

**PROCESSING VEGETABLE
ON FARM FOOD SAFETY
HANDBOOK**

**PREPARED BY THE
ONTARIO PROCESSING VEGETABLE GROWERS**

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I have again reviewed the processing vegetable On-Farm Food Safety Handbook, prepared by the Ontario Processing Vegetable Growers dated March 2009.

Food hazards in any HACCP (Hazard Analysis Critical Control Points) plan are classified as microbial, chemical and physical. Vegetables that are consumed fresh have significantly different risks than those that are processed. Vegetable processing involves a heat treatment to eliminate (canning) or significantly reduce (frozen) harmful microorganisms – and many frozen vegetable processing plants are continuously testing for *Listeria* and holding product until results are returned -- the emphasis of the OPVG on risk and hazard reduction at the grower level, particularly focused on proper pesticide use, is appropriate.

The On-Farm Food Safety Handbook continues to be useful farm management tool, providing the basis for good agricultural practices in a number of areas related to raw product supply. There have been no foodborne outbreaks involving canned or frozen product from Ontario that I am aware of, and the steps taken by OPVG growers to minimize risk are prudent.

The food safety basics remain the same, and it is incumbent on both growers and processors to undertake diligent steps to provide safe food. The OPVG food safety manual is a scientifically valid reference point but need not be distributed to all growers; those with particular questions can consult OPVG staff. The guidelines are sufficient to satisfy any reasonable auditing programs, and the requirements of the U.S. Food Safety Modernization Act.

Sincerely,



Dr. Doug Powell

Dr. Douglas Powell received a PhD in food science from the University of Guelph in 1996, and was a professor of food safety for 16 years at Guelph and subsequently Kansas State University. He currently resides in Brisbane, Australia.

BACKGROUND

In early 1998, the Ontario Processing Vegetable Growers retained Dr. Doug Powell of the University of Guelph to prepare a comprehensive risk reduction strategy for use by the growers of processing vegetables in Ontario.

Over the summer and fall of 1998, Dr. Powell visited producers and processors of a number of processing vegetable crops. A draft report was received by the board in December of 1998 and Dr. Powell presented preliminary findings at the Ontario Processing Vegetable Industry Conference in London at the end of January, 1999. At that time, the board indicated that it was intended that Dr. Powell's report would form the basis for an On Farm Food Safety Handbook which, ultimately, would be distributed to growers. A final report was issued by Dr. Powell in April of 1999.

This handbook is the working outcome of Dr. Powell's report. It is not, and is not meant to be, on-farm HACCP. True on-farm HACCP is not achievable within the production environment of vegetables for processing. However, standard operating procedures and good agricultural practices, that are consistent with a HACCP framework, are applicable to processing vegetable production. This **HACCP based** guidance focuses on the development of operating procedures that form the basis for risk and hazard reduction and is recommended to all growers of each of the crops under the jurisdiction of the Ontario Processing Vegetable Growers. With the adoption of the procedures recommended in this handbook, Ontario processors can be certain that Ontario growers are taking all reasonable steps to ensure the safety of raw product being delivered to their doors.

It is expected that the contents of this handbook will evolve over time. This second revised edition contains updates to the Ontario Processing Tomato Industry Pesticide Management Protocol and OMAFRA pesticide recommendations. It is the board's intention to continue to make every effort to maintain this handbook with current information and materials which will be forwarded to growers as they become available.

PESTICIDES

Introduction: The importance of following the pesticide label cannot be overstated. The improper use of registered products (ie. exceeding the labeled application rate) may lead to a reduction in efficiency, increased resistance and ultimately the potential loss of valuable crop protection tools. The use of unregistered products as well as the improper use of registered materials (ie. failing to observe the pre-harvest interval) is illegal.

The proper use, storage and application of agricultural chemicals is regulated and enforced by the Pest Management Regulatory Agency (PMRA) of Health Canada under the authority of the federal Pest Control Products Act. In Ontario, the Ministry of the Environment also has an enforcement role, through the provincial Pesticides Act. Lastly, the Canadian Food Inspection Agency monitors food products for pesticide residues.

Ontario Ministry of Agriculture, Food & Rural Affairs Publications 363 and 75 outline pesticide use recommendations for vegetable production. These are attached as Appendix 1. Note, however, that there may be other registered products for a particular use.

Processors may have additional restrictions regarding pesticide use, provided that these are made known, in writing, at time of contracting.

The Ontario processing tomato industry, working through the O.F.P.A. and the O.P.V.G. has developed a Pesticide Management Protocol. The Protocol, found at Appendix 1 (b), outlines the industry's policy with respect to pesticide use, general procedures and reporting responsibilities. It also sets out in detail the third party residue sampling and testing procedures to be conducted on behalf of the industry to ensure that only registered pesticides are being used and that their use is in accordance with label requirements. Lastly, this commitment to proper pesticide use is incorporated into the industry marketing agreements brought into force by the Farm Products Marketing Commission. Clause 12 of the tomato marketing agreement sets out the contractual obligations with respect to this issue.

Pesticide Application:

Pesticide applications of schedule 1, 2 or 5 pesticides may only be made by applicators certified through the Grower Pesticide Safety Course or a certified custom applicator. To become certified, a grower must attend a one day Grower Pesticide Safety Course (GPSC) and successfully complete the certification exam. To renew your certificate, a grower may attend a GPSC and pass the exam written at the course or pass an exam written at an exam only session. Most courses and exam only sessions are offered between November and April. Growers are required to renew their certification every five years.

On January 1, 2000, the Trained Assistant requirement came into effect. Trained Assistants are those individuals who handle and apply Schedule 2 or 5 pesticides under the supervision of a grower who is certified through the Grower Pesticide Safety Course. As such, at present, all agricultural workers handling and applying Schedules 2 or 5 pesticides must either be a certified agriculturist (have a Grower Pesticide Safety Course Certificate) or a Trained Assistant.

Growers who employ seasonal help to handle and apply pesticides have two options available to them to meet these requirements. Option 1 is to have assistants attend the normal one day Grower Pesticide Safety Course. For this purpose, the Ministry of the Environment recognizes course attendance as approved training. Option 2 allows for the training of assistants by a Certified Grower who has attended a train-the-trainer course. Assistants must have formal training on the safe use of pesticides every five years.

A Certified Grower may supervise up to three Trained Assistants at any given time. The supervising Certified Grower can provide supervision to a Trained Assistant in one of two ways.

- (1) Direct supervision means that the Certified Grower must be present on the farm site at all times when the assistant mixes, loads or applies Schedule 2 or 5 pesticides.
- (2) Indirect supervision means that the certified grower must meet all three of the following Ministry of the Environment requirements:
 - (i) Be available for immediate response through an effective communication system.
 - (ii) Be present within a reasonable period of time to respond to an emergency situation.

Pesticide Application: (continued)

- (iii) Provide written instructions to the Trained Assistant for the mixing, loading or applying of Schedule 5 pesticides. Written instructions must contain all the information required by the Ontario Ministry of the Environment. A sample form is enclosed at Appendix 1 (c). You may design and use a form that works for your farm, but it must contain all the information shown on the sample form.

Trained Assistants may not purchase, select or recommend the type of pesticide, select the rate of application, select the means of storage or disposal of empty containers or calibrate equipment used to apply the pesticides.

As a certified grower, you are responsible for all pesticide work done on your farm, including all pesticide work done by your Trained Assistants.

For further information, please contact the Ontario Pesticide Education Program, Ridgetown College, University of Guelph web-site at www.ridgetownc.uoguelph.ca/o pep or call at 1-800-652-8573 or 519-674-1580.

Integrated Pest Management: One of the focal points of the Grower Pesticide Safety Course is Integrated Pest Management (IPM). IPM is a decision making process that uses all necessary techniques to control pests or prevent pests from becoming problems, effectively, economically and in an environmentally sound manner.

IPM involves the use of physical (mechanical), cultural, biological, genetic and chemical practices, alone or in combinations, so that the benefits of pest control are maximized and the environmental and health risks are minimized.

IPM programs aim to:

- » provide long term solutions to pest problems
- » reduce pesticide use
- » reduce environmental and health risks
- » help control and prevent pesticide resistant pests
- » help recognize conditions that could lead to pest problems.

The five basic components of IPM are:

- » pest identification
- » monitoring
- » thresholds
- » methods of control
- » evaluations.

More information can be obtained from government publications, crop management advisors and specialists, local colleges and universities. Note that IPM is just a part of an overall integrated crop management program that incorporates all aspects of production.

Pesticide Reporting: Each marketing agreement has, as an appendix, a form to be completed by the grower that reports all pesticide applications carried out by the grower. The failure to submit this form to your contracted processor as required is a breach of contract and could result in immediate termination. Growers are not required to include on the reporting form pesticides applied by the processor or the processor's agent (ie. corn borer sprays on sweet corn.) The form found at Appendix 2 - Schedule A, sets out typical requirements. Please refer to the actual form found in the marketing agreement for the requirements particular to each crop.

Random Testing: The Tomato Marketing Agreement provides for random plant tissue and residue testing by the industry. This is over and above any testing done by individual processors on their own. If illegal residues are found and subsequently confirmed, processors will refuse to accept delivery of the affected raw product.

Expenses associated with the industry random testing program are shared equally by processors and growers. This program may be expanded to other crops in the future.

Additional Records: A well established and designed record keeping system provides the producer with the ability to prove that his vegetables for processing were produced utilizing approved products. To this end, in addition to the reporting of all pesticide usage on the applicable forms, growers are advised to retain detailed product specifications for all chemicals entering the farm, either through the label or Material Safety Data Specifications (MSDS) specification sheets.

Plants And Seed: Special mention should also be made of plants and seed. Letters of guarantee or other suitable documentation should be obtained from the supplier stating that the plants or seed have not been treated with any unregistered pesticide. The Tomato Marketing Agreement, for example, contains a clause stating that, as a condition of contract, the processor shall provide written assurance to the grower that transplants have been treated only with pesticides registered for use on greenhouse tomatoes in Canada. Retain this document for your records.

Pesticide Storage: Ontario's Pesticides Act is chiefly concerned with protecting the environment against contamination through the proper handling, transportation, storage, use, and disposal of agricultural chemicals. These principles are also crucial to protecting the health and safety of individuals who work with pesticides.

Pesticide Storage: (continued)

Following is a brief synopsis of Ontario requirements for safe storage of pest control products.

1. Pesticides must be stored in an area that is used exclusively for this purpose. There must be sufficient separation between pesticides storage and storage of other commodities to avoid the possibility of cross-contamination.
2. Pesticides and pesticide adjuvants are the only items to be stored in this building, room, or part thereof.
3. If the area to be used for pesticides storage is later to be used for other purposes, it must first be decontaminated.
4. Insecticides, herbicides and fungicides should be stored separately from each other.
5. The storage area must be screened and ventilated to the outside.
6. Warning placards must be posted on the door(s) of the storage area.
7. The storage area must be lockable to control access. One staff member should be responsible for security. No one should be able to enter the storage area without authorization.
8. There must be no floor drains, unless they flow into a separate holding area which can be pumped out. The Ontario Ministry of the Environment (MOE) can provide detailed information about disposal procedures.
9. Protective clothing must be readily available to protect handlers against adverse effects of stored pesticides. Protective gear must be stored in a manner that prevents its contamination (e.g. in an adjacent room or in polyethylene bags.)
10. Post emergency telephone numbers in a prominent place. Numbers must include the doctor, poison control centers, fire, police, Spills Action Centre, and the MOE's Pesticides Control Officer.
11. Absorbent material (i.e. sawdust, soil or rags) should be available in sufficient quantity to clean up any spills or leaks from containers.
12. Pesticide storage areas must be cool and dry to prevent product breakdown or inactivation. Check product labels for winter storage guidelines.
13. Pesticides should be stored only in their original labeled containers.
14. Any new pesticides storage structures should be placed so as to avoid contamination of watercourses in the event of a spill, explosion, or fire. Existing buildings and surrounding terrain should be modified to ensure containment of runoff.
15. Wash-up facilities with adequate supplies of soap and water must be available.
16. The MOE must be notified of any fire or spill where there is an environmental impact. Any fire, spill, or theft of pesticides must be reported to the Spills Action Centre.
17. Only trained personnel wearing adequate protective equipment should be involved in any spill clean-up.

Pesticide Storage: (continued)

In the case of a major pesticide spill, you must notify the Ministry of the Environment, Spills Action Centre at 1-800-268-6060.

For more detailed information about safe pesticide storage and handling, contact the nearest Environment Ministry office as outlined below:

ONTARIO MINISTRY OF ENVIRONMENT - REGIONAL OFFICES CONTACT INFORMATION

REGION COUNTY	ADDRESS	TELEPHONE/FAX
CENTRAL REGION: Toronto, Halton, Peel, York, Durham	5775 Yonge Street 8 th Floor North York, ON M2M 4J1 Fax: 416-325-6347	Tel: 416-326-6700 Toll Free: 1-800-810-8048
WEST-CENTRAL REGION: Haldimand, Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	119 King St. West, 12 th Floor Hamilton, ON L8P 4Y7 Fax: 905-521-7820	Tel: 905-521-7640 Toll Free: 1-800-668-4557
EASTERN REGION: Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Kawartha Lakes, Peterborough, Northumberland, Renfrew, Ottawa, Lanark, District of Nipissing (Twp of South Algonquin)	133 Dalton Avenue, P.O. Box 820 Kingston, ON K7L 4X6 Fax: 613-548-6908	Tel: 613-549-4000 Toll Free: 1-800-267-0974
SOUTHWESTERN REGION: Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Muskoka, Simcoe	753 Exeter Road London, ON N6E 1L3 Fax: 519-873-5020	Tel: 519-873-5000 Toll Free: 1-800-265-7672
NORTHERN REGION: Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Timiskaming, Sault Ste. Marie	199 Larch Street South Ste. 1101 Sudbury, ON P3E 5P9 Fax: 705-564-4180	Tel: 705-564-3237 Toll Free: 1-800-890-8516
Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane, Timmins	435 James Street South Suite 331 Thunder Bay, ON P7E 6S7 Fax: 705-475-1745	Tel: 807-475-1205 Toll Free: 1-800-875-7772
Standards Development Branch	Pesticides Section 40 St. Clair Avenue West 7 th Floor Toronto, ON M4V 1M2 Fax: 416-327-2936	Tel: 416-327-5519
Approvals Branch	Pesticides Licensing 2 St. Clair Avenue West 12A Floor Toronto, ON M4V 1L5 Fax: 416-314-8452	Tel: 416-314-8001

Pesticide Disposal: Dispose of chemicals and their packaging by following the instructions found on the label or by contacting the manufacturer or supplier.

WATER

Water is an essential element in the production of processing vegetables. For example, water is used in field irrigation, fertilizer application and crop protection sprays. Growers should identify and document the source of water used in the different operations. In this context an assessment should be made of the proximity and potential for a water source to become contaminated with chemicals, heavy metals or other pollutants. A water test should be conducted annually and the results documented. Where remedial action is required, steps taken should be documented also, as well as the results of any follow-up testing. See sample form at Appendix 2 - Schedule B. In addition, water tanks, vessels and pipes must be designed and structured so as to prevent contamination. They should be inspected on an annual basis and the results documented.

Water Testing Packages: There are a variety of water testing packages available. An example containing further information is enclosed at Appendix 3.

Environmental Farm Plan: Another means of obtaining broad based information regarding water on a grower's farm, is to complete an Environmental Farm Plan (EFP). The Environmental Farm Plan recommends an annual water test. A brochure outlining the Environmental Farm Plan is included in the inside pocket of this handbook.

Lastly, local district health units will conduct bacteria analyses for total coliform and E. coli, free of charge.

FERTILIZER

It is recommended that growers keep records of all fertilizer applications (see sample form at Appendix 2 - Schedule C) and that they obtain written assurances (letters of guarantee - see sample form at Appendix 4) from suppliers regarding their ability to produce the specified material. HACCP accredited supplier's need only supply a letter to that effect.

SOIL AMENDMENTS

Sewage Biosolids/Municipal Waste: Many processors specifically do not permit the application of sewage biosolids on land to be used to produce vegetables for processing. As such, refer to your grower contract or check with your processor if you are planning to utilize sewage biosolids. Use of sewage biosolids requires the submission of an Application for a Certificate of Approval to Spread Sewage and Other Biosolids on Agricultural Lands. The enclosed factsheet, produced by the Ontario Ministry of Agriculture, Food & Rural Affairs, found at Appendix 5, outlines some of the issues to be considered if you are contemplating the use of sewage biosolids.

For further information and the required forms, contact your local MOE office. Alternatively, information can be obtained on the Internet in the form of the documents; Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Lands at:

<http://www.ene.gov.on.ca/gp/3425e.pdf> and Guide to Applying for a Certificate of Approval to Spread Sewage and Other Biosolids on Agricultural Lands (Organic Soil Conditioning) at:

<http://www.ene.gov.on.ca/gp/3681e.pdf>.

Manure: Manure must only be used as a pre planting soil amendment. Manure should be incorporated into the soil. An OMAFRA factsheet regarding manure is found at Appendix 6.

Compost/Spent Mushroom Substrate: The benefits of compost/spent mushroom substrate, when utilized as a soil amendment, are well documented. Composted material provides crop nutrients and builds soil structure to aid in erosion control. Where utilized, soil nutrient levels should be monitored closely. For more information, the Horticultural Research Institute of Ontario, University of Guelph at Vineland Station has done work in this area. They can be reached at 905-562-4141.

Record Keeping: It is recommended that the application of any soil amendments be recorded and this information retained. See sample form at Appendix 2 - Schedule D.

Soil Testing: Soil analyses may assist growers in determining the fertilizers and soil amendments to be utilized. For information on soil testing, contact your local Ontario Ministry of Agriculture, Food & Rural Affairs extension agent or the following accredited soil testing laboratories.

ACCREDITED SOIL-TESTING LABORATORIES IN ONTARIO

The Following labs are accredited to perform soil tests for pH, P, K, Mg and Nitrate-N on Ontario Soils.

LABORATORY NAME	ADDRESS	TELEPHONE/FAX/E-MAIL	CONTACT
A & L Canada Laboratories Inc. Website: www.alcanada.com	2136 Jetstream Rd. London, ON N5V 3P5	Tel: 519-457-2575 Fax: 519-457-2664 E-Mail: aginfo@alcanada.com	Mr. Greg Patterson Mr. Ian McLachlin
Accutest Laboratories Website: www.accutestlabs.com	146 Colonnade Rd. Unit #8 Nepean, ON K2E 7Y1	Tel: 613-727-5692 Fax: 613-727-5222 E-Mail: phaulena@accutestlabs.com	Ms. Lorna Wilson Mr. Peter Haulena
Agri-Food Laboratories Website: www.agtest.com	503 Imperial Rd. Unit #1 Guelph, ON N1H 6T9	Tel: 519-837-1600 Fax: 519-837-1242 Toll Free: 1-800-265-7175 E-Mail: lab@agtest.com	Mr. Dale Cowan
Brookside Laboratories, Inc. Website: www.blinc.com/	301 South Main Street New Knoxville, Ohio 45871	Tel: 419-753-2448 Fax: 419-753-2949 E-Mail: nfisher@blinc.com	Ms. Nicole Fisher Mr. Mark Flock
Soil and Nutrient Laboratory Website: www.labservices.uoguelph.ca/units/soil-nutrient/	University of Guelph P.O. Box 3650 95 Stone Road West Guelph, ON N1H 8J7	Tel: 519-767-6226 Fax: 519-767-6240 E-Mail: nshrier@lsd.uoguelph.ca	Mr. Nick Schrier
Stratford Agri Analysis Inc. Website: www.stratfordagri.com	1131 Erie St. Box 760 Stratford, ON N5A 6W1	Tel/Fax: 519-273-4411 Toll Free: 800-323-9089 E-Mail: laboratory@daconutrition.com	Mr. Keith Lemp

There is no accreditation in Ontario for tissue analysis, but all the accredited soil-testing labs are monitored for proficiency on tissue analysis.

Source: OMAFRA Vegetable Production Recommendations, 2008-2009, Publication 363.

EQUIPMENT

Operators of mechanical harvesters should visually inspect machinery before use on a daily basis to ensure that all components are operating properly. For example, cutting blades and other mechanical components in direct contact with raw product should be examined to ensure that they are intact and do not pose a physical risk.

Field equipment can easily spread residues or physical hazards to processing vegetables and therefore, harvest personnel are advised to inspect and clean containers, brushes, buckets or other harvesting material that comes in contact with the raw product on a regular basis. Farm-specific operating procedures should document the regularity of cleaning.

Damaged and muddy totes or boxes should be repaired, cleaned (as practicable) or discarded to reduce physical contamination of raw product.

A processor may request that wagons or trailers that haul a variety of products be either cleaned between loads of different commodities or dedicated to a unique product because of allergen concerns. Both corn and soy are potential allergens.

Where applicable, ensure that trucks, trailers or containers used to ship processing vegetables do not have physical hazards that could contaminate the product, through a visual inspection recorded and documented, before each load. See sample form at Appendix 2 - Schedule E.

PREMISES

Premises include all elements on the farm and its surroundings: the outside property, roadways, drainage, building design and construction, product flow and sanitary facilities.

Outside Property: Premises should not be in close proximity to any source of pollution.

Structural Components of Establishments (Buildings): Buildings and other facilities in immediate proximity with processing vegetables must be of sound construction, maintained in good repair and must not present any chemical or physical hazards to the product, such as paint chips or physical fragments. An annual visual inspection should be conducted at the beginning of the harvest and documented.

Design and Construction: Producers that store product on-farm must have facilities designed with appropriate ventilation facilities and controlled so as to avoid major variations in storage temperature. Temperature variations and inadequate air circulation may result in condensation on ceilings and walls enhancing mould growth.

If frequent wet cleaning is required, floors should slope toward drains and gutters, so that excess water can be easily removed. Gutters should also have rounded walls to minimize accumulation of dirt and mud.

Doors must be tight fitting to exclude rodents, insects and dust.

PERSONNEL

Written procedures should be in place so that employees can be trained in the safe operation of the equipment with which they work. All employees should understand what initial actions to take should an accident occur. Employees at on-farm sorting facilities should be aware of the potential for physical contamination and instructed in basic hygiene, if necessary.

A WORD ABOUT THE ENVIRONMENTAL FARM PLAN

Many of the practices recommended in this handbook can be addressed by completing the Environmental Farm Plan Process. The Environmental Farm Plan originated in 1993.

Environmental Farm Plans are documents voluntarily proposed by farmers to raise their awareness of the environment on their farm. Through the Environmental Farm Plan process, farmers highlight the environmental strengths on their farm, identify areas of environmental concern and set goals to improve environmental conditions. Workshops are organized and delivered locally by the Ontario Soil and Crop Improvement Association. Technical direction is provided by the Ontario Ministry of Agriculture, Food & Rural Affairs. For specific dates and locations in your area, contact the Ontario Soil and Crop Improvement Association toll free at 1-800-265-9751 or visit their website at www.ontariosoilcrop.org or call your nearest Ontario Ministry of Agriculture, Food & Rural Affairs office.

SUMMARY

Document results/general records applicable to your operation:

Pesticides:

- Grower Pesticide Safety Course Certificate
 - » Trained Assistant - Indirect Supervision: Written Instructions for the Proper Application of Pesticide Products.
 - » Licensed Custom Operator
- Pesticide Reporting Form Completed
- Pesticide Labels Retained
- Letters of Guarantee
 - » Pesticides
 - » Plants/Seed
- List of all Chemicals Entering Farm - MSDS Sheets Retained
- Pesticide Storage - Who Responsible

Water:

- Annual Water Test Conducted
- Water Tanks, Vessels, Pipelines Inspected - Results Documented

Fertilizers and Soil Amendments:

- Application
- Letters of Guarantee
- Approvals Obtained (where necessary)

Equipment:

- Visual Inspection - Results Documented

Premises:

- Visual Inspection - Results Documented

Personnel:

- Accident/Emergency Training

Environmental Farm Plan



PROCESSING VEGETABLE ON FARM FOOD SAFETY HANDBOOK APPENDICES

1. (A) OMAFRA Guidelines, Publication 363 - Vegetable Production Recommendations
Publication 76 - Guide to Weed Control
 - » Carrots
 - » Cucumbers/Pumpkin/Squash
 - » Green & Wax/Lima Beans
 - » Green Peas
 - » Peppers
 - » Sweet Corn
 - » Tomatoes
 - (B) Processing Tomato Industry Pesticide Management Protocol
 - (C) Instructions for the Proper Application of Pesticide Products
2. Sample Form -
 - Schedule A - Pesticide Reporting Form
 - Schedule B - Water Test
 - Schedule C - Fertilizer Application
 - Schedule D - Soil Amendments
 - Schedule E - Harvest and Transportation Equipment
 3. Water Testing Programs
 4. Sample Form - Letter of Guarantee
 5. Land Application of Sewage Biosolids for Crop Production - Ontario Ministry of Agriculture, Food & Rural Affairs Factsheet.
 6. Manure Characteristics - Ontario Ministry of Agriculture, Food & Rural Affairs Factsheet.



Section 1

Section A

CARROTS

CARROTS

Production Requirements

Carrots are a cool-season vegetable. They grow best in deep, well-drained muck and sandy loam soils. The desired pH is 5.5 in muck soils and 6.5 in sandy loam soils. Carrots are extremely sensitive to environmental conditions such as heat, soil compaction, drought stress and saturation. Continuous high temperatures in the latter stages of plant development may reduce yield, retard growth and produce a strong-flavoured, coarse root. Temperatures below 16°C (61°F) also slow plant growth.

Carrots are planted mid-April to late-June. Most carrot varieties mature in 120–180 days. Fresh-market carrots are harvested late-July through October. Processing carrots are harvested October through November.

Average Yields

Crop	per acre	per hectare
Processing	35–40 tons	78–90 tonnes
Fresh market	15–20 tons	34–45 tonnes

Cultivars

Growers and processors are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix D, *Vegetable Seed Suppliers*, on page 229.

Seeding and Spacing

The minimum soil temperature for seed germination is 4°C (40°F). Sow as early as soil and weather conditions permit in the spring, up to July 1. Late carrots may “burn off” if they emerge during hot, dry weather. Seed into moisture, 1.2–2 cm (0.5–0.8 in.) deep.

Carrot quality may be improved by using raised beds, 15–20 cm (6–8 in.) high. Beds that are 85 cm (34 in.) wide at the bottom and 50 cm (20 in.) wide on top have yielded good results. Seed carrots in 3 or 4 rows on the centre of the bed at a rate to achieve 26 carrots/m (8 carrots/ft) for processing carrots and 120–140 carrots/m (36–43 carrots/ft.) for fresh-market carrots.

Seeding Rates

	Metric	Imperial
Fresh market:	2–4.5 kg/ha	0.8–1.8 lb/acre
Processing:	1–2 kg/ha	0.4–0.8 lb/acre

Table 9–21.
Carrot Nitrogen Recommendations

Soil	Actual N	
	kg/ha	lb/acre
Mineral Soils		
Preplant	70	62
Side-dress	40	36
Total	110	98

Muck Soils

Ontario research has shown that carrots grown on established muck soils receive adequate nitrogen from the soil, and there is no yield response to added nitrogen.

Fertility Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 1–8, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 9, Table 1–9, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 10, and Table 9–21, *Carrot Nitrogen Recommendations*, above.

Broadcast and incorporate the recommended preplant nitrogen with all the required phosphate and potash. On mineral soils, apply side-dress nitrogen when the plants are 10 cm (4 in.) tall.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 61 mg P per L soil (ppm) or higher, carrots grown on both mineral and muck soils are unlikely to respond to additional phosphate applications. For soils testing lower than 61 mg P per L soil (ppm), see Table 1–10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12, or Table 1–11, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 13.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 181 mg K per L soil (ppm) or higher, carrots grown on both mineral and muck soils are unlikely to respond to additional potash applications. For soils testing lower than 181 mg K per L soil (ppm), see Table 1–11, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 13, or Table 1–12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

Table 9-22.
Carrot Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts per Million (ppm)			
Most recently mature leaf	60 days after seeding	1.8-2.5	0.2-0.4	2-4	2-3.5	0.2-0.5	-	30-60	30-60	20-60	20-40	4-10
	Harvest	1.5-2.5	0.18-0.4	1.4-4	1-1.5	0.4-0.5	-	20-30	30-60	20-60	20-40	4-10

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*. 5th Edition. John Wiley & Sons, Inc. New York.

Magnesium

Magnesium deficiency may occur on carrots. The usual symptoms are yellowing of older leaves while the veins remain dark green. See the section *Magnesium* and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

Micronutrients

Crops vary greatly in their response to micronutrient fertilizers. For complete information, see the section *Micronutrients*, on page 17.

BORON

Boron deficiency in carrots can cause the growing point to die off or cause internal breakdown of the roots. Boron is often recommended on newly cultivated muck soils. Use caution when applying boron. This nutrient can build to toxic levels quite quickly, harming rotational crops.

Various sources of boron are available. See the section *Boron*, on page 18, and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

COPPER

Copper (Cu) deficiency may occur on acid peat and muck soils resulting in carrot roots with poor orange colour. Apply 14-29 kg Cu/ha (12.5-26 lb/acre) on newly cultivated muck soils. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. See the section *Copper*, on page 18, and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis can be useful for diagnosing crop problems or for evaluating a fertilizer program. The objective of a good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the range. Attempting to bring the nutrient analysis up to the higher end of the range could possibly result in over-fertilization and may not be economical.

See Table 9-22, *Carrot Nutrient Sufficiency Ranges*, above. Only use sufficiency ranges as a reference and a guideline. Plant analysis does not replace soil testing, or a sound soil fertility program.

For more information, see the section *Plant Analysis*, on page 3.

Integrated Pest Management

OMAFRA Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, provides a comprehensive guide to IPM for carrots.

Diseases

DAMPING-OFF AND ROOT ROTTS

For identification and management information on these common vegetable diseases, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59. Also see Table 9-23, *Carrot Seed Treatments*, below.

Table 9-23.
Carrot Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL LS	metalaxyl-M	20-40 mL per 100 kg seed	damping-off	For use in commercial seed-treatment plants only. Export use only.
Rovral	iprodione	521 mL per 100 kg seed	seed-borne <i>Alternaria</i>	For imported seed only.

LEAF BLIGHTS

Identification: Two different fungi (*Alternaria dauci* and *Cercospora carotae*) and one type of bacteria (*Xanthomonas campestris*) cause leaf blights in carrots. *Alternaria* produces irregular brown spots (often surrounded by yellowish halos), mainly along the edges of carrot leaves.

Cercospora causes circular grey or brown lesions on both leaves and petioles. Dark-brown lesions with an irregular yellow halo characterize *Xanthomonas*.

Development: Both *Alternaria* and *Cercospora* fungi overwinter in the crop residue of infected carrots. Their spores are dispersed by wind. All three diseases are favoured by warm, humid conditions in the 20°C–30°C (68°F–86°F) range. Symptoms usually appear 10 days after infection.

Thresholds: Apply protectant fungicides when blight is first detected (on 1%–2% of the leaf area.)

Management Notes: After the initial fungicide application, a recommended fungicide should be applied at 7–10-day intervals. Extend the intervals between sprays when the weather is unfavourable for blight. After the leaves have closed over the rows, spray at 7–10-day intervals.

See Table 9–24, *Carrot Disease Control Recommendations*, on page 97.

**PYTHIUM
(ROOT DIEBACK, RUSTY ROOT, CAVITY SPOT)**

Identification: A variety of symptoms may result from *Pythium* infections, including leaf wilting and discoloration, deformed roots (short, stuffy, forked), rusty red roots and the formation of fibrous roots. Dark, oval lesions on the surface of the carrot root characterize cavity spot.

Development: *Pythium* is a persistent, soil-borne fungus that likes wet soils. Cavity spot lesions usually start to appear in August and September and may slowly enlarge while carrots are in storage.

Thresholds: None established.

Management Notes: Grow resistant cultivars, avoid problem fields and grow carrots on raised beds. See Table 9–24, *Carrot Disease Control Recommendations*, on page 97.

CROWN ROT, VIOLET ROOT ROT

Identification: Foliar symptoms of crown rot and violet root rot tend to appear in patches across the field. Plants become stunted and yellow, followed by wilting and

death of the foliage. Root symptoms do not show up until the carrot is mature. Crown rot produces large, grey-brown lesions near the top of the carrot root. Violet root rot covers the root with a thick, purplish fungal layer. When the carrots are pulled, a considerable amount of soil adheres to them.

Development: Appears during mid-summer.

Management Notes: The only practical control is to avoid previously infected areas, rotate for several years with grains and practice strict sanitation procedures to avoid spreading infected soil between fields.

SCLEROTINIA WHITE ROT

Identification: Sclerotinia white rot is typically a disease of stored carrots. The disease comes from the field and may infect plants before harvest. Infection in the field starts at the base of the leaf stalk, causing the petiole to turn brown and die. In storage, infected roots develop a growth of white, cottony fungi and small black sclerotia. The fungus can quickly spread through healthy carrots while in storage.

Development: Optimum temperatures for infection are 15°C–20°C (59°F–68°F). However, sclerotinia white rot can still spread in storage as long as the temperatures are above 0°C (32°F). Development of the disease in the field occurs under cool, wet conditions. Sclerotinia overwinters in crop residue as hard, black sclerotia, which can survive in the soil for many years.

Management Notes: Rotate with onions, beets, spinach or grain crops for 2–3 years. Use wider row spacings to encourage good air movement. Initial infection of storage carrots is less likely to occur if the relative humidity is less than 92% and the field heat is removed as quickly as possible.

ASTER YELLOWS

The symptoms of aster yellows on carrots first appear as a reddening of several leaves. Crown growth becomes yellow and brittle, followed by hairy root development. Aster yellows is transmitted by the aster leafhopper. See the section *Aster Leafhopper*, on page 97.

For more information, see the following OMAFRA Factsheets:

- *Identification and Management of Carrot Root Diseases*, Order No. 98-001
- *Management of Carrot Leaf Diseases*, Order No. 00-045

Table 9-24.
Carrot Disease Control Recommendations

CARROTS

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
LEAF BLIGHT						
chloronitrile (group M5)	chlorothalonil	Bravo 500	2.4–3.2 L	1.0–1.3 L	1	
dithiocarbamate (group M3)	mancozeb	Manzate ProStick	2.25 kg	0.9 kg	7	Do not feed treated tops to livestock.
		Dithane DG	2.25 kg	0.9 kg	7	
		Penncozeb 80 WP	2.25 kg	0.9 kg	7	
	zineb	Zineb 80 W	1.1–3.3 kg	0.44–1.32 kg	7	
	metiram	Polyram DF	2.25 kg	0.9 kg	7	Do not feed treated tops to livestock.
carboxamide + QoI (group 7 + 11)	boscalid + pyraclostrobin	Pristine WG	580–735 g	232–294 g	0	Maximum 6 applications/yr. Do not make sequential applications. Use high rate under heavy disease pressure. 3-day re-entry interval for thinning or hand harvest.
QoI (group 11)	pyraclostrobin	Cabrio EG	0.56–1.1 kg	0.22–0.44 kg	3	Alternaria leaf blight Maximum 2 sequential applications. Maximum 3 applications. 72-hour re-entry (hand-thinning).
			560–840 g	0.22–0.33 kg	3	Cercospora leaf blight Maximum 2 sequential applications. Maximum 3 applications. 72-hour re-entry (hand-thinning).
carboxamide (group 7)	boscalid	Lance WDG	315 g	126 g	0	Alternaria leaf blight Maximum 2 sequential applications. Maximum 5 applications/yr. 4-hr re-entry.
phenylpyrroles + anilino-pyrimidines (group 12 + 9)	cyprodonil + fludioxonil	Switch 62.5 WG	775–975 g in a minimum of 200 L water	310–390 g in a minimum of 20 gal water	7	Alternaria leaf blight. Maximum 3 applications/yr. Maximum 2 sequential applications. Use high rate under high disease pressure.
CAVITY SPOT						
phenylamides (group 4)	metalaxyl	Ridomil Gold 1G	25 kg	10 kg		215 g/100 m of raised bed. Apply product evenly with seed in the furrow.
CROWN ROT/VIOLET ROOT ROT						
QoI (group 11)	azoxystrobin	Quadris Flowable	4–6 ml/100-m row in 50–100 L water	4–6 ml/328-ft row in 4.5–9 gal water	40	Apply in-furrow at seeding or in one banded application over the row after emergence.

