making Ontario fertilizer recommendations as stated in OMAFRA Publication 811.
14. Describe the methods used for measuring soil organic matter and the pros and cons of the analytic methods.
15. Identify the limitations of using a non-accredited soil test for the following: phosphorus, sulfur, boron, calcium, copper, chlorine, iron, molybdenum, and soil organic matter.
16. Interpret the information given on an accredited soil testing laboratory report.
17. Calculate the amounts and rates of fertilizer needed to meet specific soil test recommendations.
18. Describe the role of soil testing, plant tissue testing and visual plant symptoms in a fertilization program.
19. Describe the different forms of nitrogen found on a manure analysis report.
20. Calculate the credits for N, P and K from manure in the year of application and subsequent years, based on an analytical report.
21. Describe how nutrient credits from animal manures, compost, biosolids and legumes influence fertilizer recommendations.

Competency Area NM-3. Liming and pH

22. Define calcareous soil.
23. Describe the influence of the following factors on soil pH: slope position, parent material, and texture.
24. Distinguish between soil pH and buffer pH.
25. Describe how the recommended Ontario soil test (OMAFRA Publication 811) uses soil pH and buffer pH to determine soil lime requirements.
26. Based on OMAFRA Publication 811, define neutralizing value, fineness rating and Agricultural Index of liming materials.
27. Calculate lime application rates using an accredited soil testing report and the neutralizing value and fineness rating of the liming material.
28. Describe the advantages of proper lime incorporation.
29. Determine when to use dolomitic versus calcitic lime to correct soil pH.
30. List soil pH below which liming is recommended for: corn, soybeans, wheat, barley, and alfalfa.
31. Describe the negative effects of over-applying lime.

Competency Area NM-4. Fertilizer Placement

32. Describe the pros and cons of the different fertilizer application techniques including broadcast, banding, dribbled, and seed placed.
33. Rank the relative toxicity of common fertilizer materials to corn, wheat and soybean seedlings.
34. Identify factors affecting the amount of fertilizer that can safely be applied in a band near the seed.
35. Identify safe limits for seed placed or banded fertilizer for corn, soybeans, canola, and cereals.

Competency Area NM-5. Nitrogen

36. Identify how nitrogen is gained, lost and transformed in the soil through mineralization, nitrification, volatilization, fixation and leaching.
37. Describe how nitrogen gains, losses and transformations in the soil influence nitrogen availability to plants and nitrogen fertilization practices.
38. Describe the advantages and limitations of the soil nitrate-nitrogen test for corn and barley.
39. Describe how topography and organic matter can influence soil nitrate levels.
40. Recognize nitrogen deficiency symptoms on corn, soybeans, alfalfa and cereals.
41. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat, and forage production:

anhydrous ammonia	ammonium nitrate
urea-ammonium nitrate (UAN)	calcium ammonium nitrate
urea	ammonium sulphate
polymer coated urea (e.g. slow release nitrogen)	
42. Describe how urease inhibitors and nitrification inhibitors affect nitrogen transformation in the soil.

Competency Area NM-6. Phosphorus

43. Describe how soil chemical and physical properties affect phosphorus mobility in the soil and availability to the plants.

44. Describe the advantages and disadvantages of seed-placed, banded, strip till placed and broadcast fertilizer phosphorus placement methods.
45. Recognize phosphorus deficiency symptoms on corn, soybeans, alfalfa and cereals.
46. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat, and forage production:

triple superphosphate	monoammonium phosphate
diammonium phosphate	liquid phosphorus (ammonium polyphosphate) fertilizers

Competency Area NM-7. Potassium

47. Describe how soil chemical and physical properties affect potassium fertilizer availability, mobility and leaching.
48. Recognize potassium deficiency symptoms on corn, soybeans, alfalfa and cereals.
49. Recognize potassium luxury consumption and its potential effect on forage quality for ruminant livestock.
50. Describe the agronomic advantages and disadvantages of each of the following fertilizer materials in corn, winter wheat, and forage production:

muriate of potash
sulphate of potash
sulphate of potash magnesia

Competency Area NM-8. Secondary and Micronutrients

51. Describe how soil chemical and physical properties affect magnesium availability, mobility and leaching.
52. Recognize magnesium deficiency symptoms on corn, soybeans, and forages.
53. Describe the agronomic advantages and disadvantages of each of the following magnesium sources:

sulphate of potash magnesia
magnesium sulphate
dolomitic lime
magnesium oxide
54. Describe how soil chemical and physical properties affect sulphur availability, mobility and leaching.
55. Describe the advantages and disadvantages of the following sulphur sources:

elemental sulphur
ammonium sulphate
potassium sulphate
gypsum
56. Recognize the deficiency symptoms of:

zinc in corn
manganese in soybeans and cereals
boron in alfalfa
sulphur in canola
57. Describe how the interaction between the following can affect crop nutrition:

phosphorus and zinc	potassium and magnesium
pH and zinc	weather conditions and boron
pH and manganese	weather conditions and manganese
	newly drained fields and manganese

58. Describe the components used to calculate the zinc and manganese indexes.
59. Describe advantages and limitations of foliar and soil applied (banded or broadcast) micronutrient applications.
60. Describe the agronomic advantages and disadvantages of each of the following forms of micronutrients:

chelates	oxysulphates
oxides	sulphates
61. Describe the risks associated with over application of micronutrient fertilizers.
62. Recognize the contribution of manure or biosolids to secondary and micronutrient supply.

Nutrient Management References

Agronomy Guide for Field Crops. OMAFRA Publication 811, 2013
Soil Fertility Handbook. OMAFRA Pub 611, 2006
Soil Fertility Manual. International Plant Nutrition Institute, 1995.
Soil Management. Best Management Practices Series, AAFC/OMAFRA, 1994.
Managing Crop Nutrients. Best Management Practices Series, AAFC/OMAFRA, 2008.
Managing Crop Nutrients. Best Management Practices Series, AAFC/OMAFRA, 2008.
Manure Management. Best Management Practices Series, AAFC/OMAFRA, 2005.
Nutrient Management Planning. Best Management Practices Series, AAFC/OMAFRA, 2007.
Ontario Ministry of Agriculture Food and Rural Affairs Website: www.omafra.gov.on.ca

Section 2: Soil and Water Quality

Competency Area SWQ-1. Water Cycle and Soil Drainage

1. Describe the hydrologic cycle.
2. Define watershed.
3. Describe the various types of wetlands and their role in the local water cycle.
4. Define the following and how they influence the movement of groundwater:
recharge areas
aquifers
aquitards
5. Describe how the annual water balance influences movement of nitrate, phosphorus, bacteria and pesticides from agricultural land.
6. Describe the transport mechanisms by which losses of manure, biosolids, nitrate, phosphorus, and bacteria can impact surface water or groundwater.
7. Describe the transport mechanisms for loss of nutrients during the non-growing season.
8. Describe the significance of source load in nutrient runoff.
9. Describe how crop production practices can impact surface and groundwater.
10. Describe how spacing and depth of tile drains relate to soil texture, internal drainage and topography.
11. Identify the benefits of tile drainage to crop production.
12. Identify the potential impacts of tile drainage on the environment.
13. Describe how the following affect pesticide movement:
method of application precipitation
pesticide adsorption soil erosion
pesticide persistence soil pH
pesticide solubility soil texture

Competency Area SWQ-2. Water Quality

14. Identify the importance of the Federal and Ontario Drinking Water Objectives.
15. Describe how the following water quality problems may be caused by agricultural practices:
harmful algal blooms fish kill
water clarity/turbidity visible contaminants (oil, colour)
16. Distinguish between non-point source and point source pollution.
17. Identify the role of the following in regard to aquatic systems, water quality and water taking:
Environment and Climate Change Canada Ministry of Environment and Climate Change
Fisheries and Oceans Canada Change
Ministry of Agriculture, Food and Rural Affairs Ministry of Natural Resources and Forestry

Competency Area SWQ-3. Organic Nutrient Sources (Manures, Sewage Biosolids, and Other Non Agricultural Source Materials)

18. Identify the methods of liquid and solid manure application and list the advantages and disadvantages of each.

19. Identify the advantages and disadvantages of solid versus liquid manure and biosolids in the context of environmental sustainability and crop production.
20. List advantages and disadvantages of fall versus spring applied organic nutrient sources.
21. Describe agronomic benefits, risks and precautions for land application of organic nutrient sources.
22. Describe the role of organic nutrient sources in nutrient cycling of carbon, nitrogen, phosphorus, and potassium.
23. Describe factors influencing nitrogen release from decomposing organic materials and the microbial processes involved.
24. Identify the various factors that need to be considered when developing a nutrient management plan.