¹ PHI = Pre-Harvest Interval.

Insects

CUTWORMS, WIREWORMS

For identification and management information on these common vegetable insects affecting carrots, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, and Table 9-25, *Carrot Insect Control Recommendations*, on page 98.

ASTER LEAFHOPPER

Identification: These small, greenish-grey insects with 6 spots arranged in pairs on top of its head, feed on a

wide range of plants, especially grasses, grains and vegetables.

Period of Activity: As the winter grains mature in late May and early June, local first-generation leafhoppers disperse to vegetable crops. Migration of leafhoppers from the U.S. into Ontario may also take place. Migrations into Ontario are not consistent from year to year, because leafhopper movements are regulated by wind and weather patterns. Both local dispersal and long-distance migration influence the incidence and severity of the aster leafhopper.

Table 9-25.
Carrot Insect Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
ASTER LEAFHOPPER						
carbamate (group 1A)	carbaryl	Sevin XLR	1.25–2.5 L	0.5–1.0 L	1	Use low rate on young plants.
CARROT WEEVIL						
organophosphate (group 1B)	phosmet	Imidan 50 WP	2.25 kg	0.9 kg	40	Maximum 2 applications/yr.
CARROT RUST FLY						
pyrethroid (group 4)	cypermethrin	Ripcord 400 EC	175 mL in 550 L water	70 mL in 55 gal water	35	Maximum 3 applications/yr.
organophosphate (group 1B)	diazinon	Diazinon 50 W	1.1 kg	0.44 kg	10	
CUTWORMS²						
pyrethroid (group 4)	permethrin	Pounce 384 EC	180–390 mL	72–156 mL		Use high rate on muck soils, large larvae or dry soils. Do not disturb soil for 5 days after application.
	cypermethrin	Ripcord 400 EC	175 mL	70 mL	21	Do not disturb soil for 5 days after application.
organophosphate (group 1B)	chlorpyrifos	Lorsban 4E	2.4–4.8 L	0.96–1.9 L	60	24-hr re-entry. Use high rate on large larvae or dry soils.
		Pyrinex 480 EC	2.4–4.8 L in 200–400 L water	0.96–1.9 L in 18–26 gal water	60	24-hr re-entry. 2 applications/yr. Use high rate on large larvae or dry soils.

¹ PHI = Pre-Harvest Interval.

² Seedling treatments.

Thresholds: An Aster Yellows Index (AYI) determines the need to treat a crop. To use the AYI, monitor aster leafhoppers with a sweep net. Multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leafhoppers carrying aster yellows in your area (4%–5% is the currently recommended percent infectivity in Ontario). Use this formula:

$$\begin{array}{l} \text{Infectivity rate} \\ (4\%–5\%) \end{array} \times \begin{array}{l} \text{\# of leafhoppers} \\ \text{(per 100 sweeps)} \end{array} = \text{AYI}$$

AYI thresholds in carrots vary depending on varietal tolerance.

Carrot Tolerance ¹	Aster Yellows Index
Resistant	100
Intermediate	70
Susceptible	50

¹ If a carrot variety has not been evaluated for aster yellows tolerance, use an AYI threshold of 70.

Management Notes: Grow resistant cultivars and remove perennial weeds from fields that may act as reservoirs. See Table 9-25, *Carrot Insect Control Recommendations*, above.

CARROT RUST FLY

Identification: The adult rust fly is shiny and black, measuring approximately 6 mm (1/4 in.) in length. It has an orange head, brown eyes and pale, yellow legs. The larva is cream-white and legless with dark mouthhooks. Larvae feed on the root hairs for up to a month before tunnelling into the carrot, where they continue feeding. Feeding damage from rust fly larvae is usually limited to the lower two-thirds of the root.

Period of Activity: The carrot rust fly overwinters as a pupa in the soil and usually has two generations per year. The first generation often coincides with lilac bloom, the second begins in mid-August. Occasionally, sufficient heat units are accumulated so that a third generation emerges in late September or October. This third generation occurs too late in the season to have any serious effect on the crop.

Thresholds: Control adults if populations reach a level of 0.1 flies/trap/day (fresh market) or 0.2 flies/trap/day (processing). Rust flies are no longer a concern once the crop is within 21 days of harvest. A Growing Degree Day (GDD) model has been developed for carrot rust flies. Using a base of 3°C, first generation adults are expected between 329 and 395 GDD. Second generation adults are expected between 1399 and 1711 GDD. For more information, see the section *Growing Degree Days*, on page 32.

Management Notes: Crop rotation will reduce background populations of the carrot rust fly. Consider late seeding to avoid first-generation damage. Avoid growing carrots in sheltered areas where rust flies are more prevalent.

See Table 9–25, *Carrot Insect Control Recommendations*, on page 98.

CARROT WEEVIL

Identification: The carrot weevil adult is a dark-brown snout beetle (6 mm (1/4 in.) long). It overwinters in the plant debris of previously infested fields. Feeding damage commonly occurs in the upper third of the root. Developing larvae tunnel into young, slender roots, causing the plants to wilt and die.

Period of Activity: Adult females are not attracted to carrots prior to the first true leaf stage. Egg-laying occurs from mid-May to early June. Eggs hatch in 1–2 weeks, and larvae feed on the roots for at least 3 weeks after emergence. Adults will emerge 2 weeks later. A second generation may occur on early carrot crops under warm weather conditions.

Thresholds: A Growing Degree Day (GDD) model for egg-laying has been developed. Using a base of 7°C, first egg-laying is expected at 147 GDD, which occurs from

mid-May to early June. Expect 90% egg-laying at 455 GDD. For more information on GDD models, see the section *Growing Degree Days*, on page 32.

Management Notes: Time treatments to target adults prior to egg-laying. Crop rotation and weed control around field edges may reduce overwintering populations. The egg parasite *Anaphes sordidatus* (a small braconid wasp) provides some biological control. See Table 9–25, *Carrot Insect Control Recommendations*, on page 98.

For more information, consult the following OMAFRA Factsheets and publication:

- *Carrot Insects*, Order No. 93-077
- *The Aster Leafhopper and Aster Yellows*, Order No. 98-057
- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*

Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 63.

Storage

Mature topped carrots can be stored for up to 4–5 months at 0°C (32°F) and a relative humidity of 90%–98%. Rapid cooling of carrots after harvest is very important for reducing storage rots.

Proper sanitation of the storage and handling equipment will also help reduce storage losses. See the section *Storage Sanitation*, on page 50.

See the OMAFRA Factsheet, *Long-Term Storage of Carrots*, Order No. 98-073.

TRADE NAME (Concentration) active ingredient **CARROTS**

PRODUCT RATE PER HA active rate per ha

PRODUCT RATE PER ACRE

PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

PREPLANT INCORPORATED (PPI) – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Pay special attention to machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE (PRE) – Rainfall at 15–20 mm within 7–10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Carrots – Preplant Incorporated Followed by Postemergence

TREFLAN EC (480 g/L)	1.25 to 2.4 L/ha	0.5 to 0.96 L/ac	<ul style="list-style-type: none"> PPI followed by POST.
or RIVAL EC (500 g/L)	1.2 to 2.2 L/ha	0.48 to 0.94 L/ac	<ul style="list-style-type: none"> Use on mineral soils.
or BONANZA 400 (400 g/L)	1.5 to 2.75 L/ha	0.6 to 1.1 L/ac	<ul style="list-style-type: none"> Spray linuron when crop has 2 or more fully developed leaves (8–15 cm tall).
followed by LOROX DF (50 DF)	1.1 to 3.25 kg/ha	0.44 to 1.3 kg/ac	<ul style="list-style-type: none"> Apply POST before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high.
or by LOROX L (480 g/L)	1.3 to 2.5 L/ha	0.52 to 1.6 L/ac	<ul style="list-style-type: none"> Carrot leaves will become yellow or light green, but they soon recover.
trifluralin	0.6 to 1.1 kg/ha		<ul style="list-style-type: none"> Use nozzle pressure of 175–275 kPa. Do NOT exceed 275 kPa.
followed by linuron	0.55 to 1.625 kg/ha		<ul style="list-style-type: none"> Do NOT apply linuron with herbicidal oil.
or by linuron	0.624 to 1.2 kg/ha		<ul style="list-style-type: none"> Do NOT apply linuron during hot, dry weather (>32°C) or when crop is under stress. Do NOT apply linuron if heavy rains are expected. Use the lower rates on sandy soils and for smaller weeds. Do NOT use on coarse-textured soils low in organic matter.

Carrots – Preemergence Followed by Postemergence

GESAGARD 480 SC (480 g/L)	3.75 to 7.08 L/ha	1.5 to 2.83 L/ac	<ul style="list-style-type: none"> PRE followed by POST – Use on muck soils ONLY.
followed by LOROX DF (50 DF)	1.1 to 3.25 kg/ha	0.44 to 1.3 kg/ac	<ul style="list-style-type: none"> For POST – Spray when crop has 2 or more fully developed leaves (8–15 cm tall).
prometryne	1.8 to 3.4 kg/ha		<ul style="list-style-type: none"> Apply before annual grasses are 5 cm high and broadleaf weeds are 15 cm high.
followed by linuron	0.55 to 1.625 kg/ha		<ul style="list-style-type: none"> Carrot leaves will become yellow or light green, but they will soon regain their normal colour. Do NOT apply during hot, dry weather (>32°C) or when crop is under stress. Do NOT apply if heavy rains are expected. Use the lower rates for smaller weeds.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
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LOROX DF (50 DF)	1.1 to 2.25 kg/ha	0.44 to 0.9 kg/ac 0.9 to 1.8 kg/ac	<ul style="list-style-type: none"> • PRE followed by POST. • Do NOT apply the 2nd treatment closer than 2 weeks after the first treatment. • Do NOT apply more than 2 applications per season. • Do NOT apply when crop has 2 or more fully developed leaves (8–15 cm tall). • Spray POST when crop has 2 or more fully developed leaves (8–15 cm tall). • Apply POST before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high. • Carrot leaves will become yellow or light green, but they soon recover. • Use nozzle pressure of 175–275 kPa. Do NOT exceed 275 kPa. • Do NOT apply with herbicidal oil. • Do NOT apply during hot, dry weather (>32°C) or when crop is under stress. • Do NOT apply if heavy rains are expected. • Use the lower rates on sandy soils and for smaller weeds. • Do NOT use on coarse-textured soils low in organic matter.
LOROX DF (50 DF) followed by LOROX DF (50 DF) or LOROX L (480 g/L)	2.25 to 4.5 kg/ha 1.1 to 2.25 L/ha	0.44 to 0.9 L/ac 0.9 to 1.8 L/ac	
LOROX L (480 g/L)	2.25 to 4.5 L/ha		
linuron	0.55 to 1.125 kg/ha		
followed by linuron	1.125 to 2.25 kg/ha		

Carrots – Soil Applied Broadleaf Herbicides			
GESAGARD 480 SC (480 g/L)	3.75 to 7.08 L/ha	1.5 to 2.83 L/ac	<ul style="list-style-type: none"> • PRE – apply soon after seeding. • Apply in 200–1000 L/ha (80–400 L/ac) water. • Use the lower rate on sandy soils and the higher rate on muck soils. • Do NOT use at or near time of emergence. • Do NOT use for POST use.
prometryne	1.8 to 3.4 kg/ha		

LOROX DF (50 DF)	1.1 to 3.25 kg/ha	0.44 to 1.3 kg/ac	<ul style="list-style-type: none"> • PRE – Apply as a band or broadcast spray after planting but before carrots emerge. • Apply in 200–350 L/ha (80–140 L/ac) water. • Use the lower rate on sandy soils. • Carrots are very sensitive to this treatment at the time of emergence and severe injury can occur at this time if there is a heavy rain or if the area is irrigated.
linuron	0.55 to 1.625 kg/ha		

Carrots – Soil Applied Grass and Broadleaf Herbicides			
TREFLAN EC (480 g/L) or RIVAL EC (500 g/L) or BONANZA 400 (400 g/L)	1.25 to 2.4 L/ha 1.2 to 2.2 L/ha 1.5 to 2.75 L/ha	0.5 to 0.96 L/ac 0.48 to 0.94 L/ac 0.6 to 1.1 L/ac	<ul style="list-style-type: none"> • PPI.
trifluralin	0.6 to 1.1 kg/ha		

Carrots – Postemergence Grass Herbicides

POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

EXCEL SUPER (80.5 g/L)	0.67 L/ha	0.27 L/ac	<ul style="list-style-type: none"> • Apply when majority of annual grasses are in the 1–6 leaf stage or until volunteer corn is up to 25 cm tall. • Grasses emerging after application will not be controlled. • Do NOT apply if rain is expected within one hour after application.
fenoxprop-p-ethyl	0.054 kg/ha		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> Apply to actively growing grasses. For annual grass, use 0.32 L/ha. Apply at the 1-6 leaf stage (2-5 is optimum). For volunteer grains, use 0.47 L/ha. Apply at the 1-6 leaf stage (2-5 is optimum). For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. Use 100-200 L water/ha (40-80 L water/ac). Grasses emerging after application will not be controlled. Spray tips angled forward 45° will give better coverage. Do NOT use flood jet or hollow cone nozzles. Do NOT apply if rain is expected within one hour after application. Preharvest interval is 49 days.
sethoxydim plus surfactant/solvent	0.15 to 0.5 kg/ha 1 to 2 L/ha		
VENTURE L (125 g/L)	0.6 to 2 L/ha	0.24 to 0.8 L/ac	<ul style="list-style-type: none"> Apply when crop is 10 cm in height or less. Apply POST to actively growing grasses before tillering. Apply at 0.6 L/ha (0.24 L/ac) at 2-5 leaf stage of volunteer corn. Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of volunteer wheat and barley. Apply at 1 L/ha (0.4 L/ac) at 2-5 leaf stage of annual grasses (2-4 leaf for foxtails). Apply at 2 L/ha (0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizomes improves control. Do NOT cultivate between rows until 5 days after application. Apply other postemergence herbicides separately at least 3 days after VENTURE L.
fluzifop-p-butyl	0.075 to 0.25 kg/ha		
Carrots - Postemergence Broadleaf Herbicides			
AIM EC (240 g/L)			<ul style="list-style-type: none"> Hooded Application ONLY, refer to Chapter 6, page 80 for precautions and rates. Do NOT apply closer than 1 day to harvest.
Carrots - Postemergence Grass and Broadleaf Herbicides			
LOROX DF (50 DF)	2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	<ul style="list-style-type: none"> For carrots not treated with linuron PRE. Spray when crop has 2 or more fully developed leaves (8-15 cm tall). Apply before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high. Carrot leaves will become yellow or light green, but they will soon regain their normal colour. Use nozzle pressure of 175-275 kPa. Do NOT exceed 275 kPa. Do NOT apply with herbicidal oil. Do NOT apply during hot, dry weather (>32°C) or when crop is under stress.
linuron	1.125 to 2.25 kg/ha		<ul style="list-style-type: none"> Apply as soon as true leaves develop and before carrot roots are thicker than a pencil. Later treatments may produce an oil flavour. Weeds should be less than 10 cm high. Ragweed, wormwood, and wild carrot are not controlled.
mineral oil (herbicidal) overall spray rows only undiluted	600 to 800 L/ha 300 to 400 L/ha	240 to 320 L/ac 120 to 160 L/ac	



CUCUMBERS/ PUMPKINS/SQUASH

CUCURBITS

CUCUMBER, MUSKMELON, WATERMELON, PUMPKIN, SQUASH (ALSO KNOWN AS VINE CROPS)

Production Requirements

Cucurbits are warm-season vegetables. They do not tolerate frost. Temperatures below 10°C (50°F) may impact crop growth and negatively affect fruit quality. The vine crops require well-drained, compaction-free locations with ample fertility. The optimum soil pH is 6.1 to 6.5.

Average Time From Flower Set to Harvest

Cucumber (pickling)	4–5 days
Cucumber (slicing)	15–18 days
Muskmelon	40 days
Pumpkin	60–70 days
Summer squash	3–8 days
Winter squash	60–70 days
Watermelon	40 days

Average Yields

Crop	per acre	per hectare
Cucumbers (processing – machine harvest)	4 tons	9 tonnes
Cucumbers (processing – hand harvest)	8–12 tons	18–27 tonnes
Cucumbers (slicing)	200–400 bu	500–1,000 bu
Fresh-market dills	160–400 bu	400–1,000 bu
Muskmelons	25 bins	60 bins
Pumpkins	50 bins	125 bins
Squash (winter)	15–20 bins	40–50 bins
Watermelon	15–25 ton	34–56 tonnes
Zucchini	700 ½-bushel boxes	1,600 ½-bushel boxes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix D, *Vegetable Seed Suppliers*, on page 229.

Processing cucumber hybrids have a predominately female (gynoecious) flowering habit. However, not all gynoecious hybrids produce 100% female flowers. Ontario day-lengths and temperatures may be responsible for the presence of male flowers on these hybrids. All gynoecious hybrid seed contains 10%–15% standard (monoecious) cultivar, added as a pollinator. For satisfactory fruit set, 10%–20% of the plants should contain a large number of male flowers.

In other vine crops, the normal ratio of male to female flowers is often 10 male:1 female. This ratio can occasionally reach 100:1 without a significant impact on yield.

Seeding and Spacing

Total cucurbit yields tend to increase with plant density. Processing cucumbers for machine harvest benefit the most from close spacings. In other vine crops, high plant populations may result in harvest problems due to excessive vine growth. An overly dense canopy is also more conducive to disease pressure.

In pumpkins and squash, fruit size tends to decrease as plant density increases. Larger-sized pumpkin and winter squash varieties will benefit from wider spacing. However, extremely wide rows are slow to close canopy, resulting in higher levels of weed pressure.

Plant seeds into moisture, no more than 2–2.5 cm (1 in.) deep. Deeply planted seed is often slow to emerge, resulting in lower plant populations. Quick, uniform emergence is essential to avoid uneven stands weakened by insects and disease. Delay planting until the soil temperature is 15°C (59°F) or higher. The optimum soil temperature range at planting is 25°C–30°C (77°F–86°F).

Pickling cucumbers are usually field-seeded from late May to early June for the hand-pick crop. Seeding for mechanical harvesting can be done until mid-July, depending on the buyer's specifications.

Pumpkins and squash for the Hallowe'en market are usually seeded from late May to mid-June. Plant melon transplants after the risk of spring frost has passed (see Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario (1961–90)*, on page 31).

See Table 9–32, *Cucurbit Crop Spacing*, on page 107.

For information on producing vine crop transplants, see the section *Transplanting*, on page 39.

Seedless Watermelon Production

Triploid watermelons will not set fruit unless pollinated by a normal (diploid) watermelon variety. Use one pollinator plant for every 2 seedless ones. For the best results, mix the pollinator varieties in the same row as the triploids. Plant a pollinator with a different fruit type to distinguish it from the seedless variety at time of harvest.

Table 9–32.
Cucurbit
Crop Spacing

Crop	Metric		Imperial	
	Row Spacing	In-Row Spacing	Row Spacing	In-Row Spacing
Cucumbers				
Fresh	1.2–1.8 m	30 cm	4–6 ft	12 in.
Cucumbers (processing)				
Hand-pick	1.1–1.2 m	10–15 cm	3.5–4 ft	4–6 in.
Machine harvest	50–75 cm	10 cm	20–30 in.	4 in.
Pumpkins & Squash¹				
Standard types	1.5–3 m	60–150 cm	5–10 ft	2–5 ft
Semi-bush types	1.2–1.5 m	45–90 cm	4–6 ft	1.5–3 ft
Small bush types	0.9–1.2 m	45–90 cm	3–6 ft	1.5–3 ft
Melons²				
Muskmelons	1.5–1.8 m	60–90 cm	5–6 ft	2–3 ft
Watermelons	1.8–2.5 m	90–120 cm	6–8 ft	3–4 ft

¹ Varieties with large fruit size (over 30 lb) benefit from wider rows and plant spacings. Gourds and mini-pumpkins respond to significantly higher plant populations (up to 6,000 plants/acre).

² Approximately 2.2 kg of seed are required to produce enough melon seedlings for 1 ha.

Under cool or stressful growing conditions, some seed development may occur in seedless watermelons.

Plasticulture

Vine crops (especially musk and watermelons) respond well to plastic mulch, row covers and drip irrigation. However, keep in mind that all vine crops are very sensitive to low temperatures. Row covers may not provide significant frost protection if the crop is planted too early. Monitor the temperature inside the row cover regularly. Ventilate when the temperature inside reaches 35°C (95°F) or higher. Remove the cover once the risk of cold temperatures has passed. Covers must be removed prior to pollination. To control weed growth under the mulch, choose one that blocks most light transmission, such as black, white on black, or infrared-transmitting mulch. For more information, see the section *Season Extension*, on page 34.

Pollination

All the vine crops depend on insects to transfer pollen from the male to the female blossoms. Each female blossom must be visited 15–20 times for adequate pollination to occur. Poorly pollinated fruit exhibit awkward shape and poor size. Hollow heart of watermelons may be linked to poor pollination.

Table 9–33.
Cucurbit
Nitrogen and Potash Injection Schedules

Stage	Rate per week
Transplanting to fruit set	5 kg/ha (4.5 lb/acre)
Fruit sizing to harvest	10 kg/ha (9 lb/acre)
During harvest	5 kg/ha (4.5 lb/acre)

Native pollinators are commonly found in many pumpkin and winter squash fields. They are less common in cucumbers, muskmelons and watermelons. Assess all vine crop fields for bee activity at early bloom. If there is adequate pollination occurring, a clear “hummm” of activity can be heard in the field in the early morning hours. Consider introducing one colony of honeybees for every hectare (2.5 acres). Aim to have the hives in the field at first bloom.

Insecticides will poison bees. Spray only in the evening or at night, after bees have finished foraging for the day. If possible, remove hives from the field prior to spraying. See the section *Prevent Bee Poisoning*, on page 53.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 1–8, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 9, and Table 1–9, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 10.)

Apply up to 110 kg N/ha (98 lb N/acre). Broadcast 65 kg N/ha (58 lb/acre) and all the phosphate and potash required prior to planting. Side-dress the remainder of the nitrogen before the vines start to run. On sandy soils, a second application may be necessary after the vines begin to run.

Alternatively, up to 100 kg (90 lb) of N + K₂O/ha can be applied in a band, 5 cm to the side and 5 cm below the seed at planting. The remainder of the fertilizer requirements should be broadcast before planting. Over-application of nitrogen may result in excessive vine growth and reduced fruit yields.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 61 mg P per L soil (ppm) or higher, cucurbit fields are unlikely to respond to additional phosphate applications. For soils testing lower than 61 mg P per L soil (ppm), see Table 1–10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

Table 9-34.
Cucurbit Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts per Million (ppm)			
Cucumber												
Most recently mature leaf	before bloom	3.5-6	0.3-0.6	1.6-3	2-4	0.58-0.7	0.3-0.8	40-100	30-100	20-50	20-60	5-20
	early bloom	2.5-5	0.25-0.6	1.6-3	1.3-3.5	0.3-0.6	0.3-0.8					
Muskmelon												
Most recently mature leaf	12-in. vines	4.0-5.0	0.4-0.7	5-7	3-5	0.35-0.45	0.2-0.5	40-100	20-100	20-60	20-80	5-10
	early fruit set	3.5-4.5	0.25-0.4	1.8-4	1.8-5	0.3-0.4	0.2-0.5					
Pumpkin												
Most recently mature leaf	5 weeks after seeding	3-6	0.3-0.5	2.3-4	0.9-1.5	0.35-0.6	0.2-0.4	40-100	40-100	20-50	25-40	5-10
	8 weeks from seeding	3-4	0.25-0.4	2-3	0.9-1.5	0.3-0.5	0.2-0.4					
Squash												
Most recently mature leaf	early fruit	3-5	0.25-0.5	2-3	1-2	0.3-0.5	0.2-0.5	40-100	40-100	20-50	25-40	5-20
Watermelon												
Most recently mature leaf	last cultivation	3-4	0.25-0.5	3-4	1-2	0.25-0.5	0.2-0.4	30-100	20-100	20-40	20-40	5-10
	first flower	2.5-3.5	0.25-0.5	2.7-3.5	1-2	0.25-0.5	0.2-0.4					
	first fruit	2-3	0.25-0.5	2.3-3.5	1-2	0.25-0.5	0.2-0.4					

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*, 5th Edition. John Wiley & Sons, Inc. New York.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 181 mg K per L soil (ppm) or higher, cucurbit fields are unlikely to respond to additional potash applications. For soils testing lower than 181 mg K per L soil (ppm), see Table 1-12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

Fertigation

For fertigated vine crops, broadcast all the phosphate requirement and approximately 30%-50% of the nitrogen and potash requirements prior to planting. The remainder should be injected through the drip irrigation system at the rates shown in Table 9-33, *Cucurbit Nitrogen and Potash Injection Schedules*, on page 107.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis is a useful tool for diagnosing crop problems or for evaluating a fertilizer program. The objective of a

good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the sufficiency range. Attempting to bring the nutrient analysis up to the higher end of the range could possibly result in over-fertilization and may not be economical. For more information see the section, *Plant Analysis*, on page 3.

Only use sufficiency ranges as a reference and a guideline. Plant analysis does not replace soil testing or a sound soil fertility program. See Table 9-34, *Cucurbit Nutrient Sufficiency Ranges*, above.

Integrated Pest Management Diseases

DAMPING-OFF AND ROOT ROTTS

Use sterile soil or soil-less mix for growing seedlings. For identification and management information on these common vegetable diseases, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59. Also see Table 9-35, *Cucurbit Seed Treatments*, below.

Table 9-35.
Cucurbit Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL LS	metalaxyl-M	20-40 mL per 100 kg seed	pythium damping-off	For use on imported seed only. No domestic treatment.
Thiram 75 WP	thiram	50 g per 25 kg seed	seed decay and damping-off	

Table 9-36.
Cucurbit
Downy Mildew Fungicide Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
BROADSPECTRUM PREVENTATIVE FUNGICIDES						
Begin applications no later than vine development.						
chloronitrile (group M5)	chlorothalonil	Bravo 500	4.8 L	1.9 L	1	
dithiocarbamate (group M3)	mancozeb	Dithane DG	1.1–3.25 kg	0.44–1.3 kg	14	
		Manzate Pro-Stick	2.25–3.25 kg	0.9–1.3 kg	14	
		Penncozeb 80 WP	1.1–3.25 kg	0.44–1.3 kg	14	
DOWNY MILDEW-TARGETED PREVENTATIVE FUNGICIDES²						
Begin applications when weather conditions favour downy mildew or if downy mildew is identified in the Great Lakes region.						
QiL (group 21)	cyazotamid	Ranman 400SC	150–200 mL in 200–600 L water	40–80 mL in 20–60 gal water	1	Maximum 6 applications/yr. Do not make sequential applications. 12-hour re-entry. 30-day plant back interval.

¹ PHI = Pre-Harvest Interval.

² Contact the OMAFRA Vegetable Crops Specialist or the Ontario Processing Vegetable Growers for a list of additional downy mildew-targeted fungicides registered under Emergency Use or the Minor Use Program.

DOWNY MILDEW

Downy mildew is a serious disease of cucurbit crops. Cucumbers are the most susceptible to infection, however melons and other vine crops can be affected by certain pathotypes of this disease. Downy mildew is wind borne and highly infectious. It can destroy an unprotected crop in less than 1 week.

Identification: Downy mildew-infected leaves develop pale green areas on the upper leaf surface. The corresponding lower leaf surface may be covered with a downy, grey-to-purple mould with visible black spores (sporangia). As the infection progresses, the lesions become yellow, then brown and necrotic.

In cucumbers, the lesions are often confined by the leaf veins and take on an angular appearance. During favourable environmental conditions, downy mildew can completely kill a crop within a week of the initial infection. Fruit from infected plants are usually undersized, deformed and unmarketable.

Development: Downy mildew is favoured by cool, wet or humid weather conditions. Spore production is highest at temperatures of 15°C–20°C (59°F–69°F). Under favourable weather conditions, the pathogen will produce new inoculum in as little as 4 days.

Thresholds: Downy mildew must be managed preventatively. There are no thresholds.

Management Notes: Follow a basic 7–14-day preventative program using one of the broad spectrum fungicides listed in Table 9–36, *Cucurbit Downy Mildew Fungicide Recommendations*, above. Initiate the program no later than running. If suitable environmental conditions exist during the early stages of crop development, use a banded application to protect the young plants.

Switch to one of the targeted downy mildew fungicides listed in Table 9–36, *Cucurbit Downy Mildew Fungicide Recommendations*, above, if downy mildew is identified in the Great Lakes region, OR during prolonged periods of cool, humid weather OR when there are cool night-time temperatures followed by heavy dewfall. If downy mildew has been identified in an area, maintain a strict 5–7-day fungicide schedule.

Apply all downy mildew fungicides preventatively. Always rotate between different fungicide groups.

Ensure good spray coverage. Select nozzles and set the air pressure to deliver a medium-to-fine droplet size. All fungicides should be applied in a minimum 30 gal water/acre (or higher).

Growers who plant cucurbit transplants should ensure that the transplants are free from disease and grown in a greenhouse dedicated solely for transplant production. For cucumbers grown under plastic tunnels, apply a preventative fungicide immediately after transplanting and a second application as soon as the row covers are removed.

Note: the downy mildew-targeted fungicides will not provide protection against powdery mildew, scab and other vine crop diseases.

POWDERY MILDEW

Identification: Initial symptoms develop on the undersides of older, shaded leaves. The white, powdery growth will spread to the upper leaf surface and down the petiole. Infected leaves and stems wither and die prematurely, impacting both yield and fruit quality.

Development: This disease does not overwinter in Ontario. Spores usually arrive (from the southern U.S. and Mexico) in mid-summer. Peak infection periods occur when temperatures are in the range of 20°C–26°C (68°F–80°F). Disease development slows when temperatures climb above 26°C (80°F).

Infections develop at relatively low humidity (<20%) levels, although humid weather conditions and heavy dews lead to more rapid disease development.

Thresholds: Begin applying protectant fungicides at the first sign of disease. Late July through August is usually the most critical powdery mildew control period.

Management Notes: There is a wide selection of powdery mildew-resistant varieties available for all types of vine crops. Good spray coverage on both the upper and lower leaf surfaces is important. Use high water volumes. See Table 9–37, *Cucurbit Disease Control Recommendations*, on page 111.

BACTERIAL WILT

Identification: Infected leaves develop dull green patches. As the vascular system becomes blocked with bacterium, the runners (and eventually the whole plant) become wilted. Plants ultimately turn yellow and die.

Development: This disease overwinters in the stomachs of adult cucumber beetles. Beetles inject the bacterium into the plant as they feed. Vine crops species and cultivars differ in their susceptibility to bacterial wilt. Generally speaking, cucumbers and melons are very susceptible.

Management Notes: Control cucumber beetle feeding to prevent the spread of this disease. See the section *Cucumber Beetles*, on page 113.

ANGULAR LEAF SPOT

Identification: Small, “water-soaked” lesions develop on infected leaves. These lesions will expand in size until

they are confined by the veins, resulting in an angular appearance. Affected areas turn brown, and the centres fall out, leaving small holes in the leaf.

Development: This bacterial disease is seed-borne. Bacteria also survive in infected crop residue. In wet conditions, it spreads rapidly across the field through splashing rainwater or machinery.

Thresholds: None established. Apply copper fungicides at the first sign of infection.

Management Notes: Angular leaf spot is more prevalent in pumpkins and squash. There is good varietal resistance available in cucumbers. Purchase pathogen-free seed, do not save seed from infected fields. A two-year rotation away from cucurbit vine crops will reduce overwintering inoculum. See Table 9–37, *Cucurbit Disease Control Recommendations*, on page 111.

SCAB, ANTHRACNOSE AND ALTERNARIA

Identification: All these diseases cause leaf spotting and (occasionally) leaf distortion. Scab leaf lesions are small, numerous and pale yellow-to-white in colour. Scab fruit infection occurs as large, sunken craters with corky margins.

Anthracnose leaf spots are dry and reddish brown, often with a lighter yellow border. Severely infected leaves become dry, cracked and ragged-looking. Anthracnose-infected fruit develop sunken lesions, varying in colour from red-brown to black. Under humid conditions, these lesions may develop masses of salmon pink spores.

Alternaria lesions start as small, yellow-to-brown flecks. As the flecks enlarge in size, concentric rings become apparent. On muskmelons, alternaria lesions may grow as large as 1 cm in diameter. There are somewhat smaller on watermelons. If left untreated, the lesions often grow together, causing the entire leaf to turn brown, wither and die. The resulting reduction in the leaf canopy often causes an increase in sunscald and damage to mature fruit.

These diseases may also develop on fruit in storage.

Development: Scab development favours cool, dry days interspersed with moisture and/or heavy dews. Field infection occurs at temperatures from 17°C–20°C (63°F–68°F). Melons may develop symptoms in storage at temperatures as low as 8°C (46°F).

Table 9–37.
Cucurbit Disease Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
ANGULAR LEAF SPOT						
inorganic (group M1)	copper sulphate	Copper 53W	2.5–3.0 kg	1–1.2 kg	1	Also controls anthracnose.
	copper hydroxide	Parasol Flowable	2.3–3.1 L	0.9–1.2 L	1	Cucumbers only.
	copper oxychloride	Copper Spray	4.0 kg	1.6 kg	1	Also controls anthracnose.
POWDERY MILDEW						
chloronitrile (group M3)	chlorothalonil	Bravo 500	4.8 L	1.9 L	1	
QoI (group 11)	pyraclostrobin	Cabrio EG	560–840 g in 350 L water (30 gal water)	224–336 g in 350 L water (30 gal water)	3	Maximum 4 applications/yr. Do not make more than 1 application before alternating with a different fungicide family. 24-hr re-entry.
inorganic	potassium bicarbonate	MilStop	2.8–5.6 kg	1.1–2.25 kg	0	Suppression only. Ensure thorough spray coverage.
ALTERNARIA, ANTHRACNOSE, GUMMY STEM BLIGHT AND SCAB						
dithiocarbamate (group M3)	mancozeb	Dithane DG	1.1–3.25 kg	0.44–1.3 kg	14	Alternaria, anthracnose, gummy stem blight and scab.
		Manzate Pro-Stick	2.25–3.25 kg	0.9–1.3 kg	14	
		Penncozeb 80WP	1.1–3.25 kg	0.44–1.3 kg	14	
chloronitrile (group M5)	chlorothalonil	Bravo 500	4.8 L	1.9 L	1	Anthracnose and scab.
QoI (group 11)	pyraclostrobin	Cabrio EG	560–840 g in 350 L water	224–336 g in 30 gal water	3	Alternaria, anthracnose and gummy stem blight. Maximum 4 applications/yr. Do not make more than 1 application before alternating with a different fungicide family. 24-hr re-entry.
carboxamide (group 7)	boscalid	Lance WDG	460 g	184 g	0	Alternaria and gummy stem blight. Maximum 4 applications/yr. 4-hr re-entry.
phthalimide (group M4)	captan	Maestro 80DF	2.25–4.25 kg	0.9–1.7 kg	2	Anthracnose and scab. Cucumber only. Use low rate on young plants. Aerial applications permitted. 48-hr re-entry.
		Supra Captan 80 WDG	2.25–4.25 kg	0.9–1.7 kg	2	

¹ PHI = Pre-Harvest Interval.

Anthracnose is a late-season disease. It prefers warm temperatures of 22°C–27°C (72°F–81°F) and high relative humidity (100% for 24 hr).

Alternaria can develop under a wide range of environmental conditions. It can survive in temperatures from 12°C–30°C (54°F–86°F).

Thresholds: None established. Scab infections may occur in all vine crops. Alternaria and anthracnose are more commonly found in muskmelon and watermelon crops.

Management Notes: Practice a 2–3-year rotation away from all vine crops. Avoid night-time overhead irrigation

during cooler weather. See Table 9–37, *Cucurbit Disease Control Recommendations*, above.

GUMMY STEM BLIGHT (also known as BLACK ROT OR ALLIGATOR SKIN)

Identification: Circular tan-to-dark brown lesions develop between healthy green leaf veins. Infected leaves often curl inwards. Stem cankers often produce a gummy brown exudate. Later in the season, gummy stem blight infections cause fruit decay, often accompanied by copious amounts of black spores (known as black rot.) On butternut squash, distinct circular bronze patterns (alligator skin) develop on the surface of infected fruit.

Development: Gummy stem blight survives on crop residue and in infected seed. Infections often occur in “hot spots” spreading out from a single infected seed.

Thresholds: None established. Apply fungicides at the first sign of foliar symptoms.

Management Notes: Follow a 2–3-year crop rotation and use certified, treated seed. Do not save seed from infected fields. See Table 9–37, *Cucurbit Disease Control Recommendations*, on page 111.

FUSARIUM WILT

Identification: Fusarium wilt is a serious problem in muskmelons and an occasional problem in other vine crops. Early-season fusarium wilt infections result in the damping-off of seedlings and transplants. Later infections cause the foliage to turn a dull grey-green and wilt, followed by a general yellowing and defoliation. Fusarium infection causes the vascular tissue to turn reddish-brown. A gummy exudate may form on the underside of infected vines.

Muskmelons from infected fields may develop raspberry-pink fungal growths on the underside of the fruit.

Development: Fusarium wilt may attack the plant at any stage. Outbreaks often follow periods of crop stress, including hot, dry weather conditions. Soil temperatures of 18°C–25°C (64°F–77°F) support rapid disease progression. Vine crops grown in slightly acidic soils (pH 5.0–5.5) may be more prone to fusarium infections. The fungal spores survive in the soil for many years.

Thresholds: None established. Foliar fungicides will not control this disease.

Management Notes: Fusarium-resistant vine crop cultivars are available. As several different races of fusarium exist, look for varieties with multiple resistance genes.

Follow a 3–4-year rotation away from all vine crops and use only sterile, soil-less mix for vine crop transplants. Lime soil to a target pH of 6.0–6.5 and avoid over-fertilization, especially with fertilizers containing ammonium. Maintain adequate soil moisture levels, especially during fruit-set and sizing.

PHYTOPHTHORA BLIGHT

Identification: Phytophthora symptoms include foliar blight, fruit rot and stunting. The foliar blight/crown rot phase often starts at the growing point. Dark-green

lesions form on the crown, eventually girdling it and causing the entire plant to turn brown, collapse and die.

Fruit infections begin as a large water-soaked lesion. White spores resembling powdered sugar develop on the surface of the lesion.

Development: Phytophthora spreads rapidly during warm, wet weather. Ideal conditions for infection are moist soils above 18°C (65°F) and air temperatures between 24°C and 29°C (75°F and 85°F). Levels of soil inoculum build up over time, especially under intensive vine crop and/or solanaceous crop rotations.

Thresholds: None established.

Management Notes: Rotate fields for a minimum of 3 yr away from all host crops. Do not plant cucurbit crops in a field that has a history of phytophthora infections. Select well-drained fields. Minimize soil compaction and avoid excessive irrigation, especially in overhead systems. Clean farm equipment if travelling between infected and non-infected fields.

SEPTORIA LEAF SPOT

Septoria infections cause circular, white-to-light brown leaf lesions. Fruit lesions are raised and pimple-like. Septoria occurs only sporadically in Ontario. Muskmelons, pumpkins and winter squash are all susceptible. Septoria is more common during unseasonably cool summers or during late fall.

CUCUMBER MOSAIC VIRUS

This virus is transmitted by aphids and cucumber beetles. Transmission occurs very quickly (in less than 1 min). As a result, aphid control will not necessarily prevent an infestation. Use of resistant cultivars is the best available means of preventing yield losses.

Control perennial weeds in adjacent fencerows. Milkweed, ground cherry, pokeweed, chickweed and mother-wort are alternative hosts to the mosaic virus. See the sections *Aphids*, on page 60, and *Viruses (General)*, on page 59.

Insects

SEEDCORN MAGGOTS, WIREWORMS, APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting vine crops, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, and Table 9–38, *Cucurbit Insect Control Recommendations*, on page 113.

Table 9–38.
Cucurbit Insect Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
CUCUMBER BEETLES AND APHIDS						
Planting Treatment						
neonicotinoid (group 4)	imidacloprid	Admire 240 F	Soil:	18 mL per 100 m row	21	One application/yr applied in-furrow at planting or banded soon after planting. 24-hr re-entry.
			Transplant water:	25 mL per 1,000 plants	21	
chlorinated cycloidiene (group 2A)	endosulfan	Thiodan 50 WP	1.0 kg	0.4 kg	2	Will also control squash vine borer. ²
		Thionex 50 WP	1.1 kg	0.44 kg	2	
		Thiodan 4 EC	1.5 L	0.6 L	2	
inorganic	kaolin clay	Surround WP	12.5–25 kg in 500 L water	5–10 kg in 45 gal water	0	Cucumber beetle control only. Maximum 5 applications/yr.
organophosphate (group 1B)	malathion	Malathion 25 W	4.25 kg	1.7 kg	3	Cucumbers, squash, pumpkins.
			4.0–5.5 kg	1.6–2.2 kg	3	Melons.
		Malathion 500 E	1.8 L	0.72 L	3	Cucumbers, squash, pumpkins.
			2.25–2.75 L	0.9–1.1 L	3	Melons.
TWO-SPOTTED SPIDER MITE						
diphenylethane (group 3)	dicofol	Kelthane 50 W	1.0–1.25 kg	0.4–0.5 kg	7	Maximum 1 application/yr. Use high rate on large plants.
CUTWORMS						
organophosphate (group 1B)	chlorpyrifos	Lorsban 4E	1.2–2.4 L	0.48–0.96 L	60	Cucumbers only. Apply at 2–5-leaf stage. 24-hr re-entry.
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.96 L	60	
carbamate (group 1A)	carbaryl	Sevin XLR	2.5 L	1 L	5	Climbing cutworms only. Do not apply during bloom.

¹ PHI = Pre-Harvest Interval.

² Butternut squash is resistant to squash vine borer.

CUCUMBER BEETLES

Identification: Striped cucumber beetles are 6–7 mm (1/4 in.) long with 3 black stripes. The less common, spotted cucumber beetle is slightly larger. While feeding damage can seriously harm seedlings, the main threat to vine crop yield is the transmission of bacterial wilt.

Period of Activity: Beetles usually arrive in cucurbit fields as the crop begins to emerge. They may be present in the field throughout the summer. However, early populations are generally the most damaging. Late-season feeding on the fruit may reduce marketable yields.

Thresholds: Treat when beetles exceed 0.5–1 per plant. Use the lower threshold on bacterial wilt-susceptible varieties. A follow-up spray may be necessary, as beetle emergence is often staggered.

Management Notes: Cucumber beetles tend to congregate in certain areas of the field, making them an excellent

Bee Warning

The insecticides listed in Table 9–38, *Cucurbit Insect Control Recommendations*, are toxic to bees. Apply insecticides in the evening when bees are not working in the field. If hives are in the crop, remove them or close them off when treating the field.

candidate for spot spraying. Vine crops vary in their attractiveness to beetles. Zucchini and pumpkins are highly attractive, cucumbers and melons less so. The more attractive species offer opportunities for trap cropping.

See Table 9–38, *Cucurbit Insect Control Recommendations*, above.

TWO-SPOTTED SPIDER MITE

Identification: The adult mite is approximately 0.5–1 mm in length, barely visible to the naked eye. It is a translucent-yellowish colour with two dark spots on the

sides of its abdomen. Spider mites feed through sucking mouth parts. Injury first appears as a bronzed, stippled effect. Severe feeding causes curling and drying of the leaves. Symptoms are often confused with drought stress.

Period of Activity: Mite activity is most common in hot, dry conditions. They often move into vine crops (especially watermelons) following wheat harvest.

Thresholds: None established. Melon plants are most susceptible to damage prior to first harvest.

Management Notes: Heavy rain or overhead irrigation often reduces mite populations to tolerable levels. See Table 9-38, *Cucurbit Insect Control Recommendations*, on page 113.

LEAFHOPPERS

High levels of leafhoppers occasionally appear in vine crops after hay is cut in the spring. Feeding damage plugs the leaf veins causing V-shaped or circular yellow lesions on the leaf margins. This pest does not usually affect yields. See the section *Potato Leafhopper*, on page 75, for more information.

SQUASH BUG

Identification: Squash bug eggs are laid in small clusters, usually on the underside of the leaf. The bullet-shaped eggs are yellow when first laid, turning reddish-brown as they mature.

Squash bug nymphs have pear-shaped, pearly grey bodies with darker legs and antennae. Squash bug adults have flattened, tear-shaped bodies. They are brownish-grey with yellow-to-orange markings.

Squash bugs are commonly found in fairly large colonies with several different stages of development present at the same time.

Period of Activity: Adults emerge from overwintering sites in the spring and begin laying eggs in vine crop fields in early June. Squash bugs may be present in vine crop fields throughout the growing season.

Thresholds: One egg mass per plant. Insecticides are most effective when targeted at small young nymphs.

Management Notes: Squash bugs like to hide in well-sheltered locations. Good weed control will help reduce the potential squash bug habitat in the field.

SQUASH VINE BORER

Fleshy, white larvae feed inside the stems and fruit of gourds, pumpkins and squash. This pest is rarely a problem in commercial fields, as borers are generally controlled by cucumber beetle sprays. If feeding occurs, spray the base of plants thoroughly with one of the insecticides recommended in Table 9-38, *Cucurbit Insect Control Recommendations*, on page 113.

Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 63.

Curing and Storing Pumpkin and Squash

Curing some types of pumpkin and squash can decrease the water content and improve eating quality. Butternut and hubbard cultivars respond to this treatment, but storage life may be shortened. Curing acorn-type squashes decreases the storage life and eating quality. If deemed necessary, fruit may be cured for 10-20 days at 24°C-27°C (75°F-81°F). Windrowing squash and pumpkins in the field prior to storage often acts as a natural curing process.

Vine crops vary significantly in their storage life expectancy. Vine crops are susceptible to cold injury, which appears after the fruit has been brought back to room temperature.

For pumpkins and winter squash, maintain storage temperatures between 10°C-15°C (50°F-59°F). Aim for 50%-70% relative humidity. High humidity levels will increase storage rots, while dry conditions will increase weight loss and shrinkage. Weight loss should be kept below 15%. See Table 9-39, *Pumpkin and Squash Storage Expectancy*, below.

For information on storing cucumbers, melons and summer squash, see Table 6-3, *Storage Life for Fresh Vegetables in Commercial Storage*, on page 48.

Table 9-39.
Pumpkin and Squash Storage Expectancy

Type	Storage Expectancy
Acorn	4-7 weeks
Pumpkins	8-12 weeks
Butternut	8-12 weeks
Buttercup	10 weeks
Turban	12 weeks
Hubbard	6 months

TRADE NAME
(Concentration)
active ingredient

CUCUMBER

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS

(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

PREPLANT INCORPORATED (PPI) – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Pay special attention to machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE (PRE) – Rainfall at 15–20 mm within 7–10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improves herbicide activity in the absence of rainfall.

Cucumber – Preplant (Stale Seedbed Technique)

glyphosate (360 g/L)*	0.75 to 3.5 L/ha	0.3 to 1.4 L/ac	<ul style="list-style-type: none"> Till and fertilize soil in early spring, and then allow weeds to grow.
or glyphosate (480 g/L)*	0.56 to 2.6 L/ha	0.22 to 1 L/ac	<ul style="list-style-type: none"> Spray weeds just before seeding crop.
or glyphosate (500 g/L)*	0.54 to 2.5 L/ha	0.21 to 1 L/ac	<ul style="list-style-type: none"> Use low rate for small weeds (8 cm), medium rates for weeds 8–15 cm and higher rate for weeds over 15 cm tall.
or glyphosate (540 g/L)*	0.5 to 2.3 L/ha	0.2 to 0.92 L/ac	<ul style="list-style-type: none"> Apply recommended PRE or POST herbicides to control new flushes of weeds or use mechanical means of control.

glyphosate* 0.267 to 1.246 kg/ha

Cucumber – Soil Applied Grass Herbicides

PREFAR (480 g/L)	12 to 14 L/ha	4.8 to 5.6 L/ac	<ul style="list-style-type: none"> PPI – for mineral soils ONLY. Incorporate thoroughly into the soil to a depth of 2.5–5 cm.
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bensulfide 5.75 to 6.75 kg/ha

Cucumber – Soil Applied Broadleaf Herbicides

ALANAP (240 g/L)	11 to 30 L/ha	4.4 to 12 L/ac	<ul style="list-style-type: none"> PRE – Apply after seeding cucumbers, but before weeds emerge. May also be applied as a POST spray about one month after the preemergence spray when the crop has emerged following a clean cultivation.
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naptalam 2.64 to 7.19 kg/ha

Cucumber – Soil Applied Grass and Broadleaf Herbicides

DACTHAL W-75 (75 W/P)	9 to 15.5 kg/ha	3.6 to 6.2 kg/ac	<ul style="list-style-type: none"> PRE. Apply only when cucumber plants have 4–5 true leaves, are well established and growing conditions are favourable for good plant growth otherwise crop injury may result. Apply prior to weed seed germination. If weeds have emerged, cultivate the soil before application. Apply at a rate of 9 to 13.5 kg/ha (3.6 to 5.4 kg/ac) on light sand or sandy loam soils. Apply at a rate of 11 to 15.5 kg/ha (4.4 to 6.2 kg/ac) on medium silt loam soils. Do NOT use on muck soils. Apply in 250 L/ha (100 L/ac) of water. Rainfall or irrigation (about 1cm) is necessary for activation.
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chlorthal dimethyl 6.75 to 11.625 kg/ha

* See Table 4-1. Herbicides Used in Ontario, page 21, for formulations available. See label for specific uses and rates.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS
PREFAR (480 g/L) followed by ALANAP (240 g/L)	9.5 to 14 L/ha 9.5 to 19 L/ha	3.8 to 5.6 L/ac 3.8 to 7.7 L/ac	(For more information, see Chapter 4, page 21 and Chapter 5, page 67). <ul style="list-style-type: none"> • PREFAR PPI (incorporate to a depth of 2.5–5 cm), followed by ALANAP PRE. • May also be tank-mixed PPI. (Do NOT incorporate deeper than 2.5 cm). • Do NOT use on muck soils. • Use the lower rates on light, sandy soils.
bensulide followed by naptalam	4.56 to 6.75 kg/ha 2.28 to 4.56 kg/ha		
Cucumber – Postemergence Broadleaf Herbicides			
AIM EC (240 g/L)			<ul style="list-style-type: none"> • Hooded Application ONLY, refer to Chapter 6, page 80 for precautions and rates. • Do NOT apply closer than 1 day to harvest.
Cucumber – Postemergence Grass Herbicides			
POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.			
POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> • Apply to actively growing grasses. • For annual grass, use 0.32 L/ha. Apply at the 1–6 leaf stage. • For volunteer grains, use 0.47 L/ha. • For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. • Use 100–200 L water/ha (40–80 L water/ac). • Do NOT apply closer than 30 days to harvest.
sethoxydim plus surfactant/solvent	0.15 to 0.5 kg/ha 1 to 2 L/ha		
VENTURE L (125 g/L)	0.6 to 2 L/ha	0.24 to 0.8 L/ac	<ul style="list-style-type: none"> • Apply POST to actively growing grasses before tillering. • Apply at 0.6 L/ha (0.24 L/ac) at 2–5 leaf stage of volunteer corn. • Apply at 0.8 L/ha (0.32 L/ac) at 2–5 leaf stage of volunteer wheat and barley. • Apply at 1 L/ha (0.4 L/ac) at 2–5 leaf stage of annual grasses (2–4 leaf for foxtails). • Apply at 2 L/ha (0.8 L/ac) at 3–5 leaf stage of quackgrass and wirestem muhly. • Thorough preplant tillage, fragmenting quackgrass rhizome improves control. • Do NOT cultivate between rows until 5 days after application. • ONLY make one application per season.
fluzifop-p-butyl	0.075 to 0.25 kg/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

MUSKMELON, WATERMELON, SQUASH AND PUMPKIN

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

PREEMERGENCE (PRE) – Rainfall at 15–20 mm within 7–10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Muskmelon, Watermelon, Squash and Pumpkin – Soil Applied Broadleaf Herbicides

ALANAP (240 g/L)	11 to 30 L/ha	4.4 to 12 L/ac	<ul style="list-style-type: none"> • PRE prior to crop and weed emergence. • Do NOT use on butternut squash; some injury may occur to Table Queen squash. • May be applied to melons (not squash or pumpkins) as a POST about one month after the preemergence spray when the crop has emerged but before the weeds are up.
naptalam	2.638 to 7.194 kg/ha		

Muskmelon, Watermelon, Squash and Pumpkin – Soil Applied Grass Herbicides

DUAL II MAGNUM (915 g/L)	1.15 L/ha	0.46 L/ac	<ul style="list-style-type: none"> • For use ONLY in winter squash and pumpkins. • Apply PRE in direct seeded crops prior to weed emergence OR at 1–2 leaf winter squash or pumpkin but still PRE to weed emergence. • Make only one application per year. • DO NOT harvest within 65 days of treatment. • Reduced control in heavy weed populations may occur.
s-metolachlor/benoxacor	1.05 kg/ha		

Muskmelon, Watermelon, Squash and Pumpkin – Soil Applied Grass and Broadleaf Herbicides

DACTHAL W-75 (75 WP)	9 to 15.5 kg/ha	3.6 to 6.2 kg/ac	<ul style="list-style-type: none"> • PRE. • Do NOT use on Pumpkins. • Apply only when plants have 4–5 true leaves, are well established and growing conditions are favourable for good plant growth otherwise crop injury may result. • Apply prior to weed seed germination. If weeds have emerged, cultivate the soil before application. • Apply at a rate of 9 to 13.5 kg/ha (3.6 to 5.4 kg/ac) on light sand or sandy loam soils. • Apply at a rate of 11 to 15.5 kg/ha (4.4 to 6.2 kg/ac) on medium silt loam soils. • Do NOT use on muck soils. • Apply in 250 L/ha (100 L/ac) of water. • Rainfall or irrigation (about 1 cm) is necessary for activation.
chlorthal dimethyl	6.75 to 11.625 kg/ha		

DEVIRINOL DF (50 DF)

DEVIRINOL DF (50 DF)	2.24 to 4.5 kg/ha	0.9 to 1.8 kg/ac	<ul style="list-style-type: none"> • PRE – one application per season. • Use on direct seeded pumpkin and squash ONLY. • Apply in 200–900 L/ha (80–360 L/ac) water. • Use the lower rate on light soils (coarse textured, sandy or sandy loam). • Shepherd's purse and lady's-thumb may escape treatment at this rate. • Apply before rainfall if irrigation is not available. • Damage to subsequent crops and cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected.
napropamide	1.12 to 2.25 kg/ha		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
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Muskmelon, Watermelon, Squash and Pumpkin – Postemergence Grass Herbicides

POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.

POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> • For pumpkins and squash ONLY. • Apply to actively growing grasses. • For annual grass, use 0.32 L/ha. Apply at the 1–6 leaf stage. • For volunteer grains, use 0.47 L/ha. • For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. • Use 100–200 L water/ha (40–80 L water/ac). • Do NOT apply closer than 30 days to harvest.
sethoxydim plus surfactant/solvent	0.15 to 0.2 kg/ha 1 to 2 L/ha		

Muskmelon, Watermelon, Squash and Pumpkin – Postemergence Broadleaf Herbicides

AIM EC (240 g/L)			<ul style="list-style-type: none"> • Hooded Application ONLY, refer to Chapter 6, page 80 for precautions and rates. • Do NOT apply closer than 1 day to harvest.
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**GREEN & WAX/
LIMA BEANS**

BEANS

Production Requirements

Snap beans are grown on all types of soils, with the exception of very heavy clay loams. They require well-drained locations with good fertility. A soil pH of 6.1 to 6.5 is ideal. The maturity of snap bean varieties grown in Ontario ranges from 48–78 days from planting to harvest. Harvest usually occurs 7–14 days after full bloom.

Average Yields

Crop	per acre	per hectare
Processing (green and yellow)	3 tons	6.7 tonnes
Processing (lima)	2 tons	2.2 tonnes
Fresh market (green and yellow)	200 crates	500 crates

Cultivars

Growers and processors are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix D, *Vegetable Seed Suppliers*, on page 229.

Spacing and Seeding

Sow as shallow as soil moisture permits, usually 2.5–4 cm (1–1.5 in.) deep. Lima bean seed may be planted up to 5 cm (2 in.) deep, depending on soil moisture. Snap beans require a minimum soil temperature of 13°C (55°F) at the time of planting. Lima beans require slightly warmer planting conditions: 15°C (59°F).

Planting into cool soil conditions may result in reduced stands due to poor germination, low vigour and increased seed decay. Under good soil conditions, germination should occur within 6–10 days of planting.

The row spacings and seeding rates vary, depending on the bean type and harvest method. Because seed size varies greatly between cultivars, adjust the seeding rate according to seed count and the germination percentage. Increase the seeding rate slightly if seeding in cool soils to compensate for reduced stands. *Note:* Dark-coloured seeds have better cold soil emergence. See Table 9–4, *Snap and Lima Bean Spacing and Seeding Rates*, above.

Fertility

Nitrogen

Apply 30–40 kg N/ha (27–36 lb N/acre) prior to planting. This may be applied as a preplant broadcast application or banded through the planter, 5 cm below and 5 cm to the side of the seed. Side-dressing of nitrogen is

Table 9–4.
Snap and Lima Bean
Spacing and Seeding Rates

Crop	Row Spacing cm (in.)	In-Row Spacing cm (in.)	Recommended Plant Population (plants/acre)
Snap beans (hand harvest)	75–90 (30–36)	5–10 (2–4)	40,000
Snap beans (machine harvest)	60–75 (24–30)	5–10 (2–4)	50,000
Lima beans	60–75 (24–30)	10–20 (4–8)	35,000

only recommended if foliage shows nitrogen deficiency. Over-application of nitrogen will cause excess leaf growth, resulting in uneven maturity.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 16 mg P per L soil (ppm) or higher, lima and snap bean fields are unlikely to respond to additional phosphate applications. For soils testing lower than 16 mg P per L (ppm), see Table 1–10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 121 mg K per L soil (ppm) or higher, snap and lima bean fields are unlikely to respond to additional potash applications. For soils testing lower than 121 mg K per L (ppm), see Table 1–12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

Because high rates of banded potassium can damage emerging seedlings, banded potassium should not exceed 60 kg potash/ha.

Micronutrients

Crops vary greatly in their response to micronutrient fertilizers. For complete information, see the section *Micronutrients*, on page 17.

BORON

Beans are very sensitive to boron toxicity and should not be grown the year after boron has been applied to previous crops in the field, such as brassica crops, celery or rutabaga.

MANGANESE

Manganese deficiency may be a problem on beans, especially on soils with pH values above 6.5. Correct the deficiency as

Table 9-5.
Snap Bean Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts per Million (ppm)			
Most recently mature trifoliate leaf	before bloom	3-4	0.25-0.45	2-3	0.8-1.5	0.2-0.45	0.4	25-200	20-100	20-40	15-40	5-10
	first bloom	3-4	0.25-0.45	2-3	0.8-1.5	0.26-0.45	0.21-0.4					
	full bloom	2.5-4	0.2-0.4	1.6-2.5	0.8-1.5	0.26-0.45	0.21-0.4					

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*. 5th Edition. John Wiley & Sons, Inc. New York.

soon as detected with a foliar manganese spray. Soil application is not recommended for manganese because of the large amounts required. See the section *Manganese*, on page 19, and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis can be useful for diagnosing crop problems or for evaluating a fertilizer program. The objective of a good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the range. Attempting to bring the nutrient analysis up to the higher end of the range could result in over-fertilization and may not be economical.

See Table 9-5, *Snap Bean Nutrient Sufficiency Ranges*, above. Only use sufficiency ranges as a reference and a guideline. Plant analysis does not replace soil testing or a sound soil fertility program. For more information, see the section *Plant Analysis*, on page 3.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTTS

For more information on the identification and management of these diseases, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59. Also see Table 9-6, *Bean Seed Treatments*, below.

Table 9-6. Bean Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Insecticide and Fungicide Combinations				
Agrox B-2	diazinon + captan	80g per 25 kg seed	seed corn maggots, seed decay, damping off	Seed box treatment Do not use on seed already treated with an insecticide. Use within one month of treatment.
Agrox CD	diazinon + captan	50 g per 25 kg seed	seed corn maggots, seedling blight, seed rot.	Seed box treatment Do not use on seed already treated with an insecticide. Use only on seed previously treated with a fungicide.
Fungicide Only				
Apron XL LS	metalaxyl-M	20-40 mL per 100 kg seed	damping-off and root rot (high rate controls phytophthora root rot)	For use in commercial seed-treatment plants only. Does not control rhizoctonia.
Apron Maxx RTA	fludioxonil + metalaxyl-M	325 mL per 100 kg seed	fusarium, pythium and rhizoctonia seed decay, damping-off and seedling blight. Seed-borne anthracnose.	Ensure uniform coverage. 30-day plant-back interval to non registered crops.
Apron FL	metalaxyl	46-110 mL per 100 kg seed	pythium seed rot and seedling blight.	For use in commercial seed-treatment plants only. Do not feed to livestock for 4 weeks after planting.
Allegiance FL	metalaxyl	46-110 mL per 100 kg seed	pythium seed rot and seedling blight.	For use in commercial seed-treatment plants only. Do not feed to livestock for 4 weeks after planting.
Vitaflo	carbathiin + thiram	260 mL per 100 kg seed	rhizoctonia seed rot and seedling blight.	Also controls seed-borne anthracnose. Do not feed to livestock for 4 weeks after planting. Do not store treated seed.
Captan FL	captan	70 mL per 25 kg seed	seed decay, damping-off and root rot	
Thiram 75 WP	thiram	25-35 g per 25 kg seed	seed decay and damping-off	Seed box treatment Do not feed treated clippings to livestock.
Insecticide Only				
Cruiser 5 FS	thiamethoxam	50-83 mL per 100 kg seed	potato leafhopper, seedcorn maggot and wireworm	For use on imported seed only. Not for domestic commercial or on-farm seed treatment. Use high rate for wireworm. Use high rate where populations are expected to be high.

Table 9-7.
Bean
Disease Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
BACTERIAL BLIGHT (HALO AND COMMON)						
inorganic (group M)	copper hydroxide	Parasol Flowable	2.3–3.1 L	0.9–1.2 L	1	Make first application when plants are 15 cm (6 in.) high.
GREY MOULD (BOTRYTIS), WHITE MOULD (SCLEROTINIA)²						
carboximide (group 7)	boscalid	Lance WDG	560–770 g	224–308 g	7	Spray at 20%–50% bloom with a second application 7 days later. Maximum 2 applications/yr. Use 420 g/ha (168 g/acre) for grey mould control. 4-hr re-entry interval.
dicarboximide (group 2)	vinclozolin	Ronilan EG	1.0–1.5 kg in min. 220 L water	0.4–0.6 kg in 20 gal water	14	Spray at first bloom with a second application 7 days later. Maximum 2 applications/yr.
	iprodione	Rovral	1.5 kg in min. 300 L water	0.6 kg in min. 27 gal water	15	Spray at 50% bloom. 12-hr re-entry. Aerial application permitted.
chlorophenyl (group 14)	dicloran	Botran 75 W	3.25 kg in 800 L water	1.3 kg in 70 gal water	2	Spray at first bloom. Do not feed treated foliage to livestock.
ANGULAR LEAFSPOT AND RUST						
QoI (group 11)	pyraclostrobin	Headline EC	400 mL	160 mL	7	Snap beans (angular leaf spot control). Maximum 2 applications/yr. 48-hr re-entry.
			400–600 mL	160–240 mL	7	Lima beans (rust control). Maximum 2 applications/yr. 48-hr re-entry.
PYTHIUM DAMPING-OFF, PHYTOPHTHORA ROOT ROT						
phenylamides (group 4)	metalaxyl-M	Ridomil Gold 480EC	300 mL ³	120 mL ³		Snap beans only. Make only 1 application/yr at planting.

¹ PHI = Pre-Harvest Interval

² For snap beans grown in fields recently affected by sclerotinia white mould.

³ Based upon 2.3 mL per 100 m (328 ft) of row using a 20-cm (8-in.) spray band and a 76-cm (30-in.) row spacing.

WHITE MOULD (SCLEROTINIA)

Identification: Dark-green, water-soaked lesions develop on the pods, branches or stems during or after flowering. The lesions enlarge rapidly, encompassing the branches and stems, causing leaves to turn yellow and die. White, cottony fungal growth may develop on pods and stems.

Development: White mould overwinters in the soil as small, black (pea-sized) sclerotia. Bean plants are most susceptible during flowering and early pod development. Temperatures ranging from 20°C–25°C (68°F–77°F) and continuous leaf wetness (high humidity and/or heavy dews) favour sclerotinia white mould development. Overwintering sclerotia may survive for several years in the soil.

Thresholds: None established.

Management Notes: Practice a 3–4-year crop rotation away from susceptible crops (vine crops, edible beans, soybeans, carrots and lettuce). Reduced tillage may decrease the number of sclerotia present at the soil surface, helping to prevent germination. Excess nitrogen applications may result in an exceptionally dense canopy, resulting in restricted air movement and more favourable disease development conditions.

See Table 9-7, *Bean Disease Control Recommendations*, above. High humidity, heavy dews or wet weather during bloom may result in the need for a second spray.

**BACTERIAL BLIGHTS
(BROWN SPOT, COMMON BLIGHT, HALO BLIGHT)**

Symptoms: The three bacterial blights are difficult to distinguish in the field. On leaf tissue, look for circular, brown, necrotic lesions, often surrounded by a yellow border. Pod lesions are usually slightly sunken and dark reddish-brown. The pods often become misshapen where the lesions develop.

Development: Common blight usually occurs during warm, humid conditions of 25°C–30°C (77°F–86°F). Halo blight prefers cooler temperatures in the 16°C–20°C (61°F–68°F) range.

Thresholds: None established.

Management Notes: Use only certified seed. The bacterial blight pathogens do not generally overwinter on crop residue in Ontario. Plants damaged by high winds or sand blasting are more susceptible to infection. See Table 9–7, *Bean Disease Control Recommendations*, on page 74. In order to be effective, copper fungicides must be applied preventatively.

**VIRUSES
(BEAN COMMON MOSAIC, BEAN YELLOW MOSAIC,
CUCUMBER MOSAIC)**

Symptoms: Leaves develop patches of light- and dark-green discolouration. They may also become puckered and twisted. Plants are often stunted, with poor seed set and misshapen pods. Bean yellow mosaic may also produce bright yellow spots on the leaf tissue.

Development: These viruses are spread by aphids and usually follow periods of high aphid activity.

Management Notes: Chemical aphid controls will not necessarily reduce the amount of viral diseases in the field. See the section *Viruses (General)*, on page 59. Bean common mosaic is also seed-borne. Buy certified, treated seed and select resistant varieties where possible. Several vegetable crop viruses overwinter in red clover and alfalfa fields. If possible, avoid planting beans near perennial forage crops.

Insects**SEEDCORN MAGGOTS, WIREWORMS,
TARNISHED PLANT BUG, APHIDS**

For identification and management information on these common vegetable insects affecting beans, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, Table 9–6, *Bean Seed Treatments*, on page 73, and

Table 9–8, *Bean Insect Control Recommendations*, on page 76.

POTATO LEAFHOPPER

Identification: The adult leafhopper is yellow-green, wedge-shaped and approximately 3 mm long. Immature nymphs are smaller and wingless. When disturbed, leafhoppers quickly move forward or sideways. Both the adults and the nymphs feed on beans, causing leaf puckering and browning of the leaf margins (also known as “hopperburn”). Hopperburn is often confused with drought stress.

Period of Activity: Leafhoppers migrate to Ontario in early spring. Initial generations feed on alfalfa before moving into bean crops. Plants are most susceptible to feeding damage prior to bloom. Low levels of feeding on newly emerged seedlings can have a severe impact on yield. Leafhoppers are often found on the undersides of the leaves.

Thresholds:

Adults	seedling	2 per 33-cm (1-ft) row
	3 rd trifoliolate	5 per 33-cm (1-ft) row
Nymphs	any stage	10 per 100 leaves

Management Notes: See Table 9–8, *Bean Insect Control Recommendations*, on page 76, and Table 9–6, *Bean Seed Treatments*, on page 73. Where beans are planted in the vicinity of an alfalfa field, monitor the crop closely after the hay is cut.

EUROPEAN CORN BORER

Identification: Full-grown corn borer larvae are 2.5 cm (1 in.) in length. They are a greasy white (translucent) colour, with spots and a dark head. Eggs are shiny, white and laid in clusters of 30 that resemble fish scales. Corn borer larvae feed briefly on the leaves but soon begin tunnelling into the stems and pods. Since much of the pod damage is internal with only a small entry hole visible on the outside, grading-out infested pods is very difficult.

Period of Activity: Borers overwintering in corn stubble become active as soil temperatures consistently exceed 10°C (50°F). Southwestern Ontario experiences two generations per year, while the rest of the province has only one. Beans are susceptible to damage from flowering through to harvest.

Thresholds: None established.

**Table 9–8.
Bean
Insect Control Recommendations**

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
LEAFHOPPERS, MEXICAN BEAN BEETLES, TARNISHED PLANT BUG, APHIDS						
pyrethroid (group 3)	lambda-cyhalothrin ²	Matador 120 EC ²	83 mL	33 mL	14	Leafhoppers, tarnished plant bugs and aphids. Maximum 3 applications/yr. 24-hr re-entry.
organophosphate (group 1B)	dimethoate ²	Cygon 480 ²	0.7–1 L	0.28–0.4 L	7	Aerial application permitted. Maximum 3 applications/yr.
		Lagon 480 ²	0.7–1 L	0.28–0.4 L	7	Snap beans only. Aerial application permitted. Maximum 3 applications/yr.
	malathion	Malathion 500 E	1.5–2.75 L	0.6–1.1 L	3	Will not control tarnished plant bug.
	naled	Dibrom	1.1–2.2 L	0.44–0.88 L	4	Aphid control only. Lima beans only. Aerial application permitted. Do not apply when temperature is >32°C (90°F).
carbamate (group 1A)	carbaryl	Sevin XLR	1.25–2.5 L	0.5–1 L	5	Potato leafhopper and Mexican bean beetle. Use low rate on young plants. Use high rate for leafhoppers.
chlorinated cycloidiene (group 2A)	endosulfan ²	Thiodan 4 EC ²	1.5–2.5 L	0.6–1 L	2	Potato leafhopper and Mexican bean beetle.
		Thionex 50 WP ²	1.1–1.5 L	0.4–0.6 L	2	Do not apply on lima beans. Also controls green cloverworm.
CORN BORER						
pyrethroid (group 3)	lambda-cyhalothrin ²	Matador 120 EC ²	83 mL	33 mL	14	Apply before corn borer larvae tunnel into the stalk or pods. Maximum 3 applications/yr. 24-hr re-entry.
	permethrin	Pounce 384 EC	260 mL	104 mL	7	Aerial application permitted. Maximum 2 aerial applications/yr.
naturalyte (group 5)	spinosad	Success 480 SC	83 mL	33 mL	3	Snap beans only.
		Entrust 80 W	50 g	20 g	3	Use only on small larvae and low infestations. Maximum 2 applications/yr. Maintain a spray pH of 6 or greater.
biological (group 11)	<i>Bacillus thuringiensis</i>	Bioprotec CAF	2.8–4.0 L	1.1–1.6 L	1	Snap beans only. Maximum 4 applications/yr. Allow 5–10 days between applications.
carbamate (group 1A)	methomyl	Lannate TNG	550 g	220 g	7	24 hr re-entry interval.
CUTWORMS						
pyrethroid (group 3)	lambda-cyhalothrin ²	Matador 120 EC ²	83 mL	33 mL	14	Apply in the late evening or at night. Maximum 3 applications/yr. 24-hr re-entry interval.
SLUGS						
inorganic	ferric phosphate	Sluggo	25–50 kg	10–20 kg	0	Apply to moist soils. Use higher rates on severe infestations.
SPIDER MITE						
diphenylethane (group 3)	dicofol ²	Kelthane 50W ²	1.0–1.25 kg	0.4–0.5 kg	7	Make only 1 application/yr. Use high rate on larger plants.