Competency Area SWQ-4. Soil Health Assessment

25. Explain the concept of soil health and discuss the key indicators.
26. Describe how soil organic matter affects soil health.
27. Differentiate between the different pools of soil organic matter.
28. Describe carbon sequestration within the carbon cycle.
29. Describe how the following affect soil health and crop productivity:
 - water erosion
 - wind erosion
 - tillage erosion
 - loss of organic matter
 - compaction
 - cropping choices
 - tillage

Competency Area SWQ-5. Best Management Practices for Soil and Water Conservation

30. Identify in-field best management practices for the protection of environmentally sensitive areas (e.g. wildlife habitat, riparian zones).
31. Describe the advantages and disadvantages of maintaining or enhancing wildlife habitat.
32. Identify best management practices associated with the protection of drinking water sources and water well protection.
33. Describe how Nitrogen Index (N-Index) relates to rate and timing of nitrogen applications, and how crop removal and soil type relate to the potential for nitrate leaching to groundwater.
34. Describe how the P index relates to soil test, manure and fertilizer application, and soil erodibility.
35. Describe the value of farming systems based risk assessment tools such as the Canada-Ontario Environmental Farm Plan (EFP) and the Farmland Health Check-up (FHCU).
36. Identify the potential environmental benefits of precision farming techniques such as Global Positioning Systems (GPS), Geographic Information Systems (GIS), and variable rate application.
37. Describe the benefits of cover crops for soil health and nutrient management.
38. List the benefits of windbreaks and wind strips.
39. Identify and describe practices that protect and stabilize riparian zones.

40. Identify and describe best management practices for improving soil structure and preventing soil compaction.
41. Describe and discuss best management practices for reducing water, wind and tillage erosion.
42. Identify best management practices for maintaining and improving soil organic matter.
43. Describe and evaluate best management practices for remediation of fields damaged by wind, water or tillage erosion.

Competency Area SWQ-6. Nutrient Management Act and Regulations

44. List the major components of the Ontario *Nutrient Management Act* and Regulation 267/03 as amended.
45. Describe the role of the *Nutrient Management Act* and Regulations in the management of nutrient applications for the production of crops and the protection of surface and ground water.
46. List the criteria a non-agriculture source material (NASM) must meet to be considered for land application under the *Nutrient Management Act* and Regulations.
47. Describe the responsibilities of the farmer, the applicator, the hauler, the generator, and the Ministry of Environment and Climate Change in the land application of non-agricultural source materials.
48. Identify regulatory limitations for applying non-agricultural source materials to cropland.
49. Explain the difference between agronomic balance and crop removal balance, and where each might be used.
50. Describe the following methods for mitigating the impact of runoff to surface water:
 - flow path
 - set back distances

Soil and Water Quality References

- Water Management - Best Management Practices Series. AAFC/OMAFRA 1993.
- Fish and Wildlife Habitat Management - Best Management Practices Series. AAFC/OMAFRA 1996.
- Field Crop Production - Best Management Practices Series. AAFC/OMAFRA 2012
- Manure Management - Best Management Practices Series. AAFC/OMAFRA 2005
- No-Till: Making It Work - Best Management Practices Series. AAFC/OMAFRA 1997
- Nutrient Management Planning - Best Management Practices Series. AAFC/OMAFRA 2007
- Water Wells - Best Management Practices Series. AAFC/OMAFRA 2003
- Buffer Strips. Best Management Practices Series. AAFC/OMAFRA 2004
- Managing Crop Nutrients. Best Management Practices Series. AAFC/OMAFRA 2008
- Handbook of Drainage Principles. OMAFRA Publication 73, 1997.
- Drainage Guide for Ontario. OMAFRA Publication 29. AAFC/OMAFRA 2007.
- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Factsheet:
 Maintenance of a Subsurface Drainage System - Agdex No. 553, 2013
- Ontario Ministry of Agriculture Food and Rural Affairs Website: www.omafra.gov.on.ca

Section 3: Integrated Pest Management

Competency Area IPM-1. Principles and Practices

1. List the steps of an integrated pest management program.
2. Describe the importance of each step of an integrated pest management program.
3. Describe sampling methods for monitoring pest populations.
4. Identify the scouting techniques for the following pests:

potato leafhopper	armyworm	brown marmorated stink bug
black cutworm	corn rootworm	Gibberella stalk rot
two-spotted spider mite	fusarium head blight	alfalfa weevil
soybean aphid	wireworm	soybean rust
soybean cyst nematode (SCN)	western bean cutworm	
5. Outline methods for submitting plant and pest material for diagnosis and laboratory analysis.
6. Describe how to use the following variables to calculate the economic injury level (EIL):

cost of control	effectiveness of control action
crop value	pest density/crop damage relationship
7. Describe the unique characteristics of the following: Bt corn, glandular-haired alfalfa, herbicide tolerant crops, and SCN resistant soybeans.
8. List advantages and disadvantages of non-chemical pest control.

Competency Area IPM-2. Weed Management

Important weeds in Ontario:

- | | | |
|-------------------------------|------------------------------------|--------------------|
| annual sow-thistle | fall panicum | proso millet |
| barnyard grass | field bindweed | quackgrass |
| Canada fleabane | field horsetail | Shepherd's-purse |
| Canada thistle | foxtail (green, yellow, and giant) | spreading atriplex |
| common chickweed | giant ragweed | velvetleaf |
| common milkweed | lady's-thumb | waterhemp |
| common ragweed | lamb's-quarters | wild carrot |
| crab grass (smooth and large) | Palmer amaranth | wild parsnip |
| Eastern black nightshade | perennial sow-thistle | wire-stemmed muhly |
| | pigweed (redroot and green) | yellow nut sedge |
9. Identify all important weeds in Ontario by common name at the 3 to 6 leaf growth stage.
 10. Classify all important weeds in Ontario by life cycle (annual, biennial or perennial).
 11. Describe growth habits of all important weeds in Ontario.
 12. Describe the life cycles of:

summer annuals	biennials
winter annuals	perennials
 13. Describe the following vegetative reproductive structures: rhizomes, tubers, bulbs.
 14. Identify weeds that exhibit the following structures: rhizomes, tubers, bulbs.
 15. Describe how different tillage systems (conventional, reduced till and no-till) influence the type and populations of weeds.
 16. Compare and contrast weed control strategies for winter annual, summer annual, biennial, and perennial weeds.

17. Describe the considerations for herbicide choices when using cover crops.
18. Describe crop injury symptoms of these herbicides on corn, soybeans, alfalfa and cereals:
- | | | |
|-------------|--------------|--------------------------|
| 2,4-D | fomesafen | metribuzin |
| atrazine | glyphosate | nicosulfuron/rimsulfuron |
| bentazon | imazethapyr | pendimethalin |
| bromoxynil | isoxaflutole | saflufenacil |
| dicamba | mesotrione | surfactants |
| flumioxazin | metolachlor | thifensulfuron |
19. Describe how the following may affect herbicide retention and absorption in plant leaves:
- | | | |
|------------------|----------------|-----------------|
| additives | rain-free time | type of carrier |
| leaf orientation | spray volume | weed size |
| plant canopy | | |
20. Describe how the following factors affect cuticular penetration:
- | | |
|-------------------------------|-------------------|
| herbicide solubility in water | relative humidity |
| moisture | temperature |
21. Distinguish between contact and systemic herbicides.
22. Define weed competition and describe factors that influence competition.
23. Describe the concept of the critical weed-free period.
24. Recognize how soil organic matter, soil texture, soil pH, soil moisture, and soil temperature impact degradation and efficacy of herbicides.
25. Describe how manure can influence the effectiveness of soil applied herbicides.
26. Describe how herbicide chemical properties, environmental conditions, and application method influence volatilization.

Competency Area IPM-3. Disease and Nematode Management

27. For each of the following field crop diseases:
- describe symptoms and plant parts affected
 - identify conditions that favour pathogen development
 - identify appropriate management responses
 - identify the category of the pathogen (viruses, bacteria, fungi, nematodes)

Corn	Soybeans	Winter Wheat
Anthracnose leaf blight	Brown stem rot	Bunt (dwarf, common)
Common smut	Damping off	Fusarium head blight
Common rust	Downy mildew	Leaf rust
Ear moulds (Diplodia, Fusarium, Gibberella)	Fusarium root rot	Loose smut
Eye Spot	Phomopsis seed mould	Mosaic virus
Grey leaf spot	Phytophthora root rot	Powdery mildew
Northern leaf blight	Powdery mildew	Septoria leaf blotch
Stalk rots (Anthracnose, Fusarium, Diplodia, Gibberella)	Rhizoctonia	Stagonospora glume blotch
Stewart's wilt	Sclerotinia white mould	Stem rust
	Soybean cyst (SCN)	Stripe rust
	Soybean mosaic virus	Take-all
	Stem canker	Yellow dwarf
	Sudden death syndrome	
Alfalfa		
Aphanomyces root rot	Brown root rot	