¹ PHI = Pre-Harvest Interval.² Do not graze or feed treated foliage to livestock.

Management Notes: Where beans follow corn in rotation, consider disking the corn residue in the fall to reduce overwintering borer populations. Borers are most likely to be a pest in snap beans when other host plants are not available (early season, before corn is attractive, or late season, after the corn has dried down.) For control options, see Table 9-8, *Bean Insect Control Recommendations*, on page 76.

For more information, see the OMAFRA Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

MEXICAN BEAN BEETLE AND BEAN LEAF BEETLE

Identification: Both the adult and the larvae of these beetles are pests of snap bean in Ontario. Mexican bean beetle adults are coppery-red, oval and approximately 6 mm (1/4 in.) in length with 16 black spots on the wing casings. They resemble ladybugs. The larvae are yellow with rows of long, black-tipped spines along their backs.

Bean leaf beetle adults are 5 mm in length with four black spots on the wing covers. A small, black triangle is visible at the base of the head. The colour varies from yellow to tan or red. Bean leaf beetle larvae complete their development in the soil, feeding on roots.

Period of Activity: Mexican bean beetle adults emerge from overwintering sites (grassy fencerows and wooded areas) in early May. Eggs are laid, and feeding continues for approximately 1 month. Mexican bean beetles complete one-to-two generations per year.

Bean leaf beetles complete only one generation. The adults emerge in late April and may be found feeding on early snap bean plantings. Egg-laying occurs until late June, with the larvae feeding on the roots for up to 30 days before the adults emerge.

Thresholds: Chemical controls may be required if leaf defoliation exceeds 20% prior to bloom and 10% during pod-fill. See Figure 9-1, *Defoliation Chart for Soybean Leaf-Feeding Insects*, right. Excessive defoliation from these beetles will result in early maturity and yield losses.

Management Notes: See Table 9-8, *Bean Insect Control Recommendations*, on page 76. Border sprays may be an effective way to control the beetles as they move out of the fencerow.

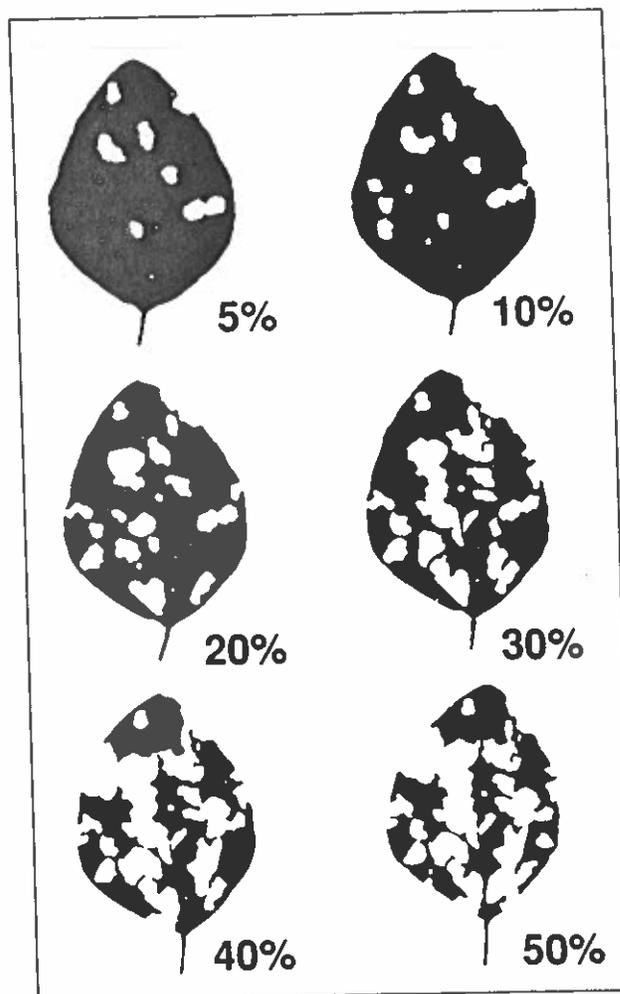


Figure 9-1.

Defoliation Chart for Soybean Leaf-Feeding Insects
Source: University of Illinois and Purdue University, 1982.

TWO-SPOTTED SPIDER MITES

Identification: The adult mite is approximately 0.5-1 mm in length and is barely visible to the naked eye. They are a translucent yellowish colour with two dark spots on the sides of their abdomen. Spider mites use sucking mouth parts to feed on individual cells. Injury first appears as yellowing or a bronzed, stippled effect. Severe feeding causes curling and drying of the leaves. Symptoms are often confused with drought stress. Mites are often found on the lower leaf surface, surrounded by a fine silk webbing.

Period of Activity: Spider mite activity is most common in hot, dry conditions. They often move into bean crops following wheat harvest.

Thresholds: Populations prior to pod fill are the greatest cause for concern. Spray if there are 4 or more mites per leaf or one severely damaged leaf per plant.

Management Notes: Heavy rain or overhead irrigation often reduces mite levels to below threshold. See Table 9-8, *Bean Insect Control Recommendations*, on page 76.

Physiological Disorders

Bronzing

Bronzing is a physiological disorder caused by high levels of atmospheric ozone associated with air pollution. A

bronze-coloured stipple develops on the pods and the upper surface of the leaves. Pod and seed set are usually reduced, and the plants age prematurely. Dry beans and limas appear more sensitive than snap beans; cultivars within these types differ in susceptibility. Be careful not to confuse air pollution injury with spider mite feeding.

Storage

Store fresh-market snap beans at 7°C–10°C (45°F–50°F) and a relative humidity of 95%. Under good conditions, beans will store for 7–10 days. If possible, keep lima beans at slightly lower temperatures.

BEANS (ADZUKI, DRY, LIMA AND SNAP)

Dry beans include black, cranberry, Dutch brown, kidney, mung, otebo, pinto, small red Mexican, yellow eye and white bean market classes.

Apply all treatments in 150–300 L/ha (60–120 L/ac) water unless otherwise specified.

When developing a weed control program, consider cultivation, rotation and other cultural practices along with herbicide treatments. Any single method of weed control, or the continuous use of the same chemical, can lead to the build up of weeds resistant or tolerant to that control method. Rotating crops and/or other control methods reduce the chance of developing new or unique weed infestations.

High speed (10–20 km/hr), shallow (2.5–3 cm) cultivation with a rotary hoe when beans are in the 1–2 leaf stage helps control small weed seedlings. This technique does not reduce herbicide action and may, in some years, enhance chemical weed control and improve crop safety.

Inter-row cultivation may be needed when weeds escape herbicide treatment; consider weeds 'escapes' when they are 5–7 cm high. Cultivate shallow to prevent exposure of untreated soil and germination of new weed seeds.

Band treatment of chemical over the row reduces costs by one-half to two-thirds, depending on row spacing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation will give some control of established perennial weeds but may also help to spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another.

Some chemicals may also be impregnated on dry bulk fertilizer. Check the label for recommended fertilizer ingredients. Please refer to Table 7-1. *Beans (Dry, Lima And Snap) Herbicide Weed Control Ratings*, page 85 to determine which market classes of edible beans are registered for the herbicide treatments listed.

Rates and application techniques vary for trifluralin products. For further information on these and other chemicals refer to label recommendations and also *Notes on Herbicides*, on page 29.

Herbicide Application Timings

- **Preplant (PP)** – Also see Special Methods, *Preplant-Site Preparation Prior To Any Crop*, on page 78 for details of products, rates and remarks.

- **Preplant Incorporated (PPI)** – Unless stated otherwise, two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Pay special attention to machinery cleanliness and/or treating fields with perennial weeds last.

- **Preemergence (PRE)** – Rainfall of 15–20 mm within 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

- **Postemergence (POST)** – Leaf stage of the weeds is critical for good weed control. Smaller weeds are usually more sensitive to herbicide injury. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Notes on Herbicides, page 29).
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Soil Applied Grass Herbicides

DUAL II MAGNUM (915 g/L)	1.15 to 1.75 L/ha	0.46 to 0.7 L/ac	<ul style="list-style-type: none"> Apply PPI or PRE on all dry bean (<i>Phaseolus vulgaris</i>) species, except Lima when applied PRE. Apply PPI to minimize the potential for crop injury. Do NOT use on adzuki beans. Do NOT use on muck, peat or high organic matter soils. Use the low rate on coarse-textured soils low in organic matter. Requires rainfall for activation. Rotary hoe if no rainfall occurs within 7 days. Improved control of yellow nutsedge is obtained when DUAL MAGNUM is applied PPI. Use the higher rate for the control of nightshade.
<i>s-metolachlor/benoxacor</i>	1.05 to 1.6 kg/ha		
EPTAM (800 g/L)	4.25 to 5.5 L/ha	1.7 to 2.2 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate immediately. Do NOT use on adzuki, lima, otebo and small red Mexican beans. If dry weather has preceded the application of EPTC, delay seeding 7–10 days. Temporary injury can occur in the emerging crop. Use the high rate for nutsedge control.
EPTC	3.4 to 4.4 kg/ha		
FRONTIER (900 g/L)	1.1 to 1.4 L/ha	0.44 to 0.56 L/ac	<ul style="list-style-type: none"> Apply PPI or PRE. Apply PPI to minimize the potential for crop injury. Use only on white and kidney beans. Do NOT use on muck, peat or high organic matter soils. Use the low rate on coarse-textured soils low in organic matter. Minimum PPI rate is 1.4 L/ha (0.5 L/ac). Improved control of yellow nutsedge is obtained when FRONTIER is applied PPI. Use the higher rate of FRONTIER for the control of nightshade and pigweed. Requires rainfall for activation. Rotary hoe if no rainfall occurs within 7 days.
<i>dimethenamid</i>	1 to 1.25 kg/ha		
TREFLAN EC (480 g/L) or RIVAL (500 g/L) or BONANZA 400 (400g/L)	1.25 to 2.4 L/ha 1.2 to 2.3 L/ha 1.5 to 2.75 L/ha	0.5 to 0.96 L/ac 0.48 to 0.92 L/ac 0.6 to 1.1 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate as soon as possible. Within 24 hours. Do NOT use on adzuki, brown, cranberry, otebo, pinto, small red Mexican and yellow-eye beans. Do NOT exceed 1.2 L/ha (0.48 L/ac) of TREFLAN on medium textured soils and 1.7 L/ha (0.68 L/ac) in heavy textured soils for lima beans.
<i>trifluralin</i>	0.6 to 1.155 kg/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Notes on Herbicides, page 29).

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Notes on Herbicides, page 29).
Soil Applied Grass and Broadleaf Herbicides			
PURSUIT (240 g/L)	0.312 L/ha	0.125 L/ac	<ul style="list-style-type: none"> Apply PPI on adzuki, cranberry, kidney and white beans. Apply PRE on adzuki, black, brown, cranberry, kidney, lima, otebo, small red Mexican, snap, yellow eye and white beans. Do NOT apply on pinto beans. Delayed maturity or stunting may occur if cold and/or wet conditions are experienced within first week after application. Requires rainfall for activation. Rotary hoe if no rainfall occurs within 7 days. Delayed maturity may result from the application of PURSUIT. Do NOT harvest within 100 days of application. Some rotational cropping restrictions apply (see Table 4-3, page 60).
imazethapyr	0.075 kg/ha		
Soil Applied Tank-Mixes			
DUAL II MAGNUM (915 EC) plus PURSUIT (240 g/L)	1.15 to 1.75 L/ha 0.312 L/ha	0.46 to 0.7 L/ac 0.125 L/ac	<ul style="list-style-type: none"> Apply PPI or PRE, for use ONLY on cranberry or kidney beans. Apply PPI to minimize the potential for crop injury. Do NOT use on muck, peat or high organic matter soils. Use the low rate on coarse-textured soils low in organic matter. Requires rainfall for activation. Rotary hoe if no rainfall occurs within 7 days. Do NOT harvest within 100 days of application. Some rotational cropping restrictions apply (see Table 4-3, page 60).
s-metolachlor/benoxacor plus imazethapyr	1.05 to 1.60 kg/ha 0.075 kg/ha		
EPTAM (800 g/L) plus TREFLAN EC (480 g/L) <u>or</u> RIVAL (500 g/L) <u>or</u> BONANZA 400 (400 g/L)	3 L/ha 1.25 L/ha 1.2 L/ha 1.5 L/ha	1.2 L/ac 0.5 L/ac 0.48 L/ac 0.6 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate immediately. Use only on white and red kidney beans. If dry weather has preceded the application of EPTC, delay seeding 7-10 days.
EPTC plus trifluralin	2.4 kg/ha 0.6 kg/ha		
PURSUIT (240 g/L) plus TREFLAN EC (480 g/L) <u>or</u> RIVAL (500 g/L) <u>or</u> BONANZA 400 (400 g/L)	0.312 L/ha 1.25 to 2.4 L/ha 1.2 to 2.3 L/ha 1.5 to 2.75 L/ha	0.125 L/ac 0.5 to 0.96 L/ac 0.48 to 0.92 L/ac 0.6 to 1.1 L/ac	<ul style="list-style-type: none"> Apply PPI and incorporate as soon as possible. Incorporate within 24 hours. Use only on white beans. Some rotational cropping restrictions apply (see Table 4-3, page 60).
imazethapyr plus trifluralin	0.075 kg/ha 0.6 to 1.15 kg/ha		

TRADE NAME **PRODUCT RATE PER HA** **PRODUCT RATE PER ACRE** **PRECAUTIONS**
 (Concentration) active rate per ha PER ACRE (For more information, see Notes on Herbicides, page 29).

Postemergence Grass Herbicides

ASSURE II (96 g/L) plus SURE-MIX	0.38 to 0.75 L/ha 5 L/1,000 L	0.15 to 0.3 L/ac 5 L/1,000 L	<ul style="list-style-type: none"> Apply to emerged annual grasses and volunteer cereals in 2 leaf to tillering stage and volunteer corn and quackgrass in the 2-6 leaf stage. For use on all market classes of edible beans listed in Table 7-1, plus mung beans. Use the 0.38 L/ha (0.15 L/ac) rate of ASSURE II for control of volunteer corn, volunteer cereals and green foxtail. The 0.5 L/ha (0.2 L/ac) rate of ASSURE II will suppress quackgrass and also control barnyard grass. Use the 0.75 L/ha (0.3 L/ac) rate of ASSURE II for control of quackgrass.
quizalofop-p-ethyl plus oil concentrate	0.036 to 0.07 kg/ha 0.5% v/v		<ul style="list-style-type: none"> Apply POST when annual grasses are in the 2-5 leaf stage. Apply POST to all dry bean (<i>Phaseolus vulgaris</i>) species listed in Table 7-1. Do NOT use on adzuki beans. Do NOT apply if rain is expected within 1 hour after application.
EXCEL SUPER (80.5 g/L)	0.67 L/ha	0.27 L/ac	<ul style="list-style-type: none"> Apply POST when annual grasses and volunteer cereals are in the 1-3 leaf stage. Apply POST to all dry bean (<i>Phaseolus vulgaris</i>) species listed in Table 7-1. Do NOT use on adzuki beans. Do NOT apply if rain is expected within 1 hour after application.
fenoxaprop-p-ethyl	0.054 kg/ha		
POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> Apply POST when annual grasses and volunteer cereals are in the 1-6 leaf stage and quackgrass is in the 1-3 leaf stage. Apply POST to Adzuki and all dry bean (<i>Phaseolus vulgaris</i>) species listed in Table 7-1. Maximum rate on snap beans is 0.65 L/ha (0.26 L/ac). Use the intermediate rate (0.47 L/ha) for volunteer spring cereals. Use the high rate (1.1 L/ha) for quackgrass. Thorough preplant tillage will ensure more uniform quackgrass emergence. Follow with a cultivation 7 days after treatment in wide row crops. Do NOT apply if rain is expected within 1 hour after application.
sethoxydim plus surfactant	0.15 to 0.5 kg/ha 1 to 2 L/ha		

SELECT (240 g/L) plus AMIGO	0.125 to 0.19 L/ha 5 L/1,000 L	0.05 to 0.076 L/ac	<ul style="list-style-type: none"> Apply POST when annual grasses and volunteer cereals are in the 1-6 leaf stage. Do NOT apply if rain is expected within 1 hour after application. Do NOT use on adzuki, dutch brown, cranberry, kidney, lima, otebo, small red Mexican, snap and yellow eye beans.
clethodim plus surfactant	0.03 to 0.046 kg/ha 0.5% v/v		

Postemergence Broadleaf Herbicides

BASAGRAN FORTÉ (480 g/L) OR	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	<ul style="list-style-type: none"> Apply POST when beans are in the unifoliolate to 4-trifoliolate leaf stage. Apply POST to all dry bean (<i>Phaseolus vulgaris</i>) species listed in Table 7-1. Do NOT use on adzuki beans.
BASAGRAN (480 g/L) plus ASSIST	1.75 to 2.25 L/ha 2 L/ha	0.7 to 0.9 L/ac 0.8 L/ac	<ul style="list-style-type: none"> Apply when weeds are small and actively growing. Two applications of 1.75 L/ha (0.7 L/ac) 10 days apart may be required to control the perennial weeds.
bentazon plus oil concentrate	0.84 to 1.08 kg/ha 2 L/ha		<ul style="list-style-type: none"> No adjuvant is required with BASAGRAN FORTÉ. Do NOT apply if rain is expected within 6 hours after application.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Notes on Herbicides, page 29).
REFLEX (240 g/L) plus AGRAL 90	1 L/ha 2.5 L/1,000 L	0.4 L/ac 2.5 L/1,000 L	<ul style="list-style-type: none"> Do NOT use on adzuki beans. Apply POST when beans are in the 1-2 trifoliolate leaf stage. Apply when weeds are small and actively growing. Apply in 200-350 L water/ha (80-140 L/ac water). Do NOT apply if rain is expected within 4 hours after application. Do NOT apply REFLEX to any field more often than once every 2 years. Do NOT apply to crop under stress. Some rotational cropping restrictions apply. Do NOT harvest dry beans within 84 days of application. Do NOT harvest snap beans within 30 days of application.
fomesafen plus adjuvant	0.24 kg/ha 0.25% v/v		
Postemergence Tank-Mixes			
BASAGRAN (480 g/L) plus REFLEX (240 g/L) plus ASSIST	1.75 L/ha 0.58 L/ha 2 L/ha	0.7 L/ac 0.23 L/ac 0.8 L/ac	<ul style="list-style-type: none"> Apply POST when beans are in the 1-2 trifoliolate leaf stage. Use only on white and kidney beans. Refer to the BASAGRAN label and the REFLEX label for information on specific weed stage and height. Do NOT apply if rain is expected within 6 hours after application.
bentazon plus fomesafen plus oil concentrate	0.84 kg/ha 0.14 kg/ha 2 L/ha		
EXCEL SUPER (80.5 g/L) plus BASAGRAN (480 g/L) plus ASSIST	0.67 L/ha 1.75 to 2.25 L/ha 2 L/ha	0.27 L/ac 0.7 to 0.9 L/ac 0.8 L/ac	<ul style="list-style-type: none"> Apply POST when beans are in the unifoliolate to 4 trifoliolate leaf stage and annual grasses are in the 2-5 leaf stage. Apply POST to all dry bean (<i>Phaseolus vulgaris</i>) species listed in Table 7-1. Do NOT use on adzuki beans. Temporary crop injury may occur under abnormally hot, humid conditions. Reduce the oil concentrate to 1 L/ha (0.4 L/ac) when these conditions occur. Apply when weeds are small and actively growing. Refer to the BASAGRAN label for information on specific weed stage and height. If broadleaf and grass weeds are not in the correct leaf stage for a tank-mix application, use a split application at the correct stage for each product. Do NOT apply if rain is expected within 6 hours after application.
fenoxaprop-p-ethyl plus bentazon plus oil concentrate	0.054 kg/ha 0.84 to 1.08 kg/ha 2 L/ha		
Preharvest			
AIM EC (240 g/L) plus non-ionic surfactant or MERGE	73 to 117 mL/ha 2.5 L/1,000 L 10 L/1,000 L	30 to 47 mL/ac 2.5 L/1,000 L 10 L/1,000 L	<ul style="list-style-type: none"> Apply to actively growing weeds, up to 10 cm. Coverage of weed and crop foliage is essential for control. Preharvest interval (PHI) is 1 day.
carfentrazone-ethyl plus non-ionic surfactant or MERGE	0.0175 to 0.028 kg/ha 0.25% v/v 0.1% V/V		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Notes on Herbicides, page 29).
glyphosate (360 g/L) or glyphosate (480 g/L) or glyphosate (500 g/L) or glyphosate (540 g/L)	2.5 L/ha 1.86 L/ha 1.8 L/ha 1.67 L/ha	1 L/ac 0.75 L/ac 0.72 L/ac 0.67 L/ac	<ul style="list-style-type: none"> Apply Preharvest when the crop is 30% grain moisture or less (yellow to brown pod colour, 80%–90% leaf drop) and at least 7 days prior to harvest. Do NOT use on snap beans. Do NOT apply to crops grown for seed. Do NOT apply by air. Apply in 50–100 L/ha of water. Do NOT apply if rain is expected within 6 hours after application.
glyphosate*	0.9 kg/ha		
IGNITE (150 g/L)	2.5 to 3 L/ha	1 to 1.2 L/ac	<ul style="list-style-type: none"> Apply Preharvest when approximately 50%–75% of the bean pods have naturally changed colour from green to yellow or brown and at least 9 days before harvest. Do NOT use on snap beans. Do NOT apply to dry beans grown for seed. Use the higher rate when the crop canopy is dense and/or there are high populations of weeds present at application. Apply in a minimum of 110 L/ha (44 L/ac) of water at a pressure of 275 kPa (40 psi). Where crop canopy is dense, or weed growth is heavy, apply 170–220 L/ha (68–88 L/ac) of water. Do NOT apply by air. Do NOT apply if rain is expected within 4 hours after application.
glufosinate ammonium	0.37 to 0.45 kg/ha		
REGLONE DESICCANT (240 g/L) plus AGRAL 90 or AG-SURF	1.25 to 2.3 L/ha 1 L/1,000 L	0.5 to 0.92 L/ac 1 L/1,000 L	<ul style="list-style-type: none"> Apply Preharvest when 80% natural leaf defoliation and 80% of the pods have turned yellow. Do NOT use on lima or snap beans. Avoid regrowth by targeting spray within 7 days of bean variety maturity date and harvest 5–7 days after application. Use 1.25 to 1.7 L/ha by ground and 1.7 to 2.3 L/ha for aerial applications. Use a minimum of 225 L/ha of spray volume. Use the higher rate for heavy canopy of crop or weeds. Do NOT apply if rain is expected within 15 minutes after application.
diquat plus surfactant	0.3 to 0.55 kg/ha 0.1% v/v		

* See Table 4-1. Herbicides Used in Ontario, page 21, for formulations available. See label for specific uses and rates.



GREEN PEAS

PEAS

Production Requirements

Peas are a hardy, cool-season vegetable crop. Optimum pea growth occurs at temperatures in the range of 10°C–17°C (50°F–63°F). Crops grown during the warmer part of the summer (temperatures above 24°C or 75°F) will develop overly fibrous pods and starchy seeds. Most pea varieties mature in 50–60 days.

Peas are suited to well-drained soils. Avoid planting the early crop into heavy soils or variable fields, as they are more prone to root rots and seed insects. The target soil pH is 6.1–6.5. Consider inoculating the seed with rhizobia if peas have not been grown in a field in the past 5 years.

Average Yields

Type	per acre	per hectare
Processing	2–3 tons	4–7 tonnes
Fresh market	150 bu	375 bu

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under Ontario growing conditions. A list of seed suppliers is available in Appendix D, *Vegetable Seed Suppliers*, on page 229.

Seeding and Spacing

Seed size varies considerably between varieties. Adjust the planting rate according to both seed size and percent germination. Pea seed requires a minimum soil temperature of 4°C (39°F) for germination. Planting into colder soils will slow early growth, resulting in uneven stand establishment. Optimum germination occurs at temperatures of 4°C–24°C (40°F–75°F.)

	Metric	Imperial
Row Spacing:	15–20 cm	6–8 in.
In-Row Spacing:	4–5 cm	1½–2 in.
Rate:	100–300 kg/ha	90–270 lb/acre
Depth: (Always plant into moisture.)	2.5–5 cm	1–2 in.

Fertility

Nitrogen

Where phosphate and potash are required, apply 15 kg N/ha (13 lb N/acre) at seeding. If no phosphate and potash are required, the nitrogen may be omitted.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 16 mg P per L soil (ppm)

or higher, peas are unlikely to respond to additional phosphate applications. For soils testing lower than 16 mg P per L soil (ppm), see Table 1–10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 121 mg K per L soil (ppm) or higher, peas are unlikely to respond to additional potash applications. For soils testing lower than 121 mg K per L soil (ppm), see Table 1–12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

If phosphate and potash are required, apply and incorporate them prior to planting. Do not drill fertilizer with the seed.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTTS

These diseases are the most prevalent causes of yield loss in peas. For information on identification and management, see the section *Damping-Off and Root Rotts (Pythium, Phytophthora, Rhizoctonia, Fusarium, Penicillium)*, on page 59.

Also see Table 9–63, *Pea Seed Treatments*, on page 144.

ASCOCHYTA (MYCOSPHAERELLA) BLIGHT

Identification: Infected seedlings develop symptoms similar to damping-off. The stem tissue above the soil-line turns black, reducing water and nutrient uptake. Plants become stunted and weakened.

Infections on established plants cause brown spots on the leaves and stems. The spots have a distinctive dark border. Infected leaves eventually turn yellow and dry off. Plants remain standing and become straw-like.

Development: This disease complex is transmitted through seed-, soil- and wind-borne spores. Spores travel for long distances and can infect large areas. Humid conditions in the crop canopy promote disease development.

Management Notes: Follow a 4–5-year rotation away from peas and other legume crops. Promote vigorous early-season growth by planting into warm soils and

Table 9-63.
Pea Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Insecticide and Fungicide Combination				
Agrox B-2	diazinon + captan	80 g/ 25 kg seed	seed and root maggots, seed decay, damping-off	Use seed within 1 month of treatment. Do not use on seed previously treated with an insecticide.
Agrox CD	diazinon + captan	50 g/ 25 kg seed	seed corn maggot, seed decay, damping-off	Use on seed previously treated with captan or thiram. Do not use on seed previously treated with an insecticide
Fungicide only				
Vitaflo 280	carbathiin + thiram	260-330 mL/ 100 kg seed	seed decay, damping off caused by <i>Pythium</i> , <i>Rhizoctonia</i> and <i>Ascochyta</i>	For use in commercial seed treatment applicators. Do not store treated seed. Do not feed crop to livestock for 4 weeks after planting.
Apron MAXX RTA	fludioxonil + metalaxyl-M	325 mL/ 100 kg seed	seedling blight and damping-off caused by <i>Fusarium</i> , <i>Pythium</i> and <i>Rhizoctonia</i> . Seed-borne ascochyta blight.	Ensure uniform coverage. 30-day re-plant interval for all non-registered crops.
Apron XL LS	metalaxyl-M	20-40 mL/ 100 kg seed	pythium damping-off and root rot	For use in commercial seed-treatment applicators.
Apron FL	metalaxyl	32-110 mL/ 100 kg seed	pythium seed decay and damping-off	For use in commercial seed-treatment plants only. Do not feed crop to livestock for 4 weeks after planting.
Allegiance FL	metalaxyl	32-110 mL/ 100 kg seed	pythium seed decay and damping-off	For use in commercial seed-treatment plants only. Do not feed crop to livestock for 4 weeks after planting.
Captan FL	captan	70 mL/ 25 kg seed	seed decay, damping-off, root rot	
Thiram 75 WP	thiram	25-35 g/ 25 kg seed	seed decay, damping-off	Do not feed treated clippings to livestock.
Insecticide Only				
Cruiser 5 FS	thiamethoxam	50-83 mL/ 100 kg seed	potato leafhopper, seedcorn maggot and wireworm	For use on imported seed only. Not for domestic commercial or on-farm seed treatment. Use high rate for wireworm. Use high rate where populations are expected to be high.

minimizing compaction. See Table 9-64, *Pea Insect and Disease Control Recommendations*, on page 145.

WHITE MOULD (SCLEROTINIA)

White mould is an occasional problem in processing peas. Infection occurs as a result of warm, wet conditions during flowering. A white, cottony growth develops on the pods. Hard, black sclerotia are often imbedded in the fungi. These sclerotia may be difficult to grade-out during processing.

White mould is commonly a problem in beans (snap, edible and soy). Follow a 2-year rotation away from all white mould host crops. For more information, see the section *White Mould (Sclerotinia)*, on page 74, and Table 9-64, *Pea Insect and Disease Control Recommendations*, on page 145.

POWDERY MILDEW AND DOWNY MILDEW

Powdery mildew and downy mildew are also an occasional problem in peas. These diseases overwinter in the

southern U.S. and are blown into Ontario annually. As a result, infections generally occur at the tail-end of the harvest season.

Powdery mildew infections may reduce the yield and quality of late crop peas. Downy mildew infections occur during cool, wet seasons. A dense grey mould develops on the underside of the leaf. Severe infections will cause the plants to turn slimy and fall over.

Insects

SEEDCORN MAGGOTS, WIREWORMS, APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting peas, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59. Also see Table 9-63, *Pea Seed Treatments*, above, and Table 9-64, *Pea Insect and Disease Control Recommendations*, on page 145.

Table 9-64.
Pea Insect and Disease Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
MYCOSPHAERELLA AND ASCOCHYTA BLIGHT						
Qol (group 11)	pyraclostrobin	Headline EC	400–600 mL	160–240 mL	7	48-hr re-entry
carboxamide (group 7)	boscalid	Lance WDG	420 g	168 g	7	Maximum 2 applications/yr. 4-hr re-entry.
WHITE MOULD (SCLEROTINIA)						
carboxamide (group 7)	boscalid	Lance WDG	560–770 g	224–308 g	7	Maximum 2 applications/yr. 4-hr re-entry.
APHIDS						
pyrethroid (group 3)	lambda cyhalothrin	Matador 120 EC	83 mL in 200 L water	33 mL in 18 gal water	14	May also control lygus bugs. Maximum 3 applications/yr. Do not feed or graze treated vines. 24-hr re-entry.
carbamate (group 1A)	pirimicarb	Pirimor 50 DF	150–275 g	60–110 g	6	
	methomyl	Lannate TNG	510 g	204 g	1	24-hr re-entry.
organophosphate (group 1B)	dimethoate	Cygon 480	275–425 mL	110–170 mL	3	Do not feed or graze vines within 21 days of last application. Maximum 2 applications/yr.
		Lagon 480	275–425 mL	110–170 mL	3	
	malathion	Malathion 25 W	4.25 kg	1.7 kg	3	
		Malathion 500 E	2.25 L	0.9 L	3	
naled	Dibrom	1.1–2.2 L	0.44–0.88 L	4	Processing only.	
chlorinated cycloidiene (group 2A)	endosulfan	Thiodan 4EC	1.5–2.0 L	0.6–0.8 L	7	Processing only. Do not feed or graze treated vines. Maximum 2 applications/yr.
		Thionex 50 WP	1.1–1.75 kg	0.4–0.7 kg	7	
SLUGS						
inorganic	ferric phosphate	Sluggo	25–50 kg	10–20 kg	0	Use higher rates on severe infestations.
CUTWORMS						
pyrethroid (group 3)	lambda cyhalothrin	Matador 120 EC	83 mL in 200 L water	33 mL in 18 gal water	14	Apply in the late evening or at night. Do not feed or graze treated vines. 24-hr re-entry.
	permethrin	Pounce 384 EC	180–390 mL	72–156 mL		Apply in the late evening or at night. Apply up to 5-leaf stage. Use high rates on dry soils and/or large cutworms. Do not disturb soil for 5 days after treating.

¹ PHI = Pre-Harvest Interval.

Harvest and Storage

Remove the field heat from peas immediately after harvest. Store at 0°C (32°F) and 95%–98% relative humidity. Under ideal conditions, fresh-market peas will store for 1–2 weeks.

Early harvested peas are an ideal opportunity to include a cover crop in your rotation. Not only do cover crops protect the soil from wind and water erosion, they also scavenge residual nitrogen from the soil and add organic matter back into the soil. For more information on cover crops, see Chapter 2, *Soil Management*, on page 21.

PEAS

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

PREPLANT INCORPORATED (PPI) – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE (PRE) – Rainfall of 15–20 mm within 7–10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Peas – Soil Applied Grass Herbicides

DUAL II MAGNUM (915 g/L) 1.25 to 1.75 L/ha 0.5 to 0.7 L/ac

s-metolachlor/ibexacor 1.14 to 1.6 kg/ha

• Apply PRE.

• **Do NOT** use on muck, peat, high organic matter soils or soils with less than 1% organic matter.

• Use the higher rate for heavier weed populations.

• Apply by ground application equipment only.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
TREFLAN EC (480 g/L) or RIVAL EC (500 g/L) or BONANZA 400 (400 g/L)	1.25 to 1.66 L/ha 1 to 1.3 kg/ha 1.5 to 2 L/ha	0.5 to 0.66 L/ac 0.4 to 0.52 kg/ac 0.6 to 0.8 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Do NOT exceed the low rate on medium textured soils. Do NOT apply to peat or muck soils (>15% organic matter). Do NOT apply to soils with < 2% organic matter. Do NOT apply to fields spread with manure within the last 12 months. Do NOT apply by air.
<i>trifluralin</i>	0.6 to 0.8 kg/ha		
Peas – Soil Applied Broadleaf Herbicides			
GESAGARD 480 (480 g/L)	3.75 to 4.58 L/ha	1.5 to 1.83 L/ac	<ul style="list-style-type: none"> Apply PRE – Apply before weeds emerge, including Eastern black nightshade. Apply in 200–1,000 L/ha (80–400 L/ac) water. Apply only once per year. Use lower rate on sandy soils. Preharvest interval is 55 days.
<i>prometryne</i>	1.8 to 2.2 kg/ha		
Peas – Soil Applied Grass and Broadleaf Herbicides			
PURSUIT (240 g/L)	0.312 L/ha	0.125 L/ac	<ul style="list-style-type: none"> Apply PPI or PRE. Apply only once per year. Allow at least 24 months between PPI applications. Preharvest interval is 50 days.
<i>imazethapyr</i>	0.075 kg/ha		
Peas – Postemergence Grass Herbicides			
POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.			
POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> Apply POST to actively growing grasses. For annual grass, use 0.32 L/ha. Apply at the 1–6 leaf stage (2–5 is optimum). For volunteer grains, use 0.47 L/ha. Apply at the 1–6 leaf stage (2–5 is optimum). For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. Use 100–200 L water/ha (40–80 L water/ac). Grasses emerging after application will not be controlled. Do NOT apply herbicides other than MCPA SODIUM 300 or PURSUIT within 4 days of application. Do NOT graze treated crop. Spray tips angled forward 45° will give better coverage. Do NOT use flood jet or hollow cone nozzles. Do NOT apply if rain is expected within one hour after application. Use ONLY on fresh or dry processing peas. NOT fresh edible pod peas. Preharvest interval is 30 days for fresh processing peas. Preharvest interval is 60 days for dry peas.
<i>sethoxydim</i> <i>surfactant/solvent</i>	0.15 to 0.5 kg/ha 1 to 2 L/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Peas – Postemergence Broadleaf Herbicides

- **Hooded Application ONLY**, refer to Chapter 6, page 80 for precautions and rates.
- **Do NOT** apply closer than 1 day to harvest.