Common leaf spot
Phytophthora root rot Verticillium wilt

28. Describe the importance of crop residue management on the following diseases: corn stalk rots Northern leaf blight in corn, brown stem rot in soybeans, Fusarium head blight in winter wheat and sudden death syndrome in soybeans.
29. Distinguish between race specific resistance and partial resistance (tolerance) for phytophthora root rot in soybeans.
30. Define mycotoxin. List the mycotoxins commonly found in Ontario grain and silage, and describe how they are detected.
31. Recognize the impact of mycotoxins on crop quality and describe strategies for minimizing contamination of commodities by mycotoxins.

Competency Area IPM-4. Insect, Mite and Slug Management

Important Insects, Mites and Slugs of Ontario:

alfalfa blotch leafminer	European chafer grub	seedcorn maggot
alfalfa snout beetle	European corn borer	soybean aphid
alfalfa weevil	fall armyworm	slugs
bean leaf beetle	corn flea beetle	swede midge
cabbage seedpod weevil	June beetle grub	true armyworm
cereal leaf beetle	Mexican bean beetle	two-spotted spider mite
corn rootworm	potato leafhopper	western bean cutworm
black cutworm		wireworm

32. Identify the pest and the crop injury symptoms for important insects, mites and slugs of Ontario.
33. Identify appropriate management responses to important insects, mites and slugs of Ontario.
34. Describe how temperature, photoperiod, competition, and moisture influence insect populations.
35. Identify beneficial organisms (predators, parasitoids and pathogens) for the following insect pests:

alfalfa weevil	soybean aphid
cereal leaf beetle	true armyworm
36. List advantages and limitations for chemical control of the following insect pests:

corn rootworm	potato leaf hopper
European corn borer	soybean aphid
37. List advantages and limitations of the following cultural controls for insect, mite and slug crop pests:

harvest date	resistant cultivars	sanitation
planting date	rotation	tillage

Competency Area IPM-5. Pesticide Resistance Management

38. Define pesticide resistance and cross resistance.
39. Describe how a pest develops resistance to pesticides.
40. Identify the following plant or pest population responses:

resistance
susceptibility
tolerance
41. Describe how to minimize pesticide resistance development.
42. Identify Ontario weed species with resistance to herbicides.

Competency Area IPM-6. Pesticide Stewardship & the Environment

43. Describe best management practices for pesticide mixing, loading, application, transportation, disposal and storage.
44. Describe the proper procedures for rinsing or cleaning a field sprayer.
45. Describe components of a pesticide label.
46. Describe how to minimize adverse effects on beneficials when using pesticides.
47. Describe and distinguish between spray drift and off-target movement of pesticides. (Note for study guide: Off-Target Movement: Point source contamination from loading and cleaning. Run-off as a function of soil type and drainage. Spray drift, as defined as physical, volatile or inversion drift.)
48. Describe the significance of a temperature inversion.
49. Describe the advantages, limitations and uses of the following spray nozzle types:

air induction (A.I.)	flood jet
angled	hollow cone
flat fan	twin
50. Describe how the following factors affect spray delivery, coverage and drift:

boom height	nozzle type	spray viscosity
droplet size	orifice size	spray volume
ground speed	spray pressure	wind speed
nozzle spacing		

Integrated Pest Management References

- Guide to Weed Control. OMAFRA Publication 75, 2016.
- Weed ID Guide for Ontario Crops - <http://fieldcropnews.com/2016/09/weed-id-guide-for-ontario-crops/>
- Diseases of Field Crops in Canada. K. L. Bailey, B. D. Gossen, R. K. Gugel & R. A. A. Morrall, 2003. Canadian Phytopathological Society.
- Agronomy Guide for Field Crops. OMAFRA Publication 811, 2013.
- Field Crop Protection Guide. OMAFRA Publication 812, 2016.
- Identification Guide to the Weeds of Quebec. ISBN 2-89457-174-7. MAPAQ, 1999.
- Integrated Pest Management. Best Management Practices Series, AAFC/OMAFRA, 1996.
- Pesticide Storage, Handling and Application. Best Management Practices Series, AAFC/OMAFRA, 1998.
- Growers' Pesticide Safety Course Training Manual (available from Ontario Pesticide Education Program, Ridgetown Campus/University of Guelph), 2016.
- Ontario Ministry of Agriculture Food and Rural Affairs Website:
<http://www.omafra.gov.on.ca/english/crops/index.html>
- Entomology and Pest Management Larry P. Pedigo & Marlin E. Rice. 6th Edition, Prentice-Hall, Inc. 2009
- CropPest Ontario. http://www.omafra.gov.on.ca/english/crops/field/news/news_croppest.html
- A Grower's Handbook – Controlling Corn Insect Pests with Bt Technology. 2nd Edition, Canadian Corn Pest Coalition. 2004.
- Weed Info, www.weedinfo.ca
- A Field Guide to Broadleaf Weeds, docplayer.net/18384525-A-field-guide-to-broadleaf-weeds.html
- A Field Guide to Grassy Weeds, <http://www.cerealcentral.ca/PDFs/a-field-guide-to-broadleaf-weeds.pdf>
- NOTE:** The link is the same for both of the preceding guides; the two guides are contained in one pdf file. Grassy weeds begins on page 51.

Section 4: Crop Management

Competency Area CM-1. Crop Adaptation

1. Describe corn, soybean and winter wheat responses to frost in late spring or early fall, severe enough to kill the above ground portion of the plants.
2. Describe how Ontario Crop Heat Units differ from Growing Degree Days (GDD).
3. Use the Ontario Crop Heat Unit map to select areas in which corn, soybean and dry bean varieties are adapted.
4. Select spring cereal varieties for a given location using the test area descriptions.
5. List factors used to select hybrids or varieties of corn, soybeans, wheat, barley, canola, alfalfa, and forage grasses.
6. Describe relative maturity (days to maturity) for corn, soybeans and edible beans.
7. Use the critical fall harvest period map in OMAFRA Publication 811 to determine harvest management for alfalfa.
8. Describe soil and climatic factors responsible for successful winter survival of alfalfa, perennial forage grasses, winter canola and winter wheat.
9. Describe relative growing characteristics of perennial forage grass species:
 - jointing versus non-jointing
 - bunching versus spreading
 - seedling vigour
 - maturity
 - yield and regrowth
 - tolerance to close grazing
 - sensitivity to poor drainage, drought, and low soil pH

Competency Area CM-2. Seed Quality

10. List advantages of pedigreed seed.
11. Describe the importance of the seed standards of the federal Seeds Regulations.
12. Describe differences between seed germination and seed vigour for soybeans.

Competency Area CM-3. Crop Growth and Development Staging

13. Describe the major growth scales (for example, Zadok's) used to identify crop development stages of corn, soybeans, and cereals.
14. Describe the impact of excess water on crop growth and quality on corn, soybeans winter wheat and alfalfa.
15. Describe the growth phases when corn, soybeans and spring canola are most affected by heat and/or drought stress.
16. Describe the growth phases when corn, soybeans, cereals and edible beans are most affected by herbicide and disease stress.

Competency Area CM-4. Tillage Systems

17. Describe how the following affect the feasibility of conservation tillage systems:
soil type and texture crop species and variety
heat unit availability cropping sequence
18. Describe how soil fertility management changes when adopting conservation tillage systems.
19. Describe how pest management changes when adopting conservation tillage systems.
20. List soil textures suited to fall and spring primary tillage.
21. Describe advantages and disadvantages of fall and spring primary tillage.
22. Describe advantages and disadvantages of rotary hoeing and inter-row cultivation after planting.

Competency Area CM-5. Seeding Factors

23. List typical seeding rates, depths and row spacings for corn, soybeans, edible beans, cereals and forages.
24. Describe the effect of plant population and row spacing on sunlight interception, weed competition, diseases, lodging and yield.
25. Describe the purpose, advantages and disadvantages of seed treatments.
26. Describe appropriate inoculant materials and inoculant handling methods for soybeans and forage legumes.
27. Explain the criteria used when assessing whether to replant corn, soybeans, edible beans or winter wheat.
28. Explain the factors that would affect seeding depth selection for corn, soybeans, winter wheat, forage grasses, forage legumes, and spring cereals.
29. Discuss the factors to consider when deciding to drill or broadcast seed for forage grasses and legumes.
30. Describe how to adjust seeding rate and maturity if environmental conditions cause a planting delay or a replant.
31. List recommended seeding dates for corn, soybeans, winter wheat, barley, oats, alfalfa, and edible beans.
32. Describe the relationship between seeding date and yield potential for corn, corn silage, soybeans, winter wheat, and barley.
33. Describe impact of seed treatments on inoculants.