AIM EC (240 g/L)

BASAGRAN (480 g/L)
plus SUPER SPREADER
or ASSIST

1.75 to 2.25 L/ha
1.25 to 2.5 L/1000 L
1 to 2 L/ha

0.7 to 0.9 L/ac
1.25 to 2.5 L/1000 L
0.4 to 0.8 L/ac

bentazon
plus surfactant
or oil concentrate

0.84 to 1.08 kg/ha
0.125% to 0.25% v/v

MCPA SODIUM 300 (300 g/L)*
or MCPA AMINE (500 g/L)*

1.25 L/ha
0.5 L/ha

0.5 L/ac
0.2 L/ac

MCPA*
or MCPA*

0.38 kg/ha
0.25 kg/ha

TROPOTOX PLUS (400 g/L)
or CLOVITOX PLUS (400 g/L)
or TOPSIDE (400 g/L)

2.75 to 4.25 L/ha

1.1 to 1.7 L/ac

MCPB/MCPA

1.1 to 1.7 kg/ha

- Apply POST when peas have at least 3 pairs of leaves.
- Under hot, humid conditions or reduce ASSIST oil concentrate to 1 L/ha (0.4 L/ac).
- For snow peas, use the low rate of 1.75 L/ha (0.7 L/ac) and apply only once per year.
- Refer to the BASAGRAN label for information on specific weed stage and height.
- Two applications, 10 days apart, of 1.75 L/ha (0.7 L/ac) may be required for top growth control of nut sedge and Canada thistle, and suppression of field bindweed.
- **Do NOT** apply if rain is expected within 6 hours after application.
- Preharvest interval is 30 days for snow peas.
- Apply POST when peas are 10–15 cm high.
- **Do NOT** apply after flower buds have formed on peas.
- **Do NOT** apply when temperatures are over 27°C, high humidity, or under drought conditions.
- **Do NOT** apply by air.
- Apply POST when peas have 3–6 expanded leaves.
- **Do NOT** apply after the 6-leaf stage as damage may occur.
- **Do NOT** apply when temperatures are over 27°C, high humidity, or under drought conditions.
- **Do NOT** apply by air.
- **Do NOT** graze or cut treated crop for forage.
- **TOPGROWTH ONLY:** Canada thistle, creeping buttercup, field bindweed, horsetail, perennial sow-thistle, tall buttercup.

* See Table 4-1. Herbicides Used in Ontario, page 21, for formulations available. See label for specific uses and rates.

PEPPERS



PEPPERS

Production Requirements

Peppers grow well in a wide variety of well-drained mineral soils. Lighter soils produce earlier crops. Peppers perform best at a pH of 6.0–6.8. Cultivars grown in Ontario take from 60–76 days to progress from transplanting to mature green fruit. Full-size green fruit are ready to harvest approximately 30–40 days after pollination. Add 20–25 days for ripe colour to develop.

Average Yields

Type	per acre	per hectare
Processing	10–12 tons	22–27 tonnes
Fresh market	6–8 tons	13–18 tonnes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Processors will determine variety selection for crops produced under a processing contract. See Appendix D, *Vegetable Seed Suppliers*, on page 229.

Seeding and Spacing

Plant 200 g of seed to get enough transplants for 1 ha (3 oz/acre). For more information, see the section *Transplanting*, on page 39.

	Row Spacing	In-Row Spacing	Bed Centres
Single rows:			
Early varieties	1.0 m (3 ft)	30 cm (12 in.)	
Standard varieties	1.0 m (3 ft)	45 cm (18 in.)	
Twin rows:	45 cm (18 in.)	45 cm (18 in.)	1.5 m (5 ft)

Plasticulture

Peppers respond well to plastic mulch, row covers and drip irrigation. However, keep in mind that peppers are very sensitive to low temperatures. Row covers may not provide significant frost protection. Monitor the temperature inside the row cover regularly and ventilate when it reaches 35°C (95°F) or higher. Remove the cover once conditions are favourable for good growth and prior to pollination. To control weed growth under the mulch, choose one that blocks most light transmission, such as black, white on black, or infrared-transmitting mulch. For more information, see the section *Season Extension*, on page 34.

Table 9–65.
Pepper Nitrogen Application Schedule

Method	Actual N	
	per hectare	per acre
Soil-applied		
Preplant	35 kg	31 lb
Side-dressed	35 kg	31 lb
Total	70 kg	62 lb
Fertigated		
Preplant (broadcast)	35 kg	31 lb
Transplanting to fruit set	3–5 kg/week	2.7–4.5 lb/week
Fruit sizing	7–10 kg/week	6–9 lb/week
Harvest	3–5 kg/week	2.7–4.5 lb/week

Fertility Nitrogen

Reduce the nitrogen (N) application if manure is applied or legume sod is plowed down. (See Table 1–8, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 9, and Table 1–9, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 10.)

Broadcast and incorporate the recommended preplant nitrogen, along with the required phosphate and potash, prior to planting. Side-dress the remainder of the nitrogen after first fruit set.

For fertigated peppers, broadcast and incorporate the recommended preplant nitrogen, along with all the required phosphate and half the required potash. Apply equal rates of nitrogen and potash through the drip tape according to the schedule in Table 9–65, *Pepper Nitrogen Application Schedule*, above. For more information, see the section *Fertigation*, on page 30.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 61 mg P per L soil (ppm) or higher, peppers are unlikely to respond to additional phosphate applications. For soils testing lower than 61 mg P per L soil (ppm), see Table 1–10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

STARTER SOLUTION

At transplanting, apply a high-phosphorus starter solution. Starter fertilizer is especially important when planting in cool soils. Starter fertilizers are available in several

Table 9–66.
Transplant Starter Solution Recommendations

Soil Temperature	Starter Concentration ¹
<18°C (64°F)	Use full label rate as recommended.
18°C–27°C (64°F–81°F)	Use half of recommended rate.
>27°C (81°F)	Starter not normally required.

¹ Under high temperature or dry conditions or in sandy soils with less than 2% organic matter, use half the recommended rates.

forms, including liquids (10-34-0 or 6-24-6), soluble or granular materials (10-30-20 or 10-52-10). Apply according to the recommendations in Table 9–66, *Transplant Starter Solution Recommendations*, above.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 181 mg K per L soil (ppm) or higher, peppers are unlikely to respond to additional potash applications. For soils testing lower than 181 mg K per L soil (ppm), see Table 1–12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis is a useful tool for diagnosing crop problems or for evaluating a fertilizer program. The objective of a good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the sufficiency range. Attempting to bring the nutrient analysis up to the higher end of the range could possibly result in over-fertilization and may not be economical. For more information, see the section *Plant Analysis*, on page 3.

Use sufficiency ranges as a reference and a guideline only. Plant analysis does not replace soil testing or a sound soil fertility program. See Table 9–67, *Pepper Nutrient Sufficiency Ranges*, below.

Integrated Pest Management TRANSPLANT PRODUCTION — DISEASE MANAGEMENT

Bacterial spot is a serious disease of peppers. Talk to your seed supplier to ensure that proper seed treatment prevention methods have been used. A greenhouse spray program with a fixed copper fungicide can greatly reduce the field infection rate later in the season. Apply every 5 days, starting 2½ weeks after seeding. Use low water volumes — wet the foliage, but not to excessive runoff. Ensure foliage is dry when shipping plants.

Fungicides registered for greenhouse transplant production are listed in Table 9–68, *Greenhouse Pepper Transplant Production Disease Control Recommendations*, on page 148. For more information on vegetable transplant production, see Chapter 5, *Seeding and Transplanting*, on page 37.

Diseases

DAMPING-OFF AND ROOT ROTS (TRANSPLANTS)
Sow seed in a sterilized soil-less mix. Seed treated with thiram is less susceptible to damping-off and root rots. Use 90 g of Thiram 75 WP per 25 kg of seed.

For more information on identification and management, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Penicillium)*, on page 59.

ANTHRACNOSE, BOTRYTIS & ALTERNARIA

Anthracnose can infect immature or mature fruit. Disease development is greatest during warm, wet weather. Fruit lesions appear as small, sunken, water-soaked, circular spots. The lesions gradually expand and darken in the centre.

Botrytis and alternaria are not important pathogens of field pepper, and generally only infect fruit that have been wounded or damaged (i.e., by blossom-end rot or sunscald). Botrytis is more common in prolonged wet conditions. Botrytis occasionally attacks pepper seedlings.

Table 9–67.
Pepper Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts per Million (ppm)			
Most recently mature leaf	prior to blossoming	4–5	0.3–0.5	5–6	0.9–1.5	0.35–0.6	0.3–0.6	30–150	30–100	25–80	20–50	5–10
	first blossom opens	3–5	0.3–0.5	2.5–5	0.9–1.5	0.3–0.5	0.3–0.6					
	early fruit set	2.9–4	0.25–0.4	2.5–4	1–1.5	0.3–0.4	0.3–0.4					
	early harvest	2.5–3	0.2–0.4	2–3	1–1.5	0.3–0.4	0.3–0.4					

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*, 5th Edition. John Wiley & Sons, Inc. New York.

Table 9-68.
Greenhouse Pepper Transplant Production Disease Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	Notes
DAMPING-OFF, ROOT ROT					
pthalamide (group M3)	captan	Maestro 80 DF	1.25 kg/1,000 L of water.		Soil drench treatment. 48-hr re-entry.
		Supra Captan 80 WDG	Apply 50–85 L of solution per 100 m ² (1,076 ft ²).		
dithiocarbamate (group M2)	oxine benzoate	No-Damp	10 mL/L of water		Damping-off. Soil treatment.
BACTERIAL DISEASE					
inorganic (group M1)	copper hydroxide	Kocide 2000	3.2 kg	1.3 kg	Apply every 5 days, when warranted, to a maximum of 5 applications over a 4-week period prior to transplanting. Apply in low water volumes. 1 day pre-harvest interval. 24-hr re-entry.

POWDERY MILDEW

Powdery mildew of peppers can develop over a wide range of temperatures in low or high humidity conditions. A brownish, powdery growth is produced on the underside of the leaves. The upper leaf surface may develop yellow patches; in severe cases, the leaf turns completely yellow and drops off. Symptoms appear on older leaves first.

The pathogen has a wide host range, which includes tomato, however it has not been found to infect tomato in our growing region. Powdery mildew infecting tomato in the northeast U.S. and Ontario has been caused by a different organism; yet another organism causes powdery mildew of cucurbits.

BACTERIAL SPOT

Identification: Leaf lesions start as small, water-soaked spots that become large, irregular lesions with pale centres and dark edges. The centre of the spots may drop out, giving leaves a “shot-hole” or ragged appearance. If the disease is severe, leaves may turn yellow and drop. Fruit lesions start as green, circular, slightly raised spots, later becoming brown and scabby.

Development: Bacterial spot prefers temperatures of 24°C–30°C (75°F–86°F). Abundant rainfall and high humidity aid infection.

Thresholds: None established.

Management Notes: Use disease-free or disinfected seed. Do not plant diseased or unhealthy transplants. Avoid working in fields when foliage is wet. Overhead irrigation may spread this disease. If possible, time irrigation activ-

ities early in the day, allowing ample drying time for the foliage. Alternatively, install drip irrigation, which does not wet the foliage.

Some varieties have tolerance to bacterial spot races 1, 2 and 3. Copper fungicides may slow bacterial spot development; see the section *Bacterial Disease Control With Copper Fungicides*, on page 202, for copper use guidelines. See also Table 9-68, *Greenhouse Pepper Transplant Production Disease Control Recommendations*, on page 148, and Table 9-69, *Pepper Disease and Insect Control Recommendations*, on page 149.

See the OMAFRA Factsheet, *Bacterial Diseases of Tomato: Bacterial Spot, Bacterial Speck, Bacterial Canker*, Order No. 05-069.

VERTICILLIUM WILT

Identification: In peppers, verticillium wilt typically begins with wilting. If severe, leaf yellowing occurs, starting with the older leaves. Eventually, necrotic areas develop, starting at the leaf tips and edges, progressing to leaf drop. Split the plant stem at the base to check for discoloration of vascular tissue.

Development: Verticillium is a soil-borne disease. Symptoms are often more severe after fruit set or during dry periods. The presence of plant parasitic nematodes may further aggravate verticillium wilt.

Thresholds: Soil *Verticillium*, root knot and root lesion nematode counts, available from the Pest Diagnostic Clinic, University of Guelph, will help determine the need for control measures. See Appendix G, *Diagnostic Services*, on page 233.

Table 9-69. Pepper Disease and Insect Control Recommendations

Group Name (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
BACTERIAL LEAF SPOT						
inorganic (group M1)	copper hydroxide	Parasol Flowable	2.3-3.12 L	0.9-1.3 L	1	Apply at 7-10-day intervals.
		Kocide 2000	2.52-3.2 kg	1.0-1.3 kg	1	
FUNGAL DISEASES						
QoI (group 11)	pyraclostrobin	Cabrio EG	560-840 g	224-336 g	0	Anthracnose and alternaria control. Maximum 6 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
carboxamide (group 7)	boscalid	Lance WDG	175-315 g	70-126 g	0	Botrytis grey mould and alternaria. Use 420 g/ha (170 g/acre) to control botrytis grey mould. Maximum 5 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group. 4-hr re-entry.
inorganic salt	potassium bicarbonate	MilStop	2.8-5.6 kg	1.1-2.3 kg	0	Powdery mildew. Spray at 7-day intervals in 1,000 L/ha (10 gal/acre) of water. Use higher rates for heavier disease pressure. 4-hr re-entry.
APHIDS AND PEPPER MAGGOT						
carbamate (group 1A)	pirimicarb	Pirimor 50 DF	275-550 g	110-220 g	3	Aphids only.
organophosphate (group 1B)	dimethoate	Cygon 480	0.7-1.0 L	0.28-0.4 L	7	
		Lagon 480	0.7-1.0 L	0.28-0.4 L	3	
	diazinon ²	Diazinon 50 W	0.5-1.0 kg	0.2-0.4 kg	5	Aphids only.
	acephate	Orthene 75 SP	750 g	300 g	7	Maximum 4 applications/yr.
chlorinated cyclodiene (group 2A)	endosulfan	Thiodan 50 WP	1.0-2.25 kg	0.4-0.9 kg	2	
		Thiodan 4 EC	1.5-2.75 L	0.6-1.1 L	2	
		Thionex 50 WP	1.1 kg	0.45 kg	2	
neonicotinoid (group 4)	acetamiprid	Assail 70 WP	56-86 g	23-35 g	7	Aphids only. 12-hr re-entry.
EUROPEAN CORN BORER						
pyrethroid (group 3)	deltamethrin	Decis 5 EC	250-300 mL	100-120 mL	3	Maximum 3 applications/yr.
	permethrin	Pounce 384 EC	180 mL	73 mL	1	
carbamate (group 1A)	carbofuran	Furadan 480 F	1.1 L	0.45 L	2	48-hr re-entry. Maximum 3 applications/yr.
organophosphate (group 1B)	carbaryl	Sevin XLR	2.5-5.25 L	1.0-2.1 L	2	In areas where corn borer has been a problem, spray every 4 days.
	acephate	Orthene 75 SP	1.1 kg	0.45 kg	7	Do not use more than 4 applications/yr.
naturalyte (group 5)	spinosad	Success 480 SC	83 mL	34 mL	1	Use only on small larvae and low infestations. Maximum 2 applications/yr.
		Entrust 80 W	50 g	20 g	1	Maximum 2 applications/yr. Time application to target egg hatch or very small larvae. Maintain a spray water pH of 6 or greater.
CUTWORMS						
pyrethroid (group 3)	permethrin	Pounce 384 EC	180-390 mL	72-156 mL	1	Apply in the late evening or at night. Use high rates on dry or muck soils or on large larvae. Do not disturb soil for 5 days after treating.
organophosphate (group 1B)	chlorpyrifos	Lorsban 4E	1.2-2.4 L	0.48-0.96 L	40	24-hr re-entry.
		Pyrinex 480 EC	1.2-2.4 L	0.48-0.96 L	40	

¹ PHI = Pre-Harvest Interval.² Control of aphids with diazinon has been inconsistent in many areas.

Management Notes: Follow a 4–6-year crop rotation. Do not rotate with related (solanaceous) crops, strawberries or raspberries. Keep fields clean of host weeds such as nightshades. Cultivars vary in tolerance to verticillium wilt. Soil fumigation may be required if verticillium and nematode counts are high. See the section *Nematodes*, on page 63.

VIRUSES (CUCUMBER MOSAIC VIRUS, TOMATO SPOTTED WILT VIRUS, ETC.)

Identification: Symptoms vary between viruses, cultivars and conditions. Interaction between viruses may occur, complicating visual diagnosis.

Development: Cucumber mosaic is spread by aphids. Thrips are a vector for tomato spotted wilt. The presence of these diseases usually follows periods of high aphid/thrips activity. Tomato mosaic virus is spread mechanically.

Management Notes: Control weed hosts such as pigweeds, nightshades and related weeds, milkweed, purslane and chickweed in and around the field. Spraying for aphids is not effective in controlling the common pepper viruses in Ontario. Tomato spotted wilt virus is rarely of economic concern. See also the section *Aphids*, on page 60.

Insects

CUTWORMS, TARNISHED PLANT BUG, WIREWORMS, APHIDS

For identification and management information on these common vegetable insects affecting peppers, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, and Table 9–69, *Pepper Disease and Insect Control Recommendations*, on page 149.

EUROPEAN CORN BORER

Identification: Larvae are greasy-looking, grey-to-tan-coloured, with small brown spots on each segment and a dark head. Full-grown borer larvae reach 2.5 cm (1 in.) in length. Adult moths are light brown with wavy lines across the wings. Larvae usually enter the fruit under the cap, leaving an entry hole with sawdust-like frass.

Period of Activity: Corn borers are present from mid-July through September. The second generation, and sometimes a partial third generation, attacks peppers. Peppers become susceptible to feeding when the fruit are the size of walnuts (3 cm (1¼ in.) in diameter).

Thresholds: There is no tolerance for this pest in processing or fresh-market pepper crops. Use pheromone traps to monitor adult flight activity. Fields can also be scouted for egg masses and feeding activity, but damage is easy to miss.

Management Notes: Protect pepper fruit from fruit set until harvest if corn borers are active in the field. For effective chemical control, distribute spray material thoroughly. See Table 9–69, *Pepper Disease and Insect Control Recommendations*, on page 149.

For more information, see the OMAFRA Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

PEPPER MAGGOT

Identification: Larvae are legless, whitish-coloured and approximately 11–12 mm (½ in.) long. They do not have a distinct head. The amber-coloured adult flies have yellow and black markings. Females lay eggs in small fruit, creating a small dimple as the fruit sizes. Larvae feed inside the fruit. They are difficult to detect during scouting and grading.

Period of Activity: Pepper maggot activity is confined to the extreme southwest of Ontario and is of concern only in some years.

Thresholds: There is no tolerance for this pest in processing or fresh-market peppers. The presence of adults can be monitored with yellow sticky traps baited with a vial of ammonia. Visual assessments and sweep nets are also used to monitor adult populations.

Management Notes: If monitoring indicates a need, apply four sprays at 7-day intervals, starting the last week of June or first week of July. See Table 9–69, *Pepper Disease and Insect Control Recommendations*, on page 149.

Nematode Control

See the section *Nematodes*, on page 63.

Physiological Disorders

Blossom Drop

Pepper flowers or small fruit may abort and fall off, due to stressful growing conditions, including:

- daytime temperatures above 30°C–32°C (86°F–90°F) or below 15°C (59°F)
- nighttime temperatures above 21°C (70°F)

- dry weather
- excessive nitrogen
- tarnished plant bug injury
- variety sensitivity

Blossom-End Rot

In peppers, blossom-end rot may occur on the side of the fruit as well as at the blossom-end. See the section *Blossom-End Rot (BER)*, on page 204, for details on the causes and management of blossom-end rot.

Harvest and Storage

Harvest green peppers when the fruits are large and firm with a glossy skin. Coloured peppers can be harvested once full, ripe colour has developed. After harvest, wash fresh-market peppers in chlorinated water (100–150 ppm chlorine) to eliminate fruit rotting organisms. Green peppers can be held for 2–3 weeks at 7°C–13°C (45°F–55°F) at a relative humidity of 90%–95%. Fully ripe peppers have a shorter storage life.

See the section *Cooling and Storage*, on page 47.

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE PER HA
active rate per ha

PRODUCT RATE PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

PEPPERS

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

All treatments should be applied in 150–300 L/ha (60–120 L/ac) water. Discussion of cultural methods can be found in the tomato section. Weed control in peppers is best accomplished by combining chemical and cultural methods.

PREPLANT INCORPORATED (PPI) – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

Peppers – Soil Applied Grass Herbicides

TREFLAN EC(480 g/L)	1.25 to 2.4 L/ha	0.5 to 0.96 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Do NOT exceed the low rate on medium textured soils. Do NOT apply to peat or muck soils (> 15% organic matter). Do NOT apply to soils with < 2% organic matter. Do NOT apply to fields spread with manure within the last 12 months. Do NOT apply by air. Do NOT apply on the same land for 2 consecutive years.
or RIVAL EC (500 g/L)	1.2 to 2.2 L/ha	0.48 to 0.94 L/ac	
or BONANZA 400 (400 g/L)	1.5 to 2.75 L/ha	0.6 to 1.1 L/ac	
trifluralin	0.6 to 1.155 kg/ha		

Peppers – Soil Applied Grass and Broadleaf Herbicides

DUAL II MAGNUM (915 g/L)	1.15 to 1.25 L/ha	0.46 to 0.5 L/ac	<ul style="list-style-type: none"> Apply within 48 hours of transplanting Bell Peppers and PREEMERGENCE to weeds. Risk of crop injury increases with early transplanting and soil temperatures below 10°C. Applications made more than 48 hours after transplanting may increase the risk of foliar injury. Do NOT harvest Bell peppers within 80 days of application. Do NOT apply to soils that contain less than 1% or more than 10% organic matter Make only one application per year. Apply in a minimum spray volume of 150 L/ha of water.
s-metolachlor/benoxacor	1.05 to 1.14 kg/ha		

DACTHAL W-75 (75 WP) 9 to 15.5 kg/ha 3.6 to 6.2 kg/ac

chlorthal dimethyl 6.75 to 11.625 kg/ha

- PRE.
- Apply 4–6 weeks after transplanting.
- Apply at a rate of 9 to 13.5 kg/ha (3.6 to 5.4 kg/ac) on light sand or sandy loam soils.
- Apply at a rate of 11 to 15.5 kg/ha (4.4 to 6.2 kg/ac) on medium silt loam soils.
- Do **NOT** use on muck soils.
- Apply in 250 L/ha (100 L/ac) of water.
- If weeds have emerged, cultivate the soil before application.
- Rainfall or irrigation (about 1cm) is necessary for activation.

DEVIRINOL DF (50 DF) 2.25 to 4.5 kg/ha 0.9 to 1.8 kg/ac

napropamide 1.12 to 2.25 kg/ha

- Apply PPI. Incorporate within 24 hours of application.
- Do **NOT** apply to soils with over 10% organic matter.
- Damage to subsequent cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
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Peppers – Postemergence Grass Herbicides

POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.

POAST ULTRA (450 g/L) plus MERGE	0.32 to 1.1 L/ha 1 to 2 L/ha	0.13 to 0.45 L/ac 0.4 to 0.8 L/ac	<ul style="list-style-type: none"> Apply to actively growing grasses. For annual grass, use 0.32 L/ha. Apply at the 1–6 leaf stage. For volunteer grains, use 0.47 L/ha. For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. Use 100–200 L water/ha (40–80 L water/ac). Grasses emerging after application will not be controlled. Spray tips angled forward 45° will give better coverage. Do NOT use flood jet or hollow cone nozzles. Do NOT apply if rain is expected within one hour after application. Do NOT apply closer than 30 days to harvest.
sethoxydim plus surfactant/solvent	0.15 to 0.5 kg/ha 1 to 2 L/ha		

Peppers – Inter-Row Weeding with AIM EC – See Chapter 6, page 78 for precautions and rates.

- Hooded Application ONLY**, refer to Chapter 6, page 80 for precautions and rates.
- Do NOT** apply closer than 1 day to harvest.

SWEET CORN

SWEET CORN

Production Requirements

Sweet corn is well adapted to a wide range of growing areas. Sweet corn is sensitive to cold soils and to frost. It performs best under warm growing conditions. Early-season production is well suited to sandy-loam soils. Later plantings benefit from the higher moisture-holding capacity of silt-loam and clay-loam soils. The target pH is 5.6–6.

Sweet corn maturity ranges from 60–100 days, depending on the variety. Fresh-market sweet corn is usually picked 21 days after 50% silk. Processing fields are harvested slightly later.

Average Yields

Crop	per acre	per hectare
Processing	6–8 tons	13–18 tonnes
Fresh market	1,000 doz (200 bags)	2,500 doz (500 bags)

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix D, *Vegetable Seed Suppliers*, on page 229. Processing sweet corn growers must grow varieties specified by the processor.

Seeding and Spacing

Plant populations of 16,000–18,000 plants/acre (40,000–45,000 plants/ha) are commonly used for early fresh-market varieties. Main season and processing densities range from 18,000–22,000 plants/acre (45,000–55,000 plants/ha).

Row spacing:	75–90 cm	30–36 in.
In-row spacing:	20–25 cm	8–10 in.
Rate:	11–17 kg seed/ha	10–15 lb/acre
Depth:	4–7.5 cm	1.5–3 in.
(Always plant into moisture.)		

Soil Temperature

The minimum soil temperature needed for germination depends on the cultivar and its gene type. Crops planted into cold soils suffer from delayed, uneven emergence. Cold soils also increase the risk of losses to early-season pests, such as 3-leaf dieback, seedcorn maggots and wireworms.

Gene Type	Minimum Soil Temperature
Normal (su)	13°C (55°F)
Sugar-enhanced (se)	16°C (61°F)
Supersweet (sh ₂)	18°C (64°F)

Isolation

All sweet corn must be isolated from field corn. Super-sweet (sh₂) varieties must be separated from both normal (su) and sugar enhanced (se) varieties. Cross pollination will turn sh₂ kernels starchy. If se varieties are pollinated with su pollen, they will revert back to normal sugar levels.

Yellow is the dominant colour gene. Isolation of white varieties is necessary to avoid colour contamination. Bicolour cobs pollinated with yellow pollen will have a lower proportion of white kernels. Isolate indian corn from all types of sweet corn. It will cause black kernels to appear in the cobs.

Separate incompatible varieties by at least 100 m (350 ft) or schedule the plantings so that pollen-shed is at least 2–3 weeks apart.

For more information, see the OMAFRA Factsheet, *High Sugar Sweet Corn*, Order No. 90-126

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 1–8, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 9, and Table 1–9, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 10.)

On all soils, 90 kg N/ha (80 lb/acre) is recommended.

A portion of the nitrogen should be applied preplant or at the time of planting. Apply the planter-fertilizer in a band 5 cm (2 in.) to the side and 5 cm (2 in.) below the seed. To avoid fertilizer injury, do not exceed the maximum banded application rates listed below. Side-dress the remainder of the nitrogen before the corn is 30 cm (12 in.) high.

Fertilizer	Maximum Banded Application Rates ¹	
	kg/ha	lb/acre
Nitrogen	75	67
Nitrogen + potash	75 + 45	67 + 40
Urea	40	36
Urea + potash	40 + 40	36 + 36

¹ Based on 75-cm (30-in.) rows

Table 9-95.
Sweet Corn Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts Per Million (ppm)			
Whole seedlings	3-leaf stage	3-4	0.35-0.5	2.5-4	0.6-0.8	0.25-0.5	0.4-0.6	50-100	40-100	30-40	10-30	5-10
	6-leaf stage	3-4	0.25-0.5	2.5-4	0.5-0.8	0.25-0.5	0.4-0.6	50-100	40-100	30-40	10-30	5-10
Most recently mature leaf	30 in. tall	2.5-4	0.2-0.4	2.5-4	0.5-0.8	0.20-0.4	0.2-0.4	40-100	40-100	25-40	10-30	4-10
	Just prior to tassel	2.5-4	0.2-0.4	2-3.5	0.3-0.6	0.15-0.4	0.2-0.4	30-100	30-100	20-40	10-20	4-10
Ear leaf	Tasselling	1.5-2.5	0.2-0.4	1.2-2	0.3-0.6	0.15-0.4	0.2-0.4	30-100	20-100	20-40	10-20	4-10

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*. 5th edition. John Wiley & Sons, Inc. New York.

Alternatively, pop-up fertilizer may be applied in the furrow directly with the seed:

- Do not use more than 9 kg nitrogen-plus-potash/ha (8 lb/acre).
- Do not place urea with the seed.

Avoid "pop-up" starter fertilizers that use urea as the nitrogen source. If the N component is more than half as much as the P component, the starter may contain urea.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 31 mg P per L soil (ppm) or higher, sweet corn fields are unlikely to respond to additional phosphate applications. For soils testing lower than 31 mg P per L soil (ppm), see Table 1-10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

Phosphate is best applied in a band at the time of planting. Depending on the soil test rating, additional broadcast P applications may or may not be necessary.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 121 mg K per L soil (ppm) or higher, sweet corn fields are unlikely to respond to additional potash applications. For soils testing lower than 121 mg K per L soil (ppm), see Table 1-12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

Micronutrients

Crops vary greatly in their response to micronutrient fertilizers. For complete information, see the section *Micronutrients*, on page 17.

ZINC

Zinc deficiencies occasionally occur on coarse sandy-loam soils with low organic matter. Plants develop pale

yellow bands between the leaf veins, particularly near the leaf axils of the new growth. Soil tests are useful for identifying potential deficiencies. Where zinc is required, it may be applied to the soil mixed in the fertilizer or as a banded application. See the section *Zinc*, on page 20, and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis is a useful tool for diagnosing crop problems or for evaluating a fertilizer program. The objective of a good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the sufficiency range. Attempting to bring the nutrient analysis up to the higher end of the range could possibly result in over-fertilization and may not be economical. For more information, see the section *Plant Analysis*, on page 3.

Only use sufficiency ranges as a reference and a guideline. Plant analysis does not replace soil testing or a sound soil fertility program. See Table 9-95, *Sweet Corn Nutrient Sufficiency Ranges*, above.

Integrated Pest Management Diseases

THREE-LEAF DIEBACK

Symptoms occur either before or shortly after emergence. The young shoot and roots suddenly die off, resulting in poor stand establishment. Two fungi are responsible: *Penicillium* occurs as a contaminant on the seed, whereas *Pythium* is common in most soils. Seeds planted into cool, wet soils and sh2 varieties are most susceptible.

To prevent three-leaf dieback, use one of the fungicide seed treatments listed in Table 9-96, *Sweet Corn Seed Treatments*, on page 190.

**Table 9–96.
Sweet Corn
Seed Treatments**

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Insecticide and Fungicide Combinations				
DCT	diazinon/captan/ thiothanate-methyl	125 g per 25 kg seed	seed maggots, seedling blights, including <i>Penicillium</i> spp.	Seed box treatment.
Agrox B-2	diazinon/captan	85 g per 25 kg seed	seed and root maggots, damping-off and seedling blights	Seed box treatment Use within 1 month of treatment. Do not use on seed previously treated with an insecticide.
Agrox CD	diazinon/captan	50 g per 25 kg seed	seed and root maggots, wireworms, damping-off and seedling blights	Seed box treatment Use on seed previously treated with captan or thiram. Do not use on seed previously treated with an insecticide.
Cruiser 5FS + Maxim 480 FS + Apron XL LS	thiamethoxam + fludioxonil + metalaxyl-M	83–166 mL +5.2–10 mL + 20–40 mL per 100 kg seed	wireworm, seedcorn maggot, white grubs and flea beetles, pythium, penicillium and fusarium damping-off and root rots	For use in commercial seed-treatment plants only. Do not graze or feed to livestock within 45 days of planting.
Cruiser 5 FS + Dynasty 100 FS	thiamethoxam + azoxystrobin	83–166 mL + 10 mL per 100 kg seed	wireworm, seedcorn maggot, white grubs and flea beetles, broad spectrum seed decay and damping-off.	For use in commercial seed-treatment plants only. Do not graze or feed to livestock within 4 weeks of planting.
Fungicide Only				
Dividend XL RTA	difenoconazole/ metalaxyl-M	325 mL per 100 kg seed	penicillium, pythium and rhizoctonia seedling blights	Do not graze or feed to livestock within 60 days of planting.
Apron FL	metalaxyl	46–110 mL per 100 kg seed	pythium seed rot and seedling blight	For use in commercial seed-treatment applicators only. Do not feed crop to livestock for 4 weeks after planting.
Allegiance FL	metalaxyl	46–110 mL per 100 kg seed	pythium seed rot and seedling blight	
Apron XL LS + Maxim 480 FS	metalaxyl-M + fludioxonil	20–40 mL +5.2–10 mL per 100 kg seed	pythium, penicillium and fusarium damping-off and seedling blights	For use in commercial seed-treatment plants only.
Dynasty 100FS + Maxim XL	azoxystrobin + fludioxonil	10 mL + 11–22 mL per 100 kg seed	broad spectrum seed decay and damping-off	For use in commercial seed-treatment plants only. Do not graze or feed to livestock within 4 weeks of planting.
Captan FL	captan	60–85 mL per 25 kg seed	seed decay, damping-off and seedling blights	
Thiram 75 WP	thiram	55 g per 25 kg seed	seed decay and damping-off	Do not feed treated clippings to livestock.
Insecticide Only				
Gaucho 480 FL	imidacloprid	140–520 mL per 100 kg seed	flea beetles and wireworms	For use in commercial seed-treatment plants only. Use high rate for flea beetles. Carry-over of Gaucho-treated seed is not recommended.
Poncho 600	clothianidin	see label for rates	wireworm, seedcorn maggot, corn root worm, white grubs, flea beetles	For use in commercial seed-treatment plants only. One-year plant-back restrictions for leafy, root and tuber vegetables.
Cruiser 5FS	thiamethoxam	83–166 mL per 100 kg seed	wireworm, seedcorn maggot, white grubs and flea beetles	For use in commercial seed-treatment plants only. Use high rate for wireworm. Do not graze or feed to livestock within 45 days of planting.

Seed treatments usually provide only 2 weeks of protection to the seed. Planting into suitably warm soils and ensuring rapid germination is the best protection against three-leaf dieback. For more information, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Penicillium)*, on page 59.

STEWART'S WILT

Identification: Plants infected before the 5-leaf stage become stunted, wilt and die. Later infections cause pale green or yellow stripes, running parallel to the leaf veins. Late damage is easily confused with magnesium deficiency. Wilt-infected plants exhibit brown, mushy tissue inside the stem.

Development: Stewart's wilt is transmitted by the corn flea beetle. Yield losses are most significant when susceptible varieties are infected before the 7-leaf stage. On susceptible varieties, losses at this stage may range from 40%–100%.

Management Notes: Mild winters favour flea beetle survival and increase the risk of problems the following season. There is no control for this disease, however, many varieties have excellent resistance to the Stewart's wilt bacteria. Corn flea beetle control may help prevent the spread of the Stewart's wilt bacterium. See the section *Corn Flea Beetle*, below, for more information.

RUST

Identification: Reddish-brown (rusty) pustules develop on the upper leaf surface. The size of each lesion ranges from 1–3 mm. Older pustules turn blackish-brown.

Development: Rust infection requires cool weather (16°C–23°C or 61°F–73°F) and 3–6 hours of leaf wetness. Heavy overnight dews favour development. The rust fungi does not overwinter in Ontario. Epidemics arise from spores blown in from the U.S. and Mexico.

Thresholds: Prior to silking, plants with more than 6 pustules per leaf will benefit from a fungicide application.

Management Notes: There is a wide range of rust resistance in sweet corn cultivars. Rust infections occurring after silk emergence are unlikely to result in yield losses. See Table 9–97, *Sweet Corn Disease and Insect Control Recommendations*, on page 192.

Insects

SEEDCORN MAGGOTS, WIREWORMS, CUTWORMS, APHIDS, SLUGS

For identification and management information on these common vegetable insects affecting sweetcorn, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, Table 9–96, *Sweet Corn Seed Treatments*, on page 190, and Table 9–97, *Sweet Corn Disease and Insect Control Recommendations*, on page 192.

CORN FLEA BEETLE

Identification: These small (2-mm), black beetles cause elongated scratches on the leaves and transmit the Stewart's wilt virus. Beetle feeding itself does not cause yield losses.

Period of Activity: Beetles overwinter in the top 5 cm (2 in.) of the soil/residue. They emerge when soil tem-

peratures reach 18°C (64°F.) The first peak of activity is in late June. Mild winters favour beetle survival and increase the risk of Stewart's wilt transmission.

Thresholds: Susceptible varieties may require foliar control if more than 10% of the plants have severe feeding injury or there are more than 2 beetles per plant.

Management Notes: Insecticide seed treatments and varietal tolerance provide the best flea beetle control. Susceptibility to Stewart's wilt varies greatly between varieties. Many early hybrids are particularly vulnerable. See Table 9–96, *Sweet Corn Seed Treatments*, on page 190.

Foliar insecticides applied for cutworm control may also reduce adult flea beetle populations.

EUROPEAN CORN BORER

Identification: Full-grown corn borer larvae are 2.5 cm (1 in.) in length. They are a greasy white colour, with a dark head and spots on each segment. Eggs are shiny, white and laid in clusters of 30 that resemble fish scales. Corn borer larvae feed briefly on the leaves but soon tunnel into the protection of the stalk. As the crop matures, borers move from the stalk into the ear.

Period of Activity: Borers overwinter as pupae in corn stubble. Southwestern Ontario experiences two generations per year. Usually, the first-generation adults emerge in mid-June, and the population peaks in mid-July. Second-generation populations peak in August.

In the rest of the province, single-generation corn borers usually emerge in late June or early July. Populations peak in late July to early August. Many areas within Southwestern Ontario (Lambton, Middlesex, Oxford, Brant, Norfolk and Niagara) have an overlap of corn borer generations. These areas experience a sustained peak flight for much of July and August.

Sweet corn is susceptible to corn borer from the late-whorl stage (12–14 leaves) until harvest.

Thresholds: 5% feeding injury or the presence of eggs warrants an insecticide application.

Management Notes: Begin monitoring at the mid-whorl stage. If monitoring indicates a need, apply the first spray at tassel emergence. Direct the sprays down into the whorl and at the developing ears. For good corn borer control, all sprays must target the small larvae. Second-generation larvae often move quickly towards the ear.

Table 9-97.
Sweet Corn
Disease and Insect Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
RUST						
DMI (group 3)	propiconazole	Tilt 250 E	500 mL in 200 L water	200 mL in 18 gal water	14	Aerial application permitted. Under severe disease pressure, make second application in 14 days. May be tank-mixed with Matador or Ripcord insecticides.
		Bumper 418 EC	300 mL in 200 L water	120 mL in 18 gal water	14	
Qoi (group 11)	pyraclostrobin	Headline EC	400-600 mL	160-240 mL	7	48-hr re-entry. Maximum 2 applications/yr.
	azoxystrobin	Quadris Flowable	453 mL in min. 200 L water	181 mL in min. 20 gal water	7	Maximum 2 applications/yr.
chloronitrile (group M5)	chlorothalonil	Bravo 500	3.2 L	1.3 L	14	Maximum 2 applications/yr.
APHIDS						
carbamate (group 1A)	pirimicarb	Pirimor 50 DF	550 g	220 g	3	Ground application. Minimum 450 L of water/ha (40 gal/acre). Aerial application. Minimum 20-45 L of water/ha (2-4 gal/acre). Maximum 1 application/yr.
CORN ROOTWORM						
pyrethroid (group 3)	tefluthrin	Force 3.0 G	37.5 g per 100 m of row	11.5 g per 100 ft of row		Apply in-furrow at planting.
carbamate (group 1A)	carbofuran	Furadan 480 F	500 mL	200 mL	7	Rootworm adults only. 48-hr re-entry.
CUTWORMS²						
pyrethroid (group 3)	cyhalothrin-lambda	Matador 120 EC	83 mL	33.2 mL	-	24-hr re-entry. Apply to moist soils up to 5-leaf stage. Do not disturb soil for 5 days after application.
		Ripcord 400 EC	175 mL	70 mL	21	Apply to moist soils up to 5-leaf stage.
		Pounce 384 EC	180-390 mL	72-156 mL	-	Do not disturb soil for 5 days after application.
organophosphate (group 1B)	chlorpyrifos	Lorsban 4E	1.2-2.4 L	0.48-0.96 L	70	Apply during 2-5 leaf stage in 200-400 L water/ha (18-36 gal/acre). 24-hr re-entry.
		Pyrinex 480 EC	1.2-2.4 L	0.48-0.96 L	70	
SLUGS						
inorganic	ferric phosphate	Sluggo	25-50 kg	10-20 kg	0	Use high rates on severe infestations.

¹ PHI = Pre-Harvest Interval.

² Cutworm treatments are most effective if applied in the early evening or at night when cutworms are most active.

Maintain good spray coverage of the leaves, tassels and ears. There is a very low tolerance for insect damage in the fresh-market industry. Applications at 5-7-day intervals usually give satisfactory control. See Table 9-98, *European Corn Borer, Corn Earworm and Fall Armyworm Control Recommendations*, on page 193.

CORN EARWORM

Identification: Earworm larvae range in colour from yellowish, to green or brown, with a fine double stripe running down their backs. The larvae are slightly larger than

the European corn borer. Female earworm moths lay their eggs on corn silk. The larvae are usually found in the top third of the ear.

Period of Activity: Corn earworm do not overwinter in Ontario. They arrive from the U.S. and Mexico on tradewinds. In Southwestern Ontario, adult moths usually appear in mid-to-late July, or earlier, depending on the season. In eastern and northern areas, arrival occurs in mid-to-late August. In cooler years, these areas may not experience corn earworm at all.

SWEET CORN

Table 9-98.
European Corn Borer, Corn Earworm and Fall Armyworm Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
pyrethroid ² (group 3)	cyhalothrin-lambda	Matador 120 EC	83 mL	33.2 mL	1	Maximum 3 ground applications or 2 aerial applications/yr. 24-hr re-entry.
	deltamethrin	Decis 5 EC	250-300 mL	100-120 mL	5	Maximum 2 ground or 1 aerial applications/yr. Not registered for fall armyworm.
	cypermethrin	Ripcord 400 EC	175 mL	70 mL	5	
	permethrin	Pounce 384 EC	275-375 mL	110-150 mL	1	Maximum 2 aerial applications permitted. Use 180 mL/ha (72 mL/acre) for fall armyworm.
biological (group 11)	<i>Bacillus thuringiensis</i>	Dipel 2X DF	0.56-1.12 kg	0.22-0.44 kg		European corn borer only. Apply when pinhole feeding is observed on 5% of plants. Maximum 6 applications/yr.
		Bioprotec CAF	2.8-4.0 L	1.1-1.6 L		
carbamate (group 1A)	carbofuran ³	Furadan 480 F	1.1 L	0.44 L	7	European corn borer only. Maximum 2 applications/yr. 48-hr re-entry. ³
	carbaryl	Sevin XLR	2.5-4.0 L	1-1.6 L	1	European corn borer only.
	methomyl	Lannate TNG	430-625 g	172-250 g	3	24-hr re-entry. Use high rate for corn borer. Not registered for fall armyworm.
organophosphate (group 1B)	acephate	Orthene 75 SP	0.75-1.1 kg	0.3-0.44 kg	21	European corn borer only. Maximum 4 applications/yr.
naturalyte (group 5)	spinosad	Success 480 SC	83 mL	33.2 mL	7	European corn borer only. Use only on very small larvae and low populations. Maximum 2 applications/yr. Maintain a spray pH of 6 or greater.
		Entrust 80 W	50 g	20 g	7	

¹ PHI = Pre-Harvest Interval.

² Pyrethroid sprays rapidly degrade at temperatures over 26.5°C (80°F), and more frequent spray applications are often required. Spraying during cooler evening temperatures may increase the performance of these products.

³ If prolonged, direct contact with corn foliage will occur, do not re-enter treated fields between 2-14 days of application without wearing appropriate protective clothing such as long pants and a long-sleeved shirt.

Earworm activity is highest in hot weather conditions. Peak flights often occur immediately after severe thunderstorms.

Thresholds: Use pheromone traps to monitor corn earworm populations. Insecticide applications are based on the number of moths caught per week and the average temperatures. See Table 9-99, *Corn Earworm Spray Intervals*, below.

Table 9-99.
Corn
Earworm Spray Intervals

Moths/trap per week	Spray Intervals	
	<27°C (81°F) ¹	27°C (81°F) ¹
1-6	5-7 days	5-7 days
7-90	5 days	4 days
More than 90	4 days	3 days

¹ Daily maximum temperature.

Management Notes: Sweet corn is only susceptible to corn earworm damage while the silks are green. Good spray coverage of the rapidly growing silks is important. Pyrethroid sprays break down quickly under high temperature conditions, and more frequent spray applications are required. See Table 9-98, *European Corn Borer, Corn Earworm and Fall Armyworm Control Recommendations*, above.

Transgenic varieties (Bt Sweet Corn) have complete resistance to corn borers and partial resistance to earworms and fall armyworms. Insecticides may be needed for other pests if pressure is high. Check with your seed company representative for availability and planting restrictions.

Bee Warning

Bees often visit sweet and field corn to collect water and pollen. Spraying may cause bee poisoning. Many of the insecticides used to control sweet corn pests are highly toxic to bees.

Damage to bees is reduced when sprays are applied in the late evening when bees are not foraging. Do not treat when the wind is blowing. Avoid spray drift to roadsides and adjacent fields where plants might be in bloom.

Advise local beekeepers of spraying activity (see the section *Prevent Bee Poisoning*, on page 53).

FALL ARMYWORM

Fall armyworm are also migratory pests. They usually arrive in Ontario slightly later than the corn earworm. The pale-green or tan-coloured larvae create large, rough holes in the leaves and the cob. The spray threshold is 5% feeding injury. Sprays used for corn borer and corn earworm usually control the armyworm as well. See Table 9-98, *European Corn Borer, Corn Earworm and Fall Armyworm Control Recommendations*, on page 193.

CORN ROOTWORM

Corn rootworm adults lay their eggs in the fall in corn fields. The following spring, emerging larvae will feed on corn roots. They weaken the root system, often causing lodging (or goosenecking). Crop rotation will almost always control corn rootworm populations; however, a new variant of the corn rootworm is present in Ontario. This variant lays its eggs in soybean crops. Additional control may be necessary if this variant is present in fields rotated solely with soybeans. See Table 9-96, *Sweet Corn Seed Treatments*, on page 190, and Table 9-97, *Sweet Corn Disease and Insect Control Recommendations*, on page 192.

Adult beetles occasionally feed on corn silks in late July-early August. Populations are usually kept under control by corn borer and earworm sprays. Severe feeding may result in poor kernel set.

GRUBS

White grubs and European chaffer are an occasional pest of sweet corn, especially on coarse, sandy-loam soils.

They feed on the roots of emerging seedlings, causing them to wilt and die. When pulled, affected plants will be root-less. White grubs have a 3-year life cycle and are most commonly associated with turf and berry crops. The European chaffer is an annual grub. Its peak feeding activity is May through mid-June. See Table 9-96, *Sweet Corn Seed Treatments*, on page 190.

For more information on integrated pest management in sweet corn, see the following OMAFRA Factsheets and publication:

- *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019
- *Corn Earworm*, Order No. 95-065
- *Managing Cutworms in Vegetable Crops*, Order No. 00-055
- *Managing Wireworm in Vegetable Crops*, Order No. 00-047
- Publication 12, *Sweet Corn Production Manual*

Birds

RED-WINGED BLACKBIRDS AND CROWS

Noisemakers, such as propane cannons and digital distress calls, are often used to scare birds away from sweet corn crops. For full effectiveness, start using these devices before the corn becomes attractive for feeding and move them around frequently. Avoid planting near marshy and wooded areas. Cultivars with ears well-covered by husks are somewhat resistant to bird damage. For complete bird control information, see the section *Birds*, on page 64.

Harvest and Storage

Sweet corn is harvested while the kernels are at the early milk stage. Eating quality declines quickly if cobs are left in the field past this stage. Under good storage conditions, supersweet varieties may last for up to 1 week. Normal (su) and sugar-enhanced (se) varieties lose quality after 2-3 days.

Remove the field heat from the crop as quickly as possible after harvest. Store at temperatures close to 0°C (32°F) with a relative humidity of 95%-98%.

For more information, see Chapter 6, *Food Safety and Storage*, on page 45.

9. CORN (FIELD, SEED & SWEET)

NOTES: Weed control ratings are given as 0-9 where 0 indicates no control, and 9 indicates 90%-100% control under ideal conditions. Ratings are subjective values based on best available information and given general comparisons based on use as described in this guide. Crop tolerance ratings are: E - Excellent, G - Good, F - Fair, P - Poor. Under unfavourable conditions (e.g. too dry, too wet, too cold or poor application) the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used. Ratings in **BOLD** indicate the weed is listed on the product label for control or suppression. Please see product label for more information on registered weed species, product uses and precautions.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS

TRADE NAME	CROP	ANNUAL BROADLEAVES														PERENNIALS																
		ANNUAL GRASSES														PERENNIALS																
Preplant Burndown Herbicides - Refer to Tables 6-1, page 75 and 6-2, page 77 for a list of herbicides and weed control ratings.																																
Soil Applied Grass Herbicides																																
DUAL II MAGNUM	✓	✓	9	9	9	8 ^a	8	9	9	9	4	2	2	2	?	2	7	2	8/9 ^c	7/8	4	3	3	0	0	0	8 ^b	0	0	0	0	E
ERADICANE	✓	✓	9	9	9	8	8	9	9	9	7	2	4	8	?	7	8	2	8	7	7	?	4	2	7	0	8 ^a	2 ^a	2	2	E	
FRONTIER	✓	✓	9	9	9	8 ^a	8	9	9	9	4	2	2	2	?	2	7	2	8/9 ^c	7/8	4	3	3	0	0	0	8 ^b	0	0	0	E	
PROWL	✓	✓	9	9	9	9	8	8	8	?	5	?	?	?	?	6	9	0	8	8	2	?	6	?	?	?	?	?	?	?	E	
Soil Applied Broadleaf Herbicides																																
LOROX	✓	✓	7	7	7	7	7	7	7	7	2	9	5	?	?	9	9	9	8	9	8	?	5	0	0	0	0	0	0	0	0	G
atrazine*	✓	✓	2	2	2	2	2	2	2	2	2	9	7	9	?	9	9	9	9	9	9	6	5	2	0	0	0	2	2	0	E	
BANVEL II, ORACLE	✓	✓	0	0	0	0	0	0	0	0	0	8	7	8	?	9	9	6	9	9	9	7	8	2	0	0	0	0	2	2	G	
CALLISTO	✓	✓	2	0	3	0	2	2	2	2	2	6	6	?	?	7	9	9	9	9	9	7	6	9	2	0	0	0	0	0	E	

✓ Can be used on this crop.
 1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties - see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 4-2, page 59 for a list of registered products.
 6 Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieve this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.

BOLD numbers indicate the weed is listed on the product label for control or suppression.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP	ANNUAL GRASSES										ANNUAL BROADLEAVES										PERENNIALS															
		seed corn	sweet corn	field corn	barnyard grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	fleabane, Canada	lady's thumb	lamb's-quarters	mustards	nightsades	pigweeds	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed	nutsedge	quackgrass	sow-thistle	thistle, Canada	Crop Tolerance				
MARKSMAN	✓	✓	2	2	2	2	2	2	2	2	2	2	9	7	9	?	9	9	9	9	9	9	9	7	8	2	0	0	0	2	2	2	2	G			
PRINCEP NINE-T, SIMADEX, SIMAZINE 480	✓	✓	9	8	8	7	9	9	9	9	9	2	9	7	9	?	9	9	9	9	9	9	8	?	5	2	0	0	5	5	2	2	E				
Soil Applied Grass and Broadleaf Herbicides																																					
BATTALION ¹	✓		9	8	8	9	8	8	8	9	7	9	?	8	?	8	9	?	8	9	?	8	9	7	8	?	?	?	?	?	?	?	?	G			
CONVERGE PRO ¹	✓		9	9	9	9	9	9	9	9	8	8	6	?	8	9	9	9	9	9	9	9	7	9	?	?	0	0	0	0	0	0	0	G			
PRIMEXTRA II MAGNUM	✓	✓	9	9	9	8	8	9	9	9	2	9	7	9	?	9	9	9	9	9	9	9	?	7	0	0	0	0	8 ^b	0	0	0	E				
Soil Applied Tank-Mixes																																					
DUAL II MAGNUM + BANVEL II, ORACLE	✓		9	9	9	8	8	9	9	9	4	8	8	8	?	9	9	6	9	9	9	9	7	8	2	0	0	7	0	2	2	G					
DUAL II MAGNUM + CALLISTO + atrazine	✓	✓	9	9	9	8	8	9	9	9	4	9	8	9	?	9	9	9	9	9	9	9	7	9	2	0	0	7	0	0	0	E					
DUAL II MAGNUM + CONVERGE PRO ¹	✓		9	9	9	8	8	9	9	9	6	?	?	?	?	9	9	9	9	9	9	9	?	9	?	?	0	0	7	0	0	G					
DUAL II MAGNUM + LOROX + atrazine*	✓		9	9	9	8	8	9	9	9	2	9	7	9	?	9	9	9	9	9	9	9	?	7	0	0	0	7	0	0	0	E					
DUAL II MAGNUM + MARKSMAN	✓		9	9	9	8	8	9	9	9	4	9	8	9	?	9	9	9	9	9	9	9	7	8	2	0	0	7	0	2	2	G					
ERADICANE + atrazine*	✓	✓	9	9	9	8	8	9	9	9	7	9	7	9	?	9	9	9	9	9	9	9	6	5	2	7	0	8 ^a	2 ^a	2	2	E					
ERADICANE + SENCOR	✓	✓	9	9	9	8	8	9	9	9	7	7	7	8	?	9	9	9	9	9	9	8	?	8	2	7	0	8 ^a	2 ^a	2	2	G					
FRONTIER + atrazine*	✓	✓	9	9	9	8	8	9	9	9	4	9	7	9	?	9	9	9	9	9	9	9	6	5	2	0	0	8 ^b	2	2	0	E					
FRONTIER + BANVEL II, ORACLE	✓		9	9	9	8	8	9	9	9	4	8	8	8	?	9	9	6	9	9	9	9	7	8	2	0	0	7	0	2	2	G					

^{*} Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
[?] Insufficient information available to make a rating.
^a Use the high rate of herbicide for optimum control.
^b PPI timing is needed to achieve this level of control.
^c Use PRE timing for optimum control.
^d The addition of atrazine is required to achieve this level of control.
¹ Can be used on this crop.
² Indicates herbicides sold as a co-pack under this trade name.
³ Use only on selected varieties – see precautions for tolerant varieties on label.
⁴ For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
⁵ For use on ROUNDUP READY corn (glufosinate tolerant) only, see Table 4-2, page 59 for a list of registered products.
⁶ Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP	ANNUAL GRASSES										ANNUAL BROADLEAVES										PERENNIALS															
		seed corn	sweet corn	field corn	barnyard grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	fleabane, Canada	lady's thumb	lamb's-quarters	mustards	nightshades	pigweeds	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed	nutsedge	quackgrass	sow-thistle	thistle, Canada	CROP TOLERANCE				
FRONTIER + MARKSMAN	✓	✓	9	9	9	9	8	8	9	9	9	9	4	9	8	9	?	9	9	9	9	9	9	7	8	2	0	0	7	2	2	2	G				
LOROX + atrazine*	✓	✓	7	7	7	7	7	7	7	7	7	2	9	7	9	?	9	9	9	9	9	9	?	5	2	0	0	0	2	2	0	G					
PRIMEXTRA II MAGNUM + BANVEL II, ORACLE	✓	✓	9	9	9	8	8	9	9	9	9	4	9	8	9	?	9	9	9	9	9	9	7	8	2	0	0	7	0	0	0	E					
PRIMEXTRA II MAGNUM + CALLISTO + atrazine	✓	✓	9	9	9	8	8	9	9	9	9	4	9	7	9	?	9	9	9	9	9	9	?	7	0	0	0	7	0	0	0	E					
PRIMEXTRA II MAGNUM + LOROX	✓	✓	9	9	9	9	8	8	8	8	?	5	9	7	9	?	9	9	9	9	9	9	6	6	2	?	?	?	?	2	?	E					
PROWL + atrazine*	✓	✓	9	9	9	9	8	8	8	8	?	5	8	8	8	?	9	9	6	9	9	9	7	8	?	?	?	?	?	?	?	E					
PROWL + BANVEL II, ORACLE	✓	✓	9	9	9	9	8	8	8	8	?	5	9	8	9	?	9	9	9	9	9	9	7	8	?	?	?	?	?	?	?	E					
PROWL + MARKSMAN	✓	✓	9	9	9	9	8	8	8	8	?	5	9	8	9	?	9	9	9	9	9	9	7	8	?	?	?	?	?	?	?	E					
Postemergence Grass Herbicides																																					
DUAL II MAGNUM	✓	✓	9	9	9	8	8	8	8	9	2	0	0	0	0	0	7	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	E			
FRONTIER	✓	✓	9	9	9	8	8	8	8	9	2	0	0	0	0	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	E			
ACCENT	✓	✓	9	0	7/8	9	9	9	8	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	?	?	?	?	?	?	?	G			
ULTIM	✓	✓	9	0	7/8	9	9	9	7	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	G			
Postemergence Broadleaf Herbicides																																					
2,4-D*	✓	✓	0	0	0	0	0	0	0	0	0	0	0	4	8	2	?	4	9	9	7	9	8	?	9	7	0	0	0	0	0	8	8	G			
2,4-DB* (CALIBER, COBUTOX, EMBUTOX)	✓	✓	0	0	0	0	0	0	0	0	0	0	0	4	8	0	?	0	7	8	7	9	8	?	8	8	0	0	0	0	0	0	8	8	G		
atrazine* + oil	✓	✓	4	4	4	0	4	4	4	4	4	4	4	9	7	9	?	9	9	9	9	9	8	7	7	5	2	5	5	7	2	G					
BANVEL II, ORACLE	✓	✓	0	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	6	9	9	9	9	9	8	0	0	0	0	0	9	8	G			

✓ Can be used on this crop.
 * Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieve this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.

1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties - see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 4-2, page 59 for a list of registered products.
 6 Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

BOLD numbers indicate the weed is listed on the product label for control or suppression.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP	ANNUAL GRASSES											ANNUAL BROADLEAVES											PERENNIALS									
		ANNUAL GRASSES											ANNUAL BROADLEAVES											PERENNIALS									
		seed corn	sweet corn	field corn	barley grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	fleabane, Canada	lady's thumb	lamb's-quarters	mustards	nights shades	pigweeds	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed	nutsedge	quackgrass	sow-thistle	thistle, Canada	CROP TOLERANCE
BASAGRAN FORTE	✓	✓	✓	0	0	0	0	0	0	0	0	0	7	9	9	?	5	9	7	9	7	8	8	8	9	6	0	0	6	0	6	8	E
BUCTRIL M, BADGE, LOGIC M, MEXTROL	✓	✓	✓	0	0	0	0	0	0	0	0	0	9	9	?	?	9	9	9	9	9	9	?	9	7	7	0	0	0	7	7	G	
CALLISTO + atrazine	✓	✓	✓	2	0	4	0	2	2	2	2	2	8	8	?	?	9	9	9	9	9	9	8	8	9	2	0	0	0	0	0	E	
DISTINCT	✓	✓	✓	?	?	?	?	?	?	?	?	?	9	9	9	9	9	6	9	9	9	9	9	9	9	8	0	0	0	0	0	E	
IMPACT + atrazine*	✓	✓	✓	7	7	7	7	8	7	7	7	7	8	9	?	?	9	9	9	9	9	9	9	9	7	?	?	?	?	?	?	E	
KORIL	✓	✓	✓	0	0	0	0	0	0	0	0	0	9	8	?	?	9	9	8	9	8	9	?	9	7	7	0	0	0	7	7	E	
LADDOK	✓	✓	✓	0	0	0	0	0	0	0	0	0	9	9	?	?	9	9	9	9	9	9	?	9	7	7	0	0	6	0	7	E	
MARKSMAN	✓	✓	✓	7	0	0	0	7	7	7	7	0	9	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	8	E	
MCPA*	✓	✓	✓	0	0	0	0	0	0	0	0	0	2	7	7	?	?	0	9	9	?	7	9	?	7	7	6	0	0	0	7	G	
PARDNER	✓	✓	✓	0	0	0	0	0	0	0	0	0	9	8	?	?	9	9	8	9	8	9	?	9	7	7	0	0	0	7	E		
PEAKPLUS ¹	✓	✓	✓	0	0	0	0	0	0	0	0	0	?	9	?	?	9	9	9	?	9	9	9	9	?	?	?	?	?	?	?	E	
SHOTGUN	✓	✓	✓	0	0	0	0	0	0	0	0	0	9	7	?	?	9	9	9	9	9	9	?	9	0	0	?	?	?	?	?	E	
SUMMIT	✓	✓	✓	?	?	?	?	?	?	?	?	?	?	9	?	?	?	9	9	?	9	9	9	9	?	?	?	?	?	?	?	G	
TROPOTOX PLUS, CLOVITOX PLUS, TOPSIDE	✓	✓	✓	0	0	0	0	0	0	0	0	0	8	8	0	?	0	7	8	7	9	9	?	9	8	0	0	0	0	8	8	G	
Postemergence Grass and Broadleaf Herbicides																																	
BATTALION ¹	✓	✓	✓	9	8	8	9	8	8	9	7	9	?	8	?	8	9	8	8	9	9	7	8	?	?	?	?	?	?	?	?	G	
PRIMEXTRA II MAGNUM	✓	✓	✓	9	9	9	8*	8	8	8	9	2	9	7	9	?	9	9	9	9	9	?	7	0	0	0	0	0	3	0	0	E	
Postemergence Grass and Broadleaf Herbicides - Herbicide Tolerant Hybrids Only																																	
LIBERTY 200 SN ³	✓ ³	✓	✓	9	9	9	9	9	9	8/9	9	9	8	9	?	7	8/9	9	9	9	9	9	?	8/9	6	6	?	6	6/7	8	7	E ³	

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieve this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.
BOLD numbers indicate the weed is listed on the product label for control or suppression.
 ✓ Can be used on this crop.
 1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties - see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

CORN

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP	ANNUAL BROADLEAVES											PERENNIALS								CROP TOLERANCE													
		ANNUAL GRASSES											ANNUAL BROADLEAVES																					
		seed corn	sweet corn	field corn	barnyard grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	flabane, Canada	lady's thumb	lamb's-quarters	mustards	nightsades	pigeons	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed	nutssedge	quackgrass	sow-thistle	thistle, Canada		
glyphosate ¹	✓	✓	✓	✓	9	9	9	9	9	9	9	9	9	8	9	8	8	8	8	9	9	9	9	7/8	9	7/8	?	8	7	9	8	9	E ⁴	
Postemergence Tank-Mixes																																		
ACCENT + BANVEL II, ORACLE	✓	✓	✓	✓	9	0	7/8	9	9	9	8	9	9	9	9	9	9	9	9	6	9	9	9	?	9	?	8	0	0	0	9	8	0	G
ACCENT + CALLISTO + atrazine*	✓	✓	✓	✓	9	0	7/8	9	9	9	8	9	9	9	8	8	?	?	9	9	9	9	8	?	9	?	2	0	0	0	9	0	0	E
ACCENT + DISTINCT, ACCENT TOTAL ¹	✓	✓	✓	✓	9	0	7/8	9	9	9	8	9	9	9	9	9	9	9	6	9	9	9	9	9	9	9	8	0	6	0	9	9	0	E
ACCENT + MARKSMAN	✓	✓	✓	✓	9	0	7/8	9	9	9	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	9	8	0	E
ACCENT + PARDNER	✓	✓	✓	✓	9	0	7/8	9	9	9	8	9	9	9	9	8	?	?	9	9	8	9	8	9	?	9	?	7	0	0	0	9	7	E
ACCENT + PEAKPLUS ¹ , ACCENT ONE PASS ¹	✓	✓	✓	✓	9	0	7/8	9	9	9	8	9	9	9	?	?	?	?	9	9	9	8 ^d	9	9	9	9	5	0	0	0	9	0	0	E
ACCENT + SHOTGUN	✓	✓	✓	✓	7	?	?	9	?	7	7	?	?	?	9	7	?	?	9	9	9	9	9	?	9	?	0	?	0	0	9	?	?	G
atrazine* + BANVEL II or ORACLE	✓	✓	✓	✓	4	4	4	0	4	4	4	4	4	4	9	9	9	9	9	9	9	9	9	9	9	9	8	5	2	5	5	9	8	G
atrazine* + BUCTRIL M or BADGE or LOGIC M or MEXTROL	✓	✓	✓	✓	4	4	4	0	4	4	4	4	4	4	9	9	9	7	9	9	9	9	9	?	9	?	7	7	2	5	5	7	7	G
atrazine* + KORIL	✓	✓	✓	✓	4	4	4	0	4	4	4	4	4	4	9	8	9	7	9	9	9	9	9	?	9	?	7	5	2	5	5	7	2	E
atrazine* + PARDNER	✓	✓	✓	✓	4	4	4	0	4	4	4	4	4	4	9	9	9	7	9	9	9	9	9	?	9	?	7	5	2	5	5	7	2	E
BANVEL II or ORACLE + 2,4-D*	✓	✓	✓	✓	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	9	8	G
BANVEL II or ORACLE + PARDNER or KORIL	✓	✓	✓	✓	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	8	9	9	9	?	9	?	8	0	0	0	0	9	8	G

✓ Can be used on this crop.
 1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties - see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 4-2, page 59 for a list of registered products.
 see Table 9-5, page 149 for a list of registered products.

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieve this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.

BOLD numbers indicate the weed is listed on the product label for control or suppression.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP		ANNUAL GRASSES										ANNUAL BROADLEAVES										PERENNIALS					CROP TOLERANCE					
	seed corn	sweet corn	field corn	barnyard grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	fleabane, Canada	lady's thumb	lamb's-quarters	mustards	nightshades	pigweeds	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed		nutsedge	quackgrass	sow-thistle	thistle, Canada	
DUAL II MAGNUM + BANVEL II or ORACLE	✓			9	9	9	8*	8	8	8	9	2	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	9	8	G	
DUAL II MAGNUM + CALLISTO + atrazine*	✓			9	9	9	8*	8	8	8	9	4	9	8	?	?	9	9	9	9	9	9	8	9	2	0	0	3	0	0	0	E	
DUAL II MAGNUM + MARKSMAN	✓			9	9	9	8*	8	8	8	9	2	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	8	8	E	
FRONTIER + BANVEL II or ORACLE	✓			9	9	9	8*	8	8	8	9	2	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	9	8	G	
FRONTIER + MARKSMAN	✓			9	9	9	8*	8	8	8	9	2	9	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	0	8	8	E	
IMPACT + FRONTIER + atrazine*	✓			9	9	9	9	8	9	9	9	?	8	9	?	9	9	9	9	9	9	9	9	7	?	?	?	?	?	?	E		
OPTION 1.2.3.	✓			9	7	7	9	9	9	9	9	7	9	?	?	?	9	9	9	9	9	9	9	7	?	0	0	0	?	?	E		
OPTION + atrazine*	✓			9	0	7	9	9	9	7	9	9	9	9	?	?	9	9	9	9	9	9	?	9	7	5	2	5	7/8	7	2	E	
OPTION + BANVEL II or ORACLE	✓			9	0	7	9	9	9	8	9	9	9	9	9	9	9	9	9	9	9	9	?	9	8	0	0	0	9	9	8	E	
OPTION + CALLISTO + atrazine*	✓			9	0	7	9	9	9	8	9	9	8	8	?	?	9	9	9	9	9	9	8	9	2	0	0	0	9	0	0	E	
OPTION + DISTINCT	✓			9	0	7	9	9	9	8	9	9	8	9	9	9	9	9	9	9	9	9	9	9	8	0	0	0	9	0	0	E	
OPTION + MARKSMAN	✓			9	0	7	9	9	9	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	?	?	?	0	7/8	8	8	E
OPTION + PARDNER + atrazine*	✓			9	0	7	9	9	9	7	9	9	9	9	?	?	9	9	9	9	9	9	?	9	7	5	2	5	8	7	5	E	
OPTION + PEAK PLUS ¹	✓			9	0	7	9	9	9	8	9	9	9	?	?	?	9	9	9	9	9	9	9	9	?	?	7	0	9	?	E		

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 * Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieved this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.

✓ Can be used on this crop.
 1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties – see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only, see Table 4-2, page 59 for a list of registered products.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

BOLD numbers indicate the weed is listed on the product label for control or suppression.

TABLE 9-1. CORN (FIELD, SEED AND SWEET) HERBICIDE WEED CONTROL RATINGS (CONT'D)

TRADE NAME	CROP	ANNUAL GRASSES													ANNUAL BROADLEAVES						PERENNIALS																		
		seed corn	sweet corn	field corn	barnyard grass	smooth crabgrass	large crabgrass	fall panicum	foxtail, giant	foxtail, green	foxtail, yellow	witch grass	proso millet	buckwheat, wild	cocklebur	corn spurry	fleabane, Canada	lady's thumb	lamb's-quarters	mustards	nightsades	pigweeds	ragweed, common	ragweed, giant	velvetleaf	bindweed, field	horsetail	milkweed	nutsedge	quackgrass	sow-thistle	thistle, Canada	CROP TOLERANCE						
ULTIM + PEAKPLUS ¹	✓	✓	9	0	7/8	9	9	9	7	9	9	9	9	?	9	?	?	9	9	9	?	9	9	9	9	?	?	?	?	?	?	?	?	?	G				
ULTIM + SHOTGUN	✓	✓	8	0	7/8	8	?	9	7	?	?	?	9	7	?	?	?	9	9	9	9	9	?	9	?	?	?	?	?	?	?	?	?	?	G				
Postemergence Tank-Mixes – Herbicide Tolerant Hybrids Only																																							
LIBERTY 200 SN ³ + atrazine	✓ ³	✓	9	9	9	9	9	9	8/9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ³	
LIBERTY 200 SN ³ + BANVEL II, ORACLE	✓ ³	✓	9	9	9	9	9	9	8/9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	G ³
LIBERTY 200 SN ³ + MARKSMAN	✓ ³	✓	9	9	9	9	9	9	8/9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ³	
LIBERTY 200 SN ³ + PROWL	✓ ³	✓	9	9	9	9	9	9	8/9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ³	
GALAXY ⁴	✓ ⁴	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ⁴	
glyphosate ^{4,5} + atrazine	✓ ⁴	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ⁴	
glyphosate ^{4,5} + CALLISTO + AATREX LIQUID 480	✓ ⁴	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ⁴	
glyphosate ^{4,5} + MARKSMAN	✓ ⁴	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ⁴	
glyphosate ^{4,5} + PRIMEXTRA II MAGNUM	✓ ⁴	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ⁴	
Directed Postemergence																																							
LOROX	✓	✓	9	7	7	9	8	8	8	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	G	
ULTIM	✓	✓	9	0	7/8	9	9	9	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	G	
Directed Postemergence – Herbicide Tolerant Hybrids Only																																							
LIBERTY 200 SN ³	✓ ³	✓	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	E ³

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b PPI timing is needed to achieve this level of control.
 c Use PRE timing for optimum control.
 d The addition of atrazine is required to achieve this level of control.

BOLD numbers indicate the weed is listed on the product label for control or suppression.
 1 Indicates herbicides sold as a co-pack under this trade name.
 2 Use only on selected varieties – see precautions for tolerant varieties on label.
 3 For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
 4 For use on ROUNDUP READY corn (glyphosate tolerant) only.
 5 Various glyphosate products are registered for use in this tank-mix, see Table 9-5, page 149 for a list of registered products.

FIGURE 9-1: LEAF OVER METHOD OF COUNTING CORN LEAVES

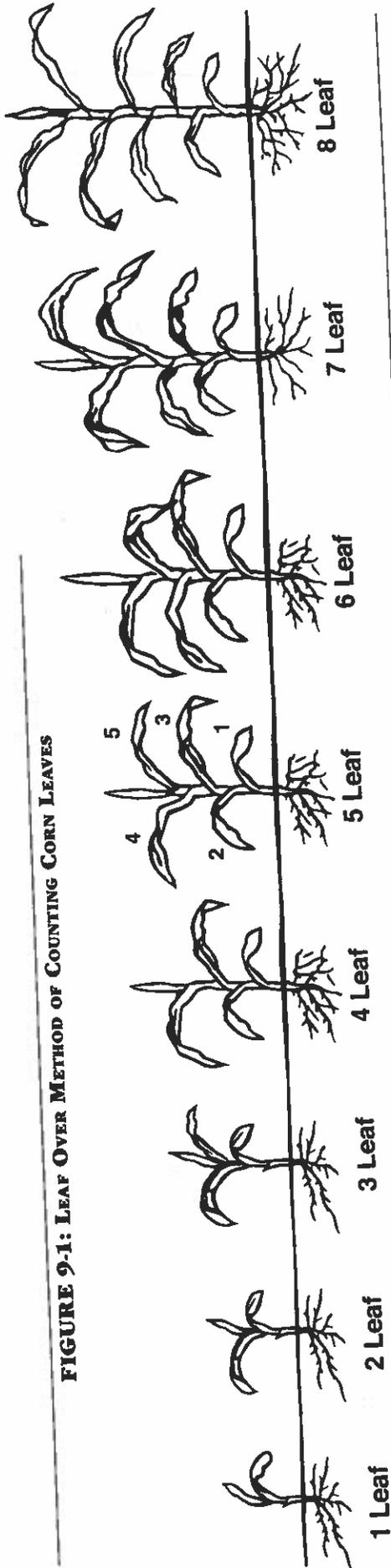


TABLE 9-2. ADDITIONAL WEED CONTROL RATINGS FOR CORN (FIELD, SEED AND SWEET)

TRADE NAME	VOLUNTEER CROPS			GRASSES		ANNUAL AND BIENNIAL BROADLEAVES										PERENNIALS						
	adzuki beans (volunteer)	wheat (volunteer)	other	sandbur	stink grass	tufted love grass	biennial wormwood	chickweed, common	flower of an hour	lettuce, prickly	nippewort	spreading atriplex	swamp smartweed	three seeded mercury	waterhemp	wild carrot	wood-sorrel (oxalis)	horsenettle	red top	vetch, tufted	wirestem muhly	
Soil Applied Grass Herbicides																						
DUAL II MAGNUM	?	?	?	5	9	9	?	?	?	?	?	?	?	?	6	?	?	?	?	?	?	?
FRONTIER	?	?	?	5	9	9	?	?	?	?	?	?	?	?	6	?	?	?	?	?	?	?
PROWL	?	6	?	6	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Soil Applied Broadleaf Herbicides																						
atrazine*	?	2	?	?	?	?	5	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
CALLISTO + atrazine	?	2	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
MARKSMAN	?	2	?	?	?	?	5	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b To achieve this level of control, volunteer cereals must be sprayed prior to flag leaf.
 c Volunteer cereals are close to heading when these products are normally applied, earlier applications will improve control.
BOLD numbers indicate the weed is listed on the product label for control or suppression.

TABLE 9-2. ADDITIONAL WEED CONTROL RATINGS FOR CORN (FIELD, SEED AND SWEET) (CONT'D)

TRADE NAME	VOLUNTEER CROPS		GRASSES		ANNUAL AND BIENNIAL BROADLEAVES											PERENNIALS						
	adzuki beans (volunteer)	wheat (volunteer)	sandbur	stink grass	tufted love grass	bur-cucumber	biennial wormwood	chickweed, common	flower of an hour	lettuce, prickly	nippewort	spreading atriplex	swamp smartweed	three seeded mercury	waterhemp	wild carrot	wood-sorrel (oxalis)	horsenettle	red top	vetch, tufted	wirestem mulhy	
Soil Applied Grass and Broadleaf Herbicides																						
BATTALION ¹	?	8	8	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
CONVERGE ¹	?	2	6	?	?	5	?	9	?	?	7	4	9	9	?	9	?	?	?	?	?	
PRIMEXTRA II MAGNUM	?	2	6	?	?	5	?	?	?	?	?	?	?	9	?	?	?	?	?	?	?	
Postemergence Grass Herbicides																						
ACCENT	?	7 ^c	7	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	8	?
OPTION 2.25 OD	?	7 ^c	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	9	?
ULTIM	?	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	9	?
Postemergence Broadleaf Herbicides																						
atrazine* + oil	?	2	?	?	?	5	8	9	7	?	9	2	0	9	0	2	9	?	?	?	?	?
BANVEL II, ORACLE	?	0	?	?	?	2	9	9	9	8	9	7	6	7	9	6	9	?	?	?	8	?
CALLISTO + atrazine	9	2	?	?	?	4	?	?	?	?	6	5	?	0	9	8	?	?	?	?	0	6
DISTINCT	?	?	?	?	?	2	9	9	9	8	9	7	5	9	9	8	?	?	?	?	5	?
LADDOK	?	?	?	?	?	6	8	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
MARKSMAN	?	?	?	?	?	6	9	9	9	9	7	3	9	9	9	?	?	?	?	?	?	?
PARDNER + atrazine*	?	?	?	?	?	8	9	9	8	9	9	1	9	9	7	?	?	?	?	?	?	?
PEAKPLUS ¹	?	?	?	?	?	3	8	9	8	8	6	7	6	8	6	9	?	?	?	?	?	?
SHOTGUN	?	?	?	?	?	6	9	9	9	8	9	?	0	9	9	?	?	?	?	?	?	?
SUMMIT	?	?	7/8	?	?	5	8	9	8	9	8	6	6	9	6	9	?	?	?	?	?	?

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b To achieve this level of control, volunteer cereals must be sprayed prior to flag leaf.
 c Volunteer cereals are close to heading when these products are normally applied, earlier applications will improve control.
BOLD numbers indicate the weed is listed on the product label for control or suppression.

¹ Indicates herbicides sold as a co-pack under this trade name.
² Use only on selected varieties - see precautions for tolerant varieties on label.
³ For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
⁴ For use on ROUNDUP READY corn (glyphosate tolerant) only. see Table 4-2, page 59 for a list of registered products.

TABLE 9-2. ADDITIONAL WEED CONTROL RATINGS FOR CORN (FIELD, SEED AND SWEET) (CONT'D)

TRADE NAME	VOLUNTEER CROPS		GRASSES		ANNUAL AND BIENNIAL BROADLEAVES										PERENNIALS							
	adzuki beans (volunteer)	wheat (volunteer)	sandbur	stink grass	tufted love grass	bur-cucumber	biennial wormwood	chickweed, common	flower of an hour	lettuce, prickly	nippewort	spreading atriplex	samp smartweed	three seeded mercury	waterhemp	wild carrot	wood-sorrel (oxalis)	horsenettle	red top	vetch, tufted	wirestem mulch	
Postemergence Grass and Broadleaf Herbicides (Herbicide Tolerant Hybrids Only)																						
LIBERTY 200 SN ²	?	?	7	?	?	4	?	?	7	?	?	1	6	?	?	?	?	7	?	?	8	?
glyphosate ³	9	9	9	?	?	8	8	9	9	9	?	7/8	5	8	9	?	?	8	?	?	5	9
Postemergence Grass and Broadleaf Herbicide Tank-Mixes																						
ACCENT + CALLISTO + atrazine*	9	7 ^c	8	9	9	?	?	?	?	?	?	5	?	?	9	8	?	?	?	?	?	?
BATTALION ¹	?	8 ^b	8	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
SUMMIT + ACCENT, SUMMIT EXTRA ¹	?	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
ULTIM + BANVEL II, ORACLE	?	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
ULTIM + CALLISTO + atrazine*	9	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
ULTIM + DISTINCT, ULTIM TOTAL ¹	?	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
ULTIM + MARKSMAN	?	7 ^c	8	9	9	6	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
ULTIM + PEAKPLUS ¹	?	7 ^c	8	9	9	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

* Various formulations available, see Table 4-1, page 21. See label for specific uses and rates.
 ? Insufficient information available to make a rating.
 a Use the high rate of herbicide for optimum control.
 b To achieve this level of control, volunteer cereals must be sprayed prior to flag leaf.
 c Volunteer cereals are close to heading when these products are normally applied, earlier applications will improve control.
BOLD numbers indicate the weed is listed on the product label for control or suppression.

¹ Indicates herbicides sold as a co-pack under this trade name.
² Use only on selected varieties - see precautions for tolerant varieties on label.
³ For use on glufosinate ammonium (LIBERTY LINK) tolerant corn only.
⁴ For use on ROUNDUP READY corn (glyphosate tolerant) only. see Table 4-2, page 59 for a list of registered products.

CORN (FIELD AND SWEET)

Critical Stage: The Critical Stage to control weeds in corn is the 2-8 leaf over stage (3-10 leaf tips).

Apply all treatments in 150-300 L/ha (60-120 L/ac) water unless otherwise specified.

Any single method of weed control or the continuous use of the same chemicals can lead to the build-up of weeds resistant or tolerant to that control method. Triazine-resistant lamb's-quarters and pigweed are problematic due to continuous corn and repeated use of triazine herbicides. Rotating to other crops and/or other control methods reduces the chance of new or unique weed infestations.

To control small annual weed seedlings, blind harrow with a set of light harrows at a shallow depth before the corn has emerged, or use a weeder harrow (with L-shaped flexible tines) when the crop is 5-10 cm high. High speed (10 kph), shallow (2.5-3 cm) cultivation with the rotary hoe when corn is 7-8 cm high also helps control small weed seedlings. These techniques will not reduce herbicide action and may in some years enhance chemical weed control. Inter-row cultivation can be used to complement other weed control measures. Row cultivation is most effective when weeds are small. Shallow cultivation will reduce:

- germination of new weed seeds
- moisture loss
- corn root injury

Inter-row cultivation may be required when weeds escape herbicide treatment; consider weeds escapes when they are 5-7 cm high.

Band treatment of chemical over the row reduces cost by one-half to two-thirds, depending on the row spacing.

ing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation gives some control of established perennial weeds but may also help to spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another. Many perennials (i.e. nutsedge) can be spread on tillage equipment. Custom operators should be particularly careful when moving from one farm to another.

Seed Corn Recommendations

Some field corn recommendations are applicable to seed corn, however, there are inbreds which are susceptible to some chemicals. Check with the contracting company before applying any herbicide. For information on specific weeds see Table 9-1, page 109, and then refer to the appropriate section for details about herbicide treatment.

Nitrogen solution can be used as a carrier, instead of water, for preplant and preemergence application of some herbicides. Weed control activity is not increased. Spray before crop emergence. Consult the herbicide label for proper methods of application and use of dispersing agents. Calibrate the sprayer to apply the required amount of nitrogen. Use stainless steel flood jet nozzles of adequate size (e.g. Teejet TK SS 5 to TK SS 10). Nitrogen solution is mildly corrosive, especially to brass; clean the sprayer immediately after use. UNITE may be used to improve liquid fertilizer herbicide compatibility and stability when a simultaneous application of a liquid fertilizer and liquid or wettable powder herbicide is desired. Because formulations and rates vary, it is essential to read the label to determine the exact amount and method to be used.

Do not apply nitrogen solution with postemergence herbicides.

Special Notes For Corn, Field and Sweet

PRECAUTIONS: Do not use 2,4-D, MCPA, MCPB, 2,4-DB or dicamba later than 2 weeks prior to the first appearance of tassels or ear silk. Use extreme care when applying these herbicides near susceptible crops because of possible herbicide movement. Soybeans, tomatoes and tobacco are extremely sensitive to dicamba and injury symptoms may persist for several weeks. Do not use dicamba in the area of susceptible crops when temperatures exceed 25°C on the day of application or if high humidity is expected, due to the possibility of dicamba volatilizing and injuring susceptible crops nearby. Leave several rows of corn unsprayed when adjacent to soybean fields or other susceptible crops.

Atrazine and Simazine Soil Residues

Atrazine and simazine residues may last for more than one year, particularly if high rates are used more than once and dry weather occurs. If atrazine or simazine is used year after year as in a continuous corn program, triazine residues may be higher. Atrazine when used at rates from 1.2-1.5 kg/ha (active ingredient) on corn generally has not caused injury on succeeding crops of oats, barley, mixed grains, or soybeans, except in years where there was very little rain the previous fall which would slow down atrazine degradation in the soil. Postemergence treatments may persist longer than preemergence treatments. Variations from this generality of 1.2-1.5 kg/ha atrazine may occur across the province.

Injury has been reported on tomatoes, white beans, forage seedlings, peas, tobacco, cucumbers, onions, and turnips following applications of atrazine at more than 1.1 kg/ha (active ingredient) on corn the previous year.

To reduce the hazard of atrazine residues on succeeding crops:

- Apply the early postemergence atrazine oil-water treatment with the lower rate of atrazine: 1.1 kg/ha (active ingredient). With this lower rate, a lower

leaves may not be immediately apparent and care must be taken to count them.

Hint: Start counting from the bottom leaf and check the first leaf to look for the rounded leaf tip.

It takes about 75–80 Crop Heat Units to produce each corn leaf. Therefore at temperatures of 30°C day, and 20°C at night, there is one new leaf every 2–3 days; and at 20°C day, and 10°C at night, one new leaf every 5–6 days.

Critical Stage: The Critical Stage to control weeds in corn is the 2–8 leaf over stage (3–10 leaf tips).

Some product labels also use plant height to indicate crop growth stages. In general, plant height is more variable depending on plant genetics and on the weather of the season. The following table gives some comparative heights for each leaf stage but your plants may be slightly more or less than the stage given depending on genetics and weather. The standing height is measured from the ground surface to the top of the plant as it stands. Leaf extended refers to the height of the plant with the leaves pulled up to their full height.

COMPARATIVE GROWTH STAGES

Leaf Tips	Leaf Collar	Leaf Over	Standing Height (cm)	Leaf Extended (cm)
3	1	2	5–6	5–11
5–6	3	4	9–17	16–25
7–8	4–5	6	18–33	29–46
9–10	5–6	8	36–54	54–77
12	8	10	58–85	86–112
14–15	10	12	99–114	121–149

9. CORN (FIELD, SEED & SWEET)

frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.

CORN LEAF STAGES

Counting leaves on a corn plant may sound like an easy task, but there are complications that can cause miscounting. There are several methods of counting leaves. It is important to know which leaf counting method is being referred to.

One method – the *leaf tip* method – counts all leaves, including any leaf tip that has emerged from the whorl at the top of the plant. (leaf tip method). The *leaf collar* method only counts those leaves that are fully emerged and have the leaf collar showing. The leaf collar is a light green band that separates the leaf blade and leaf sheath that wraps around the stem. In some states they refer to corn growth stages as V1, V2, V3, etc., where a V3 stage is a plant with 3 collars showing.

Publication 75 uses the *leaf over* method, (see Figure 9-1, on page 117) where counting starts with leaves that have emerged from the whorl and the leaf tip is starting to arch over. This normally occurs when leaves are about 50% emerged. Most product labels also use this method of leaf counting, but check the label or with the product representative to be sure. The comparative growth stages table in the next column gives a comparison among the count methods.

Another complication with leaf counting is where on the plant leaf counting begins. In Publication 75, the first leaf is the bottom leaf of the plant. The first leaf is shorter than other leaves and has a round leaf tip. However, as the plant grows the bottom leaves die and drop to the ground. For example, a 10 leaf corn plant may be incorrectly identified as a 7 leaf corn plant because 3 leaves may be “senesced” or fallen off. These

measure of weed control may result and cultivation may be necessary.

- Fall plowing will reduce TRIAZINE injury more than spring plowing will.
- Moldboard plowing will disperse herbicide residue to a greater soil depth than chisel plowing, thus reducing the concentration of herbicide in the upper soil area.
- Ensure that the sprayer used is adequate and is properly calibrated and adjusted. Spray uniformly without overlaps and do not spray while the sprayer is stopped.

Herbicide Treatments Include

- **Preplant (PP)** – Also see Special Methods, *Preplant-Site Preparation Prior To Any Crop*, page 78, for details of products, rates and remarks.
- **Preplant Incorporated (PPI)** – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Pay special attention toward machinery cleanliness, and/or treating fields with perennial weeds last.
- **Preemergence (PRE)** – Rainfall of 15–20 mm within 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing controls weed escapes and improves herbicide activity in the absence of rainfall.
- **Postemergence (POST)** – Leaf stage of the weeds is critical for good weed control. Smaller weeds are usually more sensitive to herbicide injury. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE
PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

CORN (FIELD, SEED AND SWEET)

Preplant Burndown and Residual Control

- Non-selective herbicides such as glyphosate and GRAMAXONE are used to control emerged weeds prior to no-till planting. Tank-mixing of a residual herbicide with glyphosate or GRAMAXONE can be used to improve application efficiency with a "one-pass" weed management program. Refer to Table 9-3. Registered "Two Way" Soil Applied Herbicide Tank-Mixes in Corn, page 146 for a list of registered preplant burndown tank-mixes.
- Refer also to Chapter 6, page 75 for preplant application rates for glyphosate and GRAMAXONE.
- It is also important to note that when targeting perennial weeds, the addition of a triazine-based herbicide (i.e. atrazine, Converge Pro, Primextra II Magnum) will reduce the level of activity achieved with glyphosate. Increasing the rate of glyphosate should overcome this antagonism.

Soil Applied Grass Herbicides

DUAL II MAGNUM (915 g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	<ul style="list-style-type: none">• Apply PPI or PRE. Set incorporation equipment to work soil no deeper than 10 cm.• Improved control of yellow nutsedge is obtained when DUAL II MAGNUM is applied PPI.• Optimal control of nightshade is obtained when DUAL II MAGNUM is applied PRE.• Do NOT use on muck, peat, or high organic matter soils.• See tank-mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide.• Can be tank-mixed with glyphosate or GRAMOXONE for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.• Must be PPI.• Do NOT use on seed corn.
<i>s-metolachlor/benoxacor</i>	1.14 to 1.6 kg/ha		
ERADICANE (800 g/L)	4.25 to 5.5 L/ha	1.7 to 2.2 L/ac	
EPTC/ R25788 (EPTC+)	3.4 to 4.4 kg/ha		
FRONTIER (900 g/L)	1.1 to 1.4 L/ha	0.44 to 0.56 L/ac	<ul style="list-style-type: none">• Apply PPI or PRE. Set incorporation equipment to work soil no deeper than 10 cm.• Improved control of yellow nutsedge is obtained when FRONTIER is applied PPI.• Minimum PPI rate is 1.125 kg/ha.• Use the higher rate of FRONTIER for the control of nightshade and pigweed.• Do NOT use on muck, peat, or high organic matter soils.• See tank-mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide.• Do NOT use on seed corn or popcorn.• Can be tank-mixed with glyphosate or GRAMOXONE for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.• For preemergence use on seed corn.• Use the lower rate on soils of lower organic matter and the higher rate on medium and fine textured soils.• Consult the seed corn company for information on the tolerance of seed corn inbred lines prior to the use of FRONTIER herbicide.
<i>dimethenamid</i>	1 to 1.25 kg/ha		
FRONTIER (900 g/L)	1.1 to 1.25 L/ha	0.44 to 0.5 L/ac	
<i>dimethenamid</i>	1 to 1.125 kg/ha		

TRADE NAME (Concentration) active ingredient **PRODUCT RATE PER HA** (active rate per ha) **PRODUCT RATE PER ACRE** **PRECAUTIONS** (For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Soil Applied Broadleaf Herbicides

atrazine (480 g/L) 2.1 to 3.1 L/ha 0.84 to 1.24 L/ac • Apply PRE.
 • Weeds will normally emerge and die within a few days; atrazine can persist for varying lengths of time; longer under dry, cool weather and coarse textured soils. See tank-mixes for reducing rates and avoiding residues, and for treatments to provide annual grass control.

atrazine 1.01 to 1.49 kg/ha 0.45 to 0.66 kg/ac • Can be tank-mixed with glyphosate or GRAMOXONE for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.

atrazine (480 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L) 2.1 to 3.1 L/ha
 1.25 L/ha 0.84 to 1.24 L/ac
 0.5 L/ac • Apply PRE.
 • This treatment should provide good control of triazine resistant broadleaf weeds and velvetleaf.

atrazine plus dicamba 1.01 to 1.49 kg/ha
 0.6 kg/ha • See notes on atrazine with respect to residues, on page 120.
 • See precautions for BANVEL II or ORACLE applied alone.
 • **Do NOT** apply to coarse (sand) textured soils with less than 2% organic matter.
 • **Do NOT** use on seed corn or sweet corn.

BANVEL II (480 g/L) or ORACLE (480 g/L) 1.25 L/ha 0.5 L/ac • Apply PRE to corn seed planted 4 cm or more deep before weeds and corn emerge. If corn seed is less than 4 cm below the soil surface, delay application of BANVEL II until the spike stage of corn.
 • Apply to medium to fine textured soils containing more than 2.5% organic matter.
 • **Do NOT** apply to coarse (sand) textured soils with less than 2% organic matter.
 • **Do NOT** incorporate.

dicamba 0.6 kg/ha • Apply PRE to field, seed or sweet corn.

CALLISTO (480 g/L) 0.3 L/ha 0.12 L/ac

mesotrione 0.140 kg/ha 1.5 to 1.8 L/ac • Apply PRE.
 • See notes on atrazine with respect to residues, on page 120.

MARKSMAN ((1:2) 401 g/L) 3.7 to 4.5 L/ha • See precautions for BANVEL II applied alone.
 • See precautions for atrazine with respect to residues, on page 120.
 • **Do NOT** apply to coarse (sand) textured soils with less than 2% organic matter.
 • **Do NOT** use on seed corn or sweet corn.

dicamba/atrazine 1.5 to 1.8 kg/ha

Soil Applied Grass and Broadleaf Herbicides

BATTALION¹ 24 g/ac +
 0.3 L/ac +
 0.3 L/ac • Apply PRE.
 • See precautions for BANVEL II or ORACLE alone, on this page.
 • **Do NOT** incorporate.
 • BATTALION can be applied with 28% UAN as a carrier (**PRE only**).
 • For suppression of quackgrass, apply BATTALION at the 1-6 leaf stage of quackgrass.
 • **Do NOT** use on seed corn or sweet corn.
 • BATTALION is a co-pack of ELIM EP, DUAL II MAGNUM and BANVEL II.

rimisulfuron + 15 g/ha +
 s-metolachlor/benoxacor + 684 g/ha +
 dicamba 360 g/ha

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
CONVERGE PRO ¹			
CONVERGE PRO (480 g/L)	165 to 218 mL/ha +	66 to 87 mL/ac +	• Apply PREPLANT SURFACE (up to 14 days prior to planting) or PRE.
+ CONVERGE 480 (480 g/L)	1.67 to 2.21 L/ha	0.67 to 0.88 L/ac	• Do NOT incorporate treatments prior to planting.
			• Use the higher application rates for control of fall panicum and suppression of proso millet.
isoxaflutole	79 to 105 g/ha +		• CONVERGE PRO is a co-pack of CONVERGE PRO and CONVERGE 480.
+ atrazine	0.8 to 1.063 kg/ha		• Temporary yellowing of lower corn leaves may occur under adverse weather or soil conditions.
			• Do NOT use CONVERGE PRO on sands, loamy sands and/or soils with less than 2% organic matter.
			• Do NOT use on seed corn or sweet corn.
			• Can be tank-mixed with glyphosate for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.
PRIMEXTRA II MAGNUM (1:0.8) 720 g/L)	3 to 4 L/ha	1.2 to 1.6 L/ac	• Apply PPI or PRE.
			• Use the higher rate where annual grass build up or nutsedge infestation is evident
s-metolachlor/benoxacor/ atrazine	2.16 to 2.88 kg/ha		• The equivalent rate of PRIMEXTRA II MAGNUM can be achieved by adding DUAL II MAGNUM at 0.5 to 0.7 L/ac with either AATREX NINE-O at 0.45 to 0.66 kg/ac or ATRAZINE 480 at 0.84 to 1.24 L/ac.
			• Can be tank-mixed with glyphosate or GRAMOXONE for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.
Soil Applied Tank-Mixes (For Control of Grass and Broadleaf Weeds)			
DUAL II MAGNUM (915 g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	• Apply PRE.
plus BANVEL II (480 g/L)	1.25 L/ha	0.5 L/ac	• Use higher rates on heavy grass infestations and for fall panicum. Fall panicum may not be controlled all season. BANVEL or ORACLE controls velvetleaf, and triazine (atrazine, or simazine) resistant broadleaf weeds.
or ORACLE (480 g/L)			• See precautions for BANVEL II or ORACLE alone, page 123.
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		• Do NOT apply to coarse (sand) textured soils with less than 2% organic matter.
plus dicamba	0.6 kg/ha		• Do NOT use on seed corn or sweet corn.
DUAL II MAGNUM (915 g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	• Apply PRE.
plus BANVEL II (480 g/L)	1.25 L/ha	0.5 L/ac	• Use higher rates on heavy grass infestations and for fall panicum. Fall panicum may not be controlled all season. BANVEL or ORACLE controls velvetleaf, and triazine resistant broadleaf weeds.
or ORACLE (480 g/L)			• See precautions for BANVEL II or ORACLE alone, page 123.
plus atrazine (480 g/L)*	2.1 to 3.1 L/ha	0.84 to 1.24 L/ac	• Do NOT apply to coarse (sand) textured soils with less than 2% organic matter.
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		• Do NOT use on seed corn or sweet corn.
plus dicamba	0.6 kg/ha		
plus atrazine	1.01 to 1.49 kg/ha		

¹ Indicates herbicide sold as a co-pack under this trade name.

* Numerous products exist, refer to Table 4-1. Herbicides Used in Ontario, page 21 for more information.

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

PRODUCT RATE
PER HA

PRODUCT RATE
PER ACRE

TRADE NAME
(Concentration)
active ingredient

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA	PRODUCT RATE PER ACRE	PRECAUTIONS
DUAL II MAGNUM (915 g/L) plus CALLISTO (480 g/L) plus AATREX LIQUID (480 g/L)	1.25 to 1.75 L/ha 0.3 L/ha 2.1 to 3.1 L/ha	0.5 to 0.7 L/ac 0.12 L/ac 0.85 to 1.25 L/ac	<ul style="list-style-type: none"> Apply PRE to field, seed and sweet corn. Use high rates for heavy grass infestations. Do NOT apply to corn treated with an organophosphorous insecticide.
s-metolachlor/benoxacor plus mesotrione plus atrazine	1.14 to 1.60 kg/ha 0.140 kg/ha 1.0 to 1.49 L/ha 1.5 L/ha	0.6 L/ac	<ul style="list-style-type: none"> Apply PRE only. Do NOT use on seed corn, popcorn or sweet corn. Do NOT use on sands, loamy sands and/or soils with less than 2% organic matter. Do NOT use on sands, loamy sands and/or soils with less than 2% organic matter. CONVERGE PRO must be applied with CONVERGE 480. CONVERGE PRO is a co-pack of CONVERGE PRO and CONVERGE 480.
DUAL II MAGNUM (915 g/L) plus CONVERGE PRO ¹ CONVERGE PRO (480 g/L) + CONVERGE (480 g/L)	110 mL/ha 1.1 L/ha	44 mL/ac 0.45 L/ac	
s-metolachlor/benoxacor plus isoxaflutole atrazine +	1.37 kg/ha 53 g/ha 0.528 kg/ha	0.5 L/ac	<ul style="list-style-type: none"> Use ONLY on sweet corn. Make ONLY one application per year. Apply in a minimum of 150 L water/ha. Do NOT harvest sweet corn within 50 days of treatment. Apply by ground equipment ONLY.
DUAL II MAGNUM (915 g/L) plus LOROX L (480 g/L) plus atrazine (480 g/L)*	1.25 L/ha 0.79 to 1.56 L/ha 2.06 to 3.19 L/ha	0.32 to 0.63 L/ac 0.825 to 1.28 L/ac	
s-metolachlor/benoxacor plus linuron plus atrazine	1.14 kg/ha 0.38 to 0.75 kg/ha 0.99 to 1.53 kg/ha	0.5 L/ac	<ul style="list-style-type: none"> Apply PRE. Use higher rates on heavy grass infestations and for fall panicum. Fall panicum may not be controlled all season. BANVEL controls velvetleaf, and triazine resistant broadleaf weeds. See precautions for BANVEL II alone, page 123. Do NOT apply to coarse (sand) textured soils with less than 2% organic matter. Do NOT use on seed corn or sweet corn.
DUAL II MAGNUM (915 g/L) plus MARKSMAN ((1:2) 401 g/L)	1.25 to 1.75 L/ha 3.7 to 4.5 L/ha	0.5 to 0.7 L/ac 1.5 to 1.8 L/ac	
s-metolachlor/benoxacor plus dicamba/atrazine	1.14 to 1.6 kg/ha 1.48 to 1.8 kg/ha	1.7 to 3.4 L/ac 1 to 1.24 L/ac	<ul style="list-style-type: none"> Apply PPI. For suppression of moderate to heavy infestations of wild proso millet, use the higher rate of ERADICANE with atrazine. For most effective suppression of proso millet delay treatment and planting until mid to late May. Cultivation or a directed post application of linuron may be required to control later emerging proso millet. Do NOT use on seed corn.
ERADICANE (800 g/L) plus atrazine (480 g/L)	4.25 to 8.5 L/ha 2.5 to 3.1 L/ha		
EPTC/ R25788 (EPTC+) plus atrazine	3.4 to 6.8 kg/ha 1.2 to 1.49 kg/ha		

¹ Indicates herbicide sold as a co-pack under this trade name.

* Numerous products exist, refer to Table 4-1, Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
ERADICANE (800 g/L) plus SENCOR 480 F (480 g/L) or SENCOR 75 DF (75 WG)	2.13 to 4.25 L/ha 0.6 L/ha 0.4 kg/ha	0.85 to 1.7 L/ac 0.24 L/ac 0.16 kg/ac	<ul style="list-style-type: none"> Apply PPI. Note that this is a reduced rate of SENCOR. This tank-mix provides improved velvetleaf control but will not control proso millet, triazine resistant weeds or cocklebur. Do NOT use on seed corn or sweet corn.
EPTC/ R25788 (EPTC+) plus metribuzin	1.7 to 3.4 kg/ha 0.3 kg/ha		
FRONTIER (900 g/L) plus atrazine (480 g/L)*	1.1 to 1.4 L/ha 2.08 to 3.19 L/ha	0.44 to 0.56 L/ac 0.832 to 1.28 L/ac	<ul style="list-style-type: none"> Apply PREPLANT, PPI or PRE. Use the higher rate of FRONTIER for heavier weed populations. Control of non-emerged triazine resistant weeds will be limited to pigweed. Can be tank-mixed with glyphosate or GRAMOXONE for PP burndown of emerged annual and perennial weeds, see Chapter 6, page 75 for more information.
dimethenamid plus atrazine	1 to 1.25 kg/ha 1 to 1.53 kg/ha		
FRONTIER (900 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	1.1 to 1.4 L/ha 1.25 L/ha	0.44 to 0.56 L/ac 0.5 L/ac	<ul style="list-style-type: none"> Apply PREPLANT or PRE. Use the higher rate of FRONTIER for heavier weed populations. For improved burndown control, the addition of glyphosate may be required. See precautions for BANVEL II or ORACLE applied alone, page 123. Do NOT use on seed corn, popcorn or sweet corn.
dimethenamid plus dicamba	1 to 1.25 kg/ha 0.6 kg/ha		
FRONTIER (900 g/L) plus MARKSMAN ((1:2) 401 g/L)	1.1 to 1.4 L/ha 4.5 L/ha	0.44 to 0.56 L/ac 1.8 L/ac	<ul style="list-style-type: none"> Apply PREPLANT or PRE. Use the higher rate of FRONTIER for heavier weed populations. For improved burndown control, adding glyphosate may be required. See precautions for BANVEL II or ORACLE applied alone, page 123. Do NOT use on seed corn, popcorn or sweet corn.
dimethenamid plus dicamba/ atrazine	1 to 1.25 kg/ha 1.8 kg/ha		
LOROX L (480 g/L) plus atrazine (480 g/L)	2.25 to 3.25 L/ha 2.29 L/ha	0.9 to 1.3 L/ac 0.92 L/ac	<ul style="list-style-type: none"> Apply PRE. Use this tank-mix only on clay or clay loam soil to avoid injury. This tank-mix controls annual weeds including triazine resistant redroot pigweed and lamb's-quarters and is a method of reducing atrazine residues. Annual grasses will be the first weeds to escape.
linuron plus atrazine	1.08 to 1.56 kg/ha 1.1 kg/ha		
PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) plus CALLISTO (480 g/L)	3 to 4 L/ha 0.3 L/ha	1.2 to 1.6 L/ac 0.12 L/ac	<ul style="list-style-type: none"> Apply PRE to field, seed and sweet corn. Use high rates for heavy grass infestations. Do NOT apply to corn treated with an organophosphorous insecticide.
s-metolachlor/benoxacor/atrazine plus mesotrione	2.16 to 2.88 kg/ha 0.140 kg/ha		

* Numerous products exist, refer to Table 4-1, Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) plus LOROX L (480 g/L)	3 to 4 L/ha 0.77 to 1.56 L/ha	1.2 to 1.6 L/ac 0.31 to 0.63 L/ac	<ul style="list-style-type: none"> Apply PRE. This tank-mix can be used on light textured soils with OM greater than 1.0%. Linuron controls triazine resistant lamb's-quarters and redroot pigweed. Fall panicum or velvetleaf may not be controlled for the full season. Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacorl atrazine plus linuron	2.16 to 2.88 kg/ha 0.37 to 0.75 kg/ha		
PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	3 to 4 L/ha 1.25 L/ha	1.2 to 1.6 L/ac 0.5 L/ac	<ul style="list-style-type: none"> Apply PRE. Use higher rates on heavy grass infestations and for fall panicum. Fall panicum may not be controlled all season. BANVEL II or ORACLE controls velvetleaf, and triazine (atrazine, or simazine) resistant broadleaf weeds. See precautions for BANVEL II or ORACLE alone, page 123. Do NOT apply to coarse (sand) textured soils with less than 2% organic matter. Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacorl atrazine plus dicamba	2.16 to 2.88 kg/ha 0.6 kg/ha		
PROWL 400 (400 g/L)	4.2 L/ha	1.68 L/ac	<ul style="list-style-type: none"> Apply PRE. PROWL alone will not control emerged weeds. Tank-mixing or use of a sequential herbicide program to achieve broad spectrum control is recommended. Plant corn at least 4 cm deep and ensure good seed coverage. PROWL may be applied in water or liquid fertilizer (rate of 200 L liquid fertilizer/ha (80 L liquid fertilizer/ac)). Conduct a liquid fertilizer compatibility test with any of the registered PROWL tank-mix combinations. If there is no rain within 7 days, rotary hoeing or shallow cultivation is required. Do NOT use on seed corn or sweet corn.
pendimethalin	1.68 kg/ha		
PROWL 400 (400 g/L) plus atrazine (480 g/L)*	4.2 L/ha 3.19 L/ha	1.68 L/ac 1.28 L/ac	<ul style="list-style-type: none"> Apply PRE. See precautions for PROWL alone, on this page. Do NOT use on seed corn or sweet corn.
pendimethalin plus atrazine	1.68 kg/ha 1.53 kg/ha		
PROWL 400 (400 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	4.2 L/ha 1.25 L/ha	1.68 L/ac 0.5 L/ac	<ul style="list-style-type: none"> Apply PRE. See precautions for PROWL alone, on this page, and BANVEL II or ORACLE alone, page 123. Do NOT use on seed corn or sweet corn.
pendimethalin plus dicamba	1.68 kg/ha 0.6 kg/ha		

* Numerous products exist, refer to Table 4-1. Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
PROWL 400 (400 g/L) plus MARKSMAN ((1:2) 401 g/L)	4.2 L/ha 3.7 to 4.5 L/ha	1.68 L/ac 1.5 to 1.8 L/ac	<ul style="list-style-type: none"> Apply PRE. See precautions for PROWL alone, page 127, and BANVEL II or ORACLE alone, page 123. Do NOT use on seed corn or sweet corn.
pendimethalin plus dicamba/triazine	1.68 kg/ha 1.48 to 1.8 kg/ha		
PRINCEP NINE-T (90 WG)	1.5 to 2.5 kg/ha	0.6 to 1 kg/ac	<ul style="list-style-type: none"> Apply PRE. These products are listed separately because of their widely differing rate ranges. In both cases the low rates should be used on sandy soils while the higher rates may be used on loams and clays.
simazine	1.35 to 2.25 kg/ha		
OR SIMADAX (500 g/L)	3.2 to 8 L/ha	1.28 to 3.2 L/ac	<ul style="list-style-type: none"> Full season annual weed control can be expected except for crabgrass or fall panicum where infestations have built up.
OR SIMAZINE 480 (480 g/L)	3.4 to 8.3 L/ha	1.36 to 3.32 L/ac	<ul style="list-style-type: none"> Cautions are advised when considering rates beyond 2.0 kg/ha (0.8 kg/ac) as soil residues may be high.
simazine	1.6 to 4 kg/ha		
Postemergence Grass Herbicides			
ACCENT (75 DF) plus non-ionic surfactant plus liquid urea ammonium nitrate (UAN)	33 g/ha 2 L/1,000 L 5 L/ha	13 g/ac 2 L/1,000 L 2 L/ac	<ul style="list-style-type: none"> Do NOT add liquid urea ammonium nitrate (UAN) when applying ACCENT to seed or sweet corn. For use on all sweet corn varieties, however not all varieties have been tested. Contact the variety manufacturer for more information on the tolerance of a specific variety. Adding UAN will give improved control of yellow foxtail in Field Corn. Adapt oil concentrate (1% v/v), Merge or Sure-Mix (0.5% v/v) can be used in place of a non-ionic surfactant (Field Corn only). Always add water soluble packages to clean water with the agitator running. Corn should be within the 1-8 leaf stage of growth. Apply ACCENT when annual grasses are in the 1-6-leaf stage and/or quackgrass is in the 3-6 leaf stage (10-20 cm).
nicosulfuron plus non-ionic surfactant plus liquid urea ammonium	25 g/ha 0.2% v/v 5 L/ha		
DUAL II MAGNUM (915 g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	<ul style="list-style-type: none"> Corn should be at the spike to 2-leaf stage and annual grasses not beyond 2-leaf stage. Do NOT add oil or surfactants.
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		
FRONTIER (900 g/L)	1.1 to 1.4 L/ha	0.44 to 0.56 L/ac	<ul style="list-style-type: none"> Annual grasses should not be beyond the 2-leaf stage and corn should be at the spike to 3-leaf stage. Do NOT add oil or surfactants. Do NOT use on seed corn, popcorn or sweet corn.
dimethenamid	1 to 1.25 kg/ha		
ULTIM ((1:1 75 DF) plus non-ionic surfactant	33 g/ha 2 L/1,000 L	13g/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply one water soluble bag/ha of ULTIM. Always add water soluble packages to clean water with the agitator running. Corn should be within the 1-6 leaf stage (30 cm). Apply ULTIM when annual grasses are in the 1-6 leaf stage, and/or quackgrass is in the 3-6 leaf stage (10-20 cm). ONLY apply ULTIM when air temperatures in the 24 hours before and after application range between 5°C and 28°C. Do NOT use on seed corn or sweet corn.
nicosulfuron/rimsulfuron plus non-ionic surfactant	25 g/ha 0.2% v/v		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Postemergence Broadleaf Herbicides and Tank-Mixes (For Broadleaf Weed Control)

2,4-D (470 g/L) 0.6 to 1.2 L/ha 0.24 to 0.48 L/ac • Apply as an overall spray until corn is 15 cm high (leaf extended); thereafter, use drop nozzles. Use amine formulation.

2,4-D* 0.28 to 0.56 kg/ha • See special notes on postemergence use of 2,4-D and related hormone chemicals, page 120.

atrazine (480 g/L) plus oil 2.1 to 3.1 L/ha 10 to 17 L/ha 0.84 to 1.24 L/ac 4 to 6.8 L/ac • For increased activity and extended period of activity, apply in an oil water emulsion of 10–17 L/ha (4–6.8 L/ac) of emulsifiable light mineral oil and 150–200 L/ha water (60–80 L/ac). Apply when most weeds have emerged. The low rate can be used successfully with later cultivation.

atrazine plus oil 1.01 to 1.49 kg/ha 10 to 17 L/ha 0.84 to 1.24 L/ac • Apply from the 4–8 leaf stage of corn. A reduced rate of atrazine at 0.5 kg/ha (1/2 the low rate) can be used to control weeds listed for PARDNER (or KORIL) alone plus ragweed up to the 8-leaf stage, velvetleaf and triazine susceptible red root pigweed up to 6 leaves.

atrazine plus PARDNER (280 g/L) or KORIL (235 g/L) 2.1 to 3.1 L/ha 1 L/ha 1.2 L/ha 0.84 to 1.24 L/ac 0.4 L/ac 0.48 L/ac • Controls a wider spectrum of broadleaf weeds than PARDNER or KORIL alone; larger pigweed, ragweed and velvetleaf will be controlled.

atrazine plus bromoxynil 1.01 to 1.49 kg/ha 0.28 kg/ha • Do NOT add oil or surfactant.

atrazine (480 g/L) plus BUCTRIL M ((1:1) 560 g/L) or BADGE ((1:1) 450 g/L) or LOGIC M ((1:1) 450 g/L) or MEXTROL ((1:1) 450 g/L) 2.29 to 3.1 L/ha 1 L/ha 1.25 L/ha 0.96 to 1.24 L/ac 0.4 L/ac 0.5 L/ac • Apply from the 4–6 leaf stage of corn but injury may occur if applied after the 6-leaf stage.

atrazine plus bromoxynil/MCPA 1.1 to 1.49 kg/ha 0.56 kg/ha • Controls a wider spectrum of broadleaf weeds than bromoxynil/MCPA alone; larger velvetleaf will be controlled.

atrazine (480 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L) 2.1 to 3.1 L/ha 0.6 L/ha 1.01 to 1.49 kg/ha 0.288 kg/ha • Do NOT add oil or surfactant.

atrazine plus dicamba 1.01 to 1.49 kg/ha 0.288 kg/ha • Do NOT use formulated atrazine/oil products in this tank-mixture.

atrazine plus dicamba 1.01 to 1.49 kg/ha 0.288 kg/ha • Do NOT use on seed corn or sweet corn.

atrazine plus dicamba 1.01 to 1.49 kg/ha 0.288 kg/ha • This treatment will provide good to excellent control of broadleaf weeds including those triazine resistant and velvetleaf. Use the higher rate for residual control.

atrazine plus dicamba 1.01 to 1.49 kg/ha 0.288 kg/ha • See special notes for corn regarding dicamba applications, page 120 and precautions for BANVEL II or ORACLE alone POST, page 130.

atrazine plus dicamba 1.01 to 1.49 kg/ha 0.288 kg/ha • Do NOT use on seed corn or sweet corn.

* Numerous products exist, refer to Table 4-1, Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
BANVEL II (480 g/L) or ORACLE (480 g/L)	0.6 to 1.25 L/ha 0.288 to 0.6 kg/ha	0.24 to 0.5 L/ac	<ul style="list-style-type: none"> Application of the lower rate can be made up to 20 cm standing corn. Use drop pipes when corn is 20–50 cm tall. The 0.6 kg/ha rate commonly referred to as the overlay treatment is particularly effective in controlling velvetleaf and providing extended residual control of other late germinating deep rooted broadleaf annuals and can be applied from the spike stage to the 5-leaf stage (13 cm standing corn). See special notes on postemergence use of dicamba and related hormone chemicals, page 120. Do NOT use dicamba if temperature exceeds 25°C at the time of application, or if high humidity is expected, due to the possibility of dicamba volatilizing and injury to susceptible crops nearby. Do NOT add oil or surfactant. Do NOT use on seed corn or sweet corn.
dicamba			
BANVEL II (480 g/L) or ORACLE (480 g/L) plus 2,4-D (470 g/L)*	0.29 L/ha 0.85 L/ha	0.12 L/ac 0.34 L/ac	<ul style="list-style-type: none"> Application can be made up to 10 cm standing corn. Use drop pipes when corn is 10–50 cm tall. Use amine formulation of 2,4-D. See special notes on postemergence use of dicamba and 2,4-D and related hormone chemicals, page 120. Do NOT add oil or surfactant. Do NOT use on seed corn or sweet corn.
dicamba plus 2,4-D	0.14 kg/ha 0.4 kg/ha		
BASAGRAN FORTÉ (480 g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	<ul style="list-style-type: none"> Top growth of nutsedge and Canada thistle are controlled and field bindweed may be suppressed by 2 applications of 1.75 L/ha (0.7 L/ac) (0.84 kg active/ha) applied 10 days apart.
bentazon plus oil concentrate	0.84 to 1.08 kg/ha 2 L/ha		<ul style="list-style-type: none"> Cool weather or drought may delay control.
BUCTRIL M ((1:1) 560 g/L) or BADGE ((1:1) 450 g/L) or LOGIC M ((1:1) 450 g/L) or MEXTROL ((1:1) 450 g/L)	1 L/ha 1.25 L/ha	0.4 L/ha 0.5 L/ha	<ul style="list-style-type: none"> Apply from the 4–6 leaf stage of corn but injury may occur if applied after the 6-leaf stage. Controls most annual broadleaf weeds up to the 4-leaf stage (lamb's-quarters and mustards to 8-leaf stage). Use in preference to PARDNER or KORIL when wild mustard is a particular problem. Do NOT use on seed corn or sweet corn.
bromoxynil MCPA	0.558 kg/ha		
EMBUTOX (625 g/L) or CALIBER 625 (625 g/L) or COBUTOX 625 (625 g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	<ul style="list-style-type: none"> See special notes on postemergence use of 2,4-DB and related hormone chemicals, page 120. Note: The maximum label rate for EMBUTOX 625 is 2.25 L/ha (0.9 L/ac) of product. Do NOT add oil or surfactant. Do NOT use on seed corn or sweet corn.
2,4-DB	1.1 to 1.5 kg/ha		

* Numerous products exist, refer to Table 4-1. Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
CALLISTO (480 g/L) plus AATREX LIQUID (480 g/L) plus non-ionic surfactant	0.21 L/ha 0.58 L/ha 2 L/1,000 L	0.085 L/ac 0.235 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply from the 3 to 8 leaf stage of corn. Do NOT use on seed or sweet corn. Apply in 100 – 200 L/ha of water. Do NOT apply to corn treated with an organophosphorous insecticide.
mesotrione plus atrazine plus non-ionic surfactant	0.1 kg/ha 0.28 kg/ha 0.2% v/v		<ul style="list-style-type: none"> Apply to actively growing weeds when corn is in the 2–6 leaf stage. Apply when temperatures above 4°C are predicted for the 24 hours before and after application. Do NOT use on seed corn or sweet corn.
DISTINCT (70 WG) plus non-ionic surfactant plus liquid urea ammonium nitrate (UAN)	0.285 kg/ha 2.5 L/1,000 L 12.5 L/1,000 L	0.115 kg/ac 2.5 L/1,000 L 12.5 L/1,000 L	<ul style="list-style-type: none"> Apply postemergence up to 4 leaf grassy weeds and up to 8 leaf broadleaf weeds. Apply between the spike and 7 leaf stage of corn. Do NOT use on sweet or seed corn. Do NOT use on corn hybrids less than 2700 CHU's.
diflufenzopyr/dicamba plus non-ionic surfactant plus liquid urea ammonium	0.2 kg/ha 0.25% v/v 1.25% v/v		
IMPACT (336g/L) plus atrazine (480g/L)* plus ASSIST OIL plus liquid urea ammonium nitrate (UAN)	0.037 L/ha 1.04 L/ha 12.5 L/1,000 L 12.5 L/1,000 L	15 ml/ac 0.42 L/ac 12.5 L/1,000 L 12.5 L/1,000 L	
topramezone plus atrazine LADDOK ((1:1) 400 g/L) plus ASSIST	12.5 g/ha 0.5 kg/ha 2 to 4 L/ha 2 L/ha	0.8 to 1.6 L/ac 0.8 L/ac	<ul style="list-style-type: none"> The recommended rate of 1.2–1.6 kg/ha of LADDOK (3–4 L/ha (1.2–1.6 L/ac) LADDOK may be reduced to 0.8–1 kg/ha (2–2.5 L/ha (0.8–1 L/ac). If FRONTIER or DUAL II MAGNUM has been applied at the recommended rate for preemergence grass control. Use LADDOK at 3–4 L/ha (1.2–1.6 L/ac) for nutsedge control; repeat 7–10 days if necessary.
bentazon/ atrazine plus oil concentrate MARKSMAN ((1:2) 401 g/L)	0.8 to 1.6 kg/ha 2 L/ha 3.7 to 4.5 L/ha	1.5 to 1.8 L/ac	<ul style="list-style-type: none"> Application can be made up to 13 cm standing corn (5-leaf). Use the lower rate on coarse textured soils and the higher rate on medium to fine textured soils. See special notes on postemergence use of dicamba and related hormone chemicals. Do NOT use on seed corn or sweet corn.
dicamba/atrazine	1.48 to 1.8 kg/ha		<ul style="list-style-type: none"> Treat before the corn reaches 15 cm tall (leaf extended). Use the lower rate for small, actively growing weeds and the higher rate for larger weeds or under adverse weather conditions. Top growth control of fully developed HORSETAIL (15–25 cm) can be achieved with 1 L/ha (0.4 L/ac) of product. Do NOT use on seed corn or sweet corn.
MCPA AMINE (500 g/L)*	0.76 to 1.26 L/ha	0.3 to 0.5 L/ac	
MCPA	0.38 to 0.63 kg/ha		

* Numerous products exist, refer to Table 4-1. Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
PARDNER (280 g/L) or KORIL (235 g/L)	1 to 1.2 L/ha 1.2 to 1.4 L/ha	0.4 to 0.48 L/ac 0.48 to 0.56 L/ac	<ul style="list-style-type: none"> Controls most annual broadleaf weeds, including triazine resistant species at the 1-4 leaf stage. PARDNER and KORIL are contact herbicides and are non volatile. KORIL is not registered for use on seed corn.
bromoxynil	0.28 to 0.34 kg/ha		
PARDNER (280 g/L) or KORIL (235 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	1 L/ha 1.2 L/ha 0.3 L/ha	0.4 L/ac 0.48 L/ac 0.12 L/ac	<ul style="list-style-type: none"> Apply when the corn is in the 4-6 leaf stage as an overall treatment and up to 50 cm standing corn, using drop pipes. Controls most annual broadleaf weeds including triazine resistant lamb's-quarters, pigweed and ragweed up to the 6-leaf stage. See special notes on postemergence use of dicamba and precautions for BANVEL II or ORACLE alone POST, page 130. Do NOT use on seed corn or sweet corn.
bromoxynil plus dicamba	0.28 kg/ha 0.144 kg/ha		
PEAKPLUS ¹			
PEAK (75 WG) + BANVEL II (480 g/L) plus non-ionic surfactant	13.3 g/ha + 0.3 L/ha 2 L/1,000 L	5.3 g/ac + 0.12 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply when the corn is in the 2-7 leaf stage. Controls most annual broadleaf weeds including triazine resistant lamb's-quarters and pigweed up to the 6-leaf stage; cocklebur and velvetleaf up to the 6-leaf stage; and ragweed up to the 8-leaf stage. Do NOT apply to corn treated with organophosphorus insecticides. Do NOT apply to popcorn or sweet corn. PEAKPLUS is a co-pack of PEAK 75WG and BANVEL II.
pro sulfuron + dicamba plus non-ionic surfactant	10 g/ha + 0.14 kg/ha 0.2% v/v		
SHOTGUN ((2.3:1) 390 g/L)	2.4 to 3.59 L/ha	0.96 to 1.44 L/ac	<ul style="list-style-type: none"> Apply as an overall spray from the spike to the 4-leaf stage of corn. Do NOT add oil or surfactant. Do NOT use on seed corn or sweet corn.
atrazine/2,4-D	0.936 to 1.404 kg/ha		
SUMMIT (47.4 WG) plus non-ionic surfactant	0.35 kg/ha 2 L/1,000 L	0.14 kg/ac 2 L/1,000 L	<ul style="list-style-type: none"> Corn should be within the 2-7 leaf stage. Apply when the quackgrass is within the 3-6 leaf stage. Controls quackgrass and most annual broadleaf weeds. Does not provide control of annual grasses. Apply when temperature, during the 24 hours before and after application, ranges between 5°C and 28°C. Do NOT use on seed corn or sweet corn. Do NOT apply to corn treated with an organophosphate insecticide.
primisulfuron-methyl/dicamba plus non-ionic surfactant	0.166 kg/ha 0.2% v/v		
TROPOTOX PLUS (400 g/L) or CLOVITOX PLUS (400 g/L) or TOPSIDE (400 g/L)	2.75 to 4.25 L/ha	1.1 to 1.7 L/ac	<ul style="list-style-type: none"> Apply when corn is 30-60 cm high, using drop pipes. Some control of field horsetail may be obtained with the higher rates of MCPB/MCPA. See special notes on postemergence use of MCPB/MCPA and related hormone chemicals, page 120. Do NOT add oil or surfactant. Do NOT use on seed corn or sweet corn.
MCPB/MCPA (15:1)	1.1 to 1.7 kg/ha		

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient **PRODUCT RATE PER HA active rate per ha** **PRODUCT RATE PER ACRE** **PRECAUTIONS**
 (For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Postemergence Grass and Broadleaf Herbicides

BATTALION¹			
ELIM EP (25 DF) +	50 g/ha +	20 g/ac +	• Apply at the spike to 3-leaf stage of corn.
DUAL II MAGNUM (915 g/L) +	0.625 L/ha +	0.25 L/ac +	• See precautions for BANVEL II alone, page 130.
BANVEL II (480 g/L)	0.625 L/ha	0.25 L/ac	• Refer to individual product labels for use precautions.
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	• For suppression of quackgrass, apply BATTALION at the 1-6 leaf stage of quackgrass.
			• Do NOT use on seed corn or sweet corn.
			• BATTALION is a co-pack of ELIM EP, DUAL II MAGNUM and BANVEL II.
rim sulfuron +	12.5 g/ha +		
s-metolachlor/benoxacor +	573 g/ha +		
dicamba	300 g/ha +		
plus non-ionic surfactant	0.2% v/v		
PRIMEXTRA II MAGNUM	3 to 4 L/ha	1.2 to 1.6 L/ac	• Apply when the corn is in the spike to 6-leaf stage and annual grasses are not beyond the 2-leaf stage.
((1:0.8) 720 g/L)			• Use high rates for heavy grass infestation areas and for fall panicum control.
s-metolachlor/benoxacor/	2.16 to 2.88 kg/ha		• Do NOT add oil or surfactants to this mixture.
atrazine			• The equivalent rate of PRIMEXTRA II MAGNUM can be achieved by adding DUAL II MAGNUM at 0.5 to 0.7 L/ac with either AATREX NINE-O at 0.45 to 0.66 kg/ac or ATRAZINE 480 at 0.84 to 1.24 L/ac.

Postemergence Tank-Mixes (For Control of Grass and Broadleaf Weeds)

ACCENT (75 DF)	33 g/ha	13 g/ac	• See precautions for ACCENT, page 128 and BANVEL II or ORACLE, page 130.
plus BANVEL II (480 g/L)	0.6 L/ha	0.24 L/ac	• Do NOT apply to corn beyond the 6-leaf stage.
or ORACLE (480 g/L)			
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	
nicosulfuron	25 g/ha		
plus dicamba	0.288 kg/ha		
plus non-ionic surfactant	0.2% v/v		
ACCENT (75 DF)	33 g/ha	13 g/ac	• Apply from the 3 to 8 leaf stage of corn.
plus CALLISTO (480 g/L)	0.21 L/ha	0.085 L/ac	• Do NOT use on seed or sweet corn.
plus AATREX LIQUID (480 g/L)	0.58 L/ha	0.235 L/ac	• Apply in 100-200 L/ha of water.
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	• See precautions for ACCENT, page 128 and CALLISTO + atrazine, page 131.
nicosulfuron	25 g/ha		
plus mesotrione	0.1 kg/ha		
plus atrazine	0.28 kg/ha		
plus non-ionic surfactant	0.2% v/v		

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
ACCENT TOTAL ¹			
ACCENT (75 DF) + DISTINCT (70 WG)	33 g/ha + 0.285 kg/ha	13 g/ac 0.115 kg/ac	• Apply to active growth stage of seedling broadleaf weeds (less than 5 cm tall). • Apply to annual grasses in the 1-6 leaf stage and to quackgrass in the 3-6 leaf stage (10-20 cm).
plus non-ionic surfactant	2.5 L/1,000 L	2.5 L/1,000 L	• Apply when corn is in the 2-8 leaf stage.
plus liquid urea ammonium nitrate (UAN)	5 L/ha	2 L/ac	• Do NOT use on seed corn or sweet corn. • ACCENT TOTAL is co-pack of ACCENT and DISTINCT.
nicosulfuron + diflufenzopyr/dicamba plus non-ionic surfactant plus urea ammonium nitrate	25 g/ha + 0.2 kg/ha 0.2% v/v 5 L/ha		• See precautions for ACCENT, page 128 and DISTINCT, page 131.
ACCENT (75 DF) plus MARKSMAN (1:2) 401 g/L	33 g/ha 2.5 L/ha	13 g/ac 1 L/ac	• See precautions for ACCENT, page 128 and MARKSMAN, page 131.
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	• Do NOT apply to corn beyond the 6-leaf stage.
nicosulfuron plus dicamba/ atrazine plus non-ionic surfactant	25 g/ha 1 kg/ha 0.2% v/v		
ACCENT (75 DF) plus PARDNER (280 g/L) or KORIL (235 g/L)	33 g/ha 1 L/ha 1.2 L/ha	13 g/ac 0.4 L/ac 0.5 L/ac	• Use only when the corn is between the 4 and 8-leaf stage. • See precautions for ACCENT, page 128 and PARDNER, page 132.
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	
nicosulfuron plus bromoxynil plus non-ionic surfactant	25 g/ha 0.28 kg/ha 0.2% v/v		
ACCENT ONE-PASS ¹ ACCENT (75 DF) + PEAKPLUS ¹ (PEAK (75 WG) + BANVEL II (480 g/L))	33 g/ha + 13.3 g/ha + 0.3 L/ha 2 L/1,000 L	13.3 g/ac + 5.3 g/ac + 0.12 L/ac 2 L/1,000 L	• Apply when the corn is in the 2-7 leaf stage. • Do NOT apply to corn treated with organophosphorus insecticides. • Do NOT apply to seed corn, popcorn or sweet corn. • ACCENT 1-PASS is a co-pack of ACCENT and PEAKPLUS. • To control eastern black nightshade at the cotyledon to 6 leaf stage, add atrazine (480 g/L) at a rate of 1.04 L/ha (0.42 L/ac).
plus non-ionic surfactant	2 L/1,000 L		
nicosulfuron + prosulfuron + dicamba plus non-ionic surfactant	25 g/ha + 10 g/ha + 0.14 kg/ha 0.2% v/v		

¹Indicates herbicide sold as a co-pack under this trade name.

PRECAUTIONS

(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

- Apply as an overall spray from 1-4 leaf stage of corn or 1-6 leaf stage of grasses.
- See precautions for ACCENT, page 128 and SHOTGUN, page 132.
- **Do NOT use on seed corn, popcorn or sweet corn.**

PRODUCT RATE PER HA

active rate per ha

33 g/ha
 2.4 to 3.6 L/ha
 2 L/1,000 L

25 g/ha
 0.94 to 1.4 kg/ha
 0.2% v/v

1.25 to 1.75 L/ha
 2.1 to 3.1 L/ha
 0.6 to 1.25 L/ha

1.14 to 1.6 kg/ha
 1.01 to 1.49 kg/ha
 0.288 to 0.6 kg/ha

1.25 to 1.75 L/ha
 0.6 to 1.25 L/ha
 0.6 to 1.25 L/ha

1.14 to 1.6 kg/ha
 0.288 to 0.6 kg/ha

1.25 to 1.75 L/ha
 0.3 L/ha
 2.1 to 3.1 L/ha

1.14 to 1.60 kg/ha
 0.140 kg/ha
 1.0 to 1.49 L/ha

1.25 to 1.75 L/ha
 3.7 to 4.5 L/ha

1.14 to 1.6 kg/ha
 1.48 to 1.8 kg/ha

1.1 to 1.4 L/ha
 1.25 L/ha

1 to 1.25 kg/ha
 0.6 kg/ha

PRODUCT RATE PER ACRE

13 g/ac
 0.96 to 1.44 L/ac
 2 L/1,000 L

0.5 to 0.7 L/ac
 0.84 to 1.24 L/ac
 0.24 to 0.5 L/ac

0.5 to 0.7 L/ac
 0.24 to 0.5 L/ac
 0.24 to 0.5 L/ac

0.5 to 0.7 L/ac
 0.12 L/ac
 0.85 to 1.25 L/ac

0.5 to 0.7 L/ac
 1.5 to 1.8 L/ac

0.44 to 0.56 L/ac
 0.5 L/ac

TRADE NAME (Concentration) <i>active ingredient</i>	PRODUCT RATE PER HA <i>active rate per ha</i>	PRODUCT RATE PER ACRE	PRECAUTIONS
ACCENT (75 DF) plus SHOTGUN ((2.3:1) 390 g/L) plus non-ionic surfactant	33 g/ha 2.4 to 3.6 L/ha 2 L/1,000 L	13 g/ac 0.96 to 1.44 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II, or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
nicosulfuron plus atrazine/2,4-D plus non-ionic surfactant	25 g/ha 0.94 to 1.4 kg/ha 0.2% v/v	0.5 to 0.7 L/ac 0.84 to 1.24 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II, or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
DUAL II MAGNUM (915 g/L) or atrazine (480 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	1.25 to 1.75 L/ha 2.1 to 3.1 L/ha 0.6 to 1.25 L/ha	0.5 to 0.7 L/ac 0.84 to 1.24 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacor plus atrazine plus dicamba	1.14 to 1.6 kg/ha 1.01 to 1.49 kg/ha 0.288 to 0.6 kg/ha	0.5 to 0.7 L/ac 0.24 to 0.5 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
DUAL II MAGNUM (915 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	1.25 to 1.75 L/ha 0.6 to 1.25 L/ha 0.6 to 1.25 L/ha	0.5 to 0.7 L/ac 0.24 to 0.5 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacor plus dicamba	1.14 to 1.6 kg/ha 0.288 to 0.6 kg/ha	0.5 to 0.7 L/ac 0.12 L/ac 0.85 to 1.25 L/ac	<ul style="list-style-type: none"> • Apply when field corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. • Do NOT use on seed or sweet corn. • Use high rates for heavy grass infestations.
DUAL II MAGNUM (915 g/L) plus CALLISTO (480 g/L) plus AATREX LIQUID (480 g/L)	1.25 to 1.75 L/ha 0.3 L/ha 2.1 to 3.1 L/ha	0.5 to 0.7 L/ac 0.12 L/ac 0.85 to 1.25 L/ac	<ul style="list-style-type: none"> • Apply when field corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. • Do NOT use on seed or sweet corn.
s-metolachlor/benoxacor plus mesotrione plus atrazine	1.14 to 1.60 kg/ha 0.140 kg/ha 1.0 to 1.49 L/ha	0.5 to 0.7 L/ac 1.5 to 1.8 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. See precautions for BANVEL II or ORACLE alone POST, page 130. • Do NOT use on seed corn or sweet corn.
DUAL II MAGNUM (915 g/L) plus MARKSMAN ((1:2) 401 g/L)	1.25 to 1.75 L/ha 3.7 to 4.5 L/ha	0.5 to 0.7 L/ac 1.5 to 1.8 L/ac	<ul style="list-style-type: none"> • Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. • Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacor plus dicamba/ atrazine	1.14 to 1.6 kg/ha 1.48 to 1.8 kg/ha	0.44 to 0.56 L/ac 0.5 L/ac	<ul style="list-style-type: none"> • Application can be made when the corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. • Do NOT apply to coarse textured soils with less than 2% organic matter. • Do NOT use on seed corn, popcorn or sweet corn.
FRONTIER (900 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	1.1 to 1.4 L/ha 1.25 L/ha	0.44 to 0.56 L/ac 0.5 L/ac	<ul style="list-style-type: none"> • Application can be made when the corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. • Do NOT apply to coarse textured soils with less than 2% organic matter. • Do NOT use on seed corn, popcorn or sweet corn.
dimethenamid plus dicamba	1 to 1.25 kg/ha 0.6 kg/ha	0.44 to 0.56 L/ac 0.5 L/ac	<ul style="list-style-type: none"> • Application can be made when the corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. • See special notes on postemergence use of dicamba and related hormone chemicals, page 120. • Do NOT apply to coarse textured soils with less than 2% organic matter. • Do NOT use on seed corn, popcorn or sweet corn.

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

FRONTIER (900 g/L) plus MARKSMAN ((1:2) 401 g/L)	1.1 to 1.4 L/ha 4.5 L/ha	0.44 to 0.56 L/ac 1.8 L/ac	<ul style="list-style-type: none"> Application can be made when the corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. See special notes on postemergence use of dicamba and related hormone chemicals, page 120. Do NOT apply to coarse textured soils with less than 2% organic matter. Do NOT use on seed corn, popcorn or sweet corn.
dimethenamid plus dicamba/atrazine	1 to 1.25 kg/ha 1.8 kg/ha		
IMPACT (336 g/L) plus FRONTIER (900 g/L) plus atrazine (480 g/L)* plus ASSIST OIL plus liquid urea ammonium nitrate (UAN)	37 mL/ha 1.11 L/ha 1.04 L/ha 12.5 L/1,000 L 12.5 L/1,000 L	15 mL/ac 0.45 L/ac 0.42 L/ac 12.5 L/1,000 L 12.5 L/1,000 L	<ul style="list-style-type: none"> Apply postemergence up to 4 leaf grassy weeds and up to 8 leaf broadleaf weeds. Apply between the spike and 3 leaf stage of corn. Do NOT use on sweet or seed corn. Do NOT use on corn hybrids less than 2700 CHU's. The addition of FRONTIER provides residual grassy weed control.

topramezone plus dimethenamid plus atrazine	0.0125 kg/ha 1.0 kg/ha 0.5 kg/ha		
OPTION 1.2.3. OPTION 2.25 OD (22.5 g/L) + DEFINE DF (60%) plus atrazine (480 g/L)* plus liquid urea ammonium nitrate (UAN)	0.67 L/ha 750 g/ha 1.75 L/ha 2.5 L/ha	0.27 L/ac 304 g/ac 0.71 L/ac 1.0 L/ac	<ul style="list-style-type: none"> Apply at the 1- to 3-leaf stage of corn. Atrazine and UAN (28%) are required tank-mix partners and are to be purchased separately. Will not provide control of un-emerged triazine resistant lamb's-quarters.

foramsulfuron + flufenacet + atrazine plus UAN	15 g/ha 450 g/ha 840 g/ha 2.5 L/ha		
OPTION 2.25 OD (22.5 g/L) plus AATREX 480 (480 g/L) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 1.75 to 2.33 L/ha 2.5 L/ha	0.63 L/ac 0.7 to 0.93 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 8-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.

foramsulfuron plus atrazine plus liquid urea ammonium	35 g/ha 0.84 to 1.12 kg/ha 2.5 L/ha		
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* Numerous products exist, refer to Table 4-1. Herbicides Used in Ontario, page 21 for more information.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
OPTION 2.25 OD (22.5 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 0.3 L/ha 2.5 L/ha	0.63 L/ac 0.12 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 8-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
foramsulfuron plus dicamba plus liquid urea ammonium	35 g/ha 0.144 kg/ha 2.5 L/ha	0.63 L/ac 0.085 L/ac 0.235 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 8-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten. Apply in 175 L/ha (70 L/ac) of water.
OPTION 2.25 OD (22.5 g/L) plus CALLISTO (480 g/L) plus AATREX LIQUID (480 g/L) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 0.21 L/ha 0.58 L/ha 2.5 L/ha	0.63 L/ac 0.085 L/ac 0.235 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 8-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten. Apply in 175 L/ha (70 L/ac) of water.
foramsulfuron plus mesotrione plus atrazine plus liquid urea ammonium	35 g/ha 0.1 kg/ha 0.28 L/ha 2.5 L/ha	0.63 L/ac 0.115 kg/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 6-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
OPTION 2.25 OD (22.5 g/L) plus DISTINCT (70 WG) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 0.285 kg/ha 2.5 L/ha	0.63 L/ac 0.115 kg/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 6-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
foramsulfuron plus diflufenzopyr/dicamba plus UAN	35 g/ha 0.2 kg/ha 2.5 L/ha	0.63 L/ac 1 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 5-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
OPTION 2.25 OD (22.5 g/L) MARKSMAN ((1:2)401 g/L) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 2.5 L/ha 2.5 L/ha	0.63 L/ac 1 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 5-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
foramsulfuron plus dicamba/atrazine plus UAN	35 g/ha 1kg/ha 2.5 L/ha	0.63 L/ac 1 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 5-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
OPTION 2.25 OD (22.5 g/L) plus PARDNER (280 g/L) or KORIL (235 g/L) plus AATREX 480 (480 g/L) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 0.5 L/ha 0.6 L/ha 1.04 L/ha 2.5 L/ha	0.63 L/ac 0.2 L/ac 0.24 L/ac 0.42 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 8-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
foramsulfuron plus bromoxynil plus atrazine plus UAN	35 g/ha 0.14 kg/ha 0.5 kg/ha 2.5 L/ha		
OPTION 2.25 OD (22.5 g/L) plus PEAKPLUS ¹ (PEAK (75 WG) + BANVEL II (480 g/L)) plus liquid urea ammonium nitrate (UAN)	1.56 L/ha 13.3 g/ha + 0.3 L/ha 2.5 L/ha	0.63 L/ac 5.3 g/ac + 0.12 L/ac 1 L/ac	<ul style="list-style-type: none"> Apply up to the 7-leaf stage of corn. Do NOT use on seed or sweet corn. If using OPTION 35 DF, apply at a product rate of 100 g/ha (40 g/ac) plus Hasten at a rate of 1.75 L/ha (0.7 L/ac). OPTION 2.25 OD does not require the addition of Hasten.
foramsulfuron plus prosulfuron + dicamba plus urea ammonium nitrate	35 g/ha 10 g/ha + 0.14 kg/ha 2.5 L/ha		
PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	3 to 4 L/ha 0.6 to 1.25 L/ha	1.2 to 1.6 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> Apply when the corn is in the spike to 5-leaf stage and annual grasses are not beyond the 2-leaf stage. See special notes on postemergence use of dicamba and related hormone chemicals, page 120 and precautions for BANVEL II or ORACLE alone POST, page 130. Do NOT use on seed corn or sweet corn.
s-metolachlor/benoxacor/ atrazine plus dicamba	2.16 to 2.88 kg/ha