Competency Area CM-6. Crop Utilization and Harvesting Quality

34. List optimum development stages to harvest corn, corn silage, soybeans, winter wheat and barley.
35. List development stages for harvesting alfalfa and grass forages at optimum forage quality (crude protein, acid detergent fibre, neutral detergent fibre, and neutral detergent fibre digestibility) and at optimum dry matter yield.
36. Describe the unique characteristics and end uses of the following crop types:
 - a) Corn: waxy, high oil, low phytate, white, highly digestible starch, silage quality (high digestibility)
 - b) Soybean: yellow hilum, high protein, natto, identity preserved
 - c) Wheat: hard, soft, red, white

37. Describe the key components in an Identity Preserved Crop program.
38. Describe the strategies to maintain the integrity of identity preserved crops.

Competency Area CM-7. Cropping Systems

39. Describe the advantages and disadvantages of a monoculture versus a crop rotation system.
40. Describe the advantages and disadvantages of organic cropping systems.
41. Describe the advantages and disadvantages of direct seeding forages compared to seeding with a companion crop.
42. Describe grazing systems that optimize pasture production and livestock productivity.
43. List advantages and limitations of the following cultural practices with respect to control of weeds, pests and diseases:

crop rotation	planting date	use of tramlines
cover crops	soil fertility	variety selection
nurse crops	tillage	
44. Describe the potential problems with poor residue management.
45. Describe the advantages and disadvantages to using cover crops.

Competency Area CM-8. Safe Storage and Quality

46. List the safe moisture levels to store corn silage, haylage, wrapped bales, and cereal silage.
47. List the conditions necessary for grains to retain optimum quality in storage.
48. Describe the factors involved in evaluating grade quality of corn, soybeans, edible beans, canola, and cereals.
49. Describe the causes and the effects of silo gases.

Competency Area CM-9. Economics

50. Define maximum economic yield in terms of the law of diminishing returns.
51. Use crop budgets to estimate costs and evaluate cropping alternatives.
52. Recognize key components of Ontario Production Insurance Programs administered by Agricorp.

Competency Area CM-10. Regulatory

53. Recognize key components of Canada's *Seeds Act*.
54. Recognize key components of Canada's Plant Breeders' Rights legislation.
55. Understand the role of the Canadian Food Inspection Agency relating to crop production. Understand the steps involved in the approval of plants with novel traits (genetically engineered plants).
56. Discuss the consequences of recommending and using non-registered products (seed varieties, novel traits, fertilizers and supplements).
57. Recognize requirements of Canada's Organic Products Regulations and the related standards for the production and marketing of organic crops and related products.

Crop Management References

The Agronomy Guide for Field Crops. OMAFRA Publication 811, ~~2009~~ 2013.
Field Crop Protection Guide. OMAFRA Publication 812, 2016.
Crop Budgets. OMAFRA Publication 60, 2017.
Field Crop Production. Best Management Practices Series, AAFC/ OMAFRA, 2012.
How An Alfalfa Plant Develops. National Alfalfa Alliance, 4630 Churchill Street, #1, St. Paul, MN
55126 (651) 484-3888
No-Till: Making it Work. Best Management Practices Series, BMP11, AAFC/OMAFRA, 1997.
Pasture Production. OMAFRA Publication 19, 2015.
OMAFRA Factsheet: Crop Heat Units For Corn and Other Warm-Season Crops In Ontario - Agdex No.
111/31 Order # 93-119, 1997.
Organic Field Crop Handbook. Canadian Organic Growers, www.cog.ca 2001
How a Corn Plant Develops. Iowa State University, 1997 replaced with Corn Growth and Development,
Iowa State University, 2011.
Soybean Growth and Development. Iowa State University, 2014.
Ontario Ministry of Agriculture Food and Rural Affairs Website:
www.omafra.gov.on.ca/english/crops/index.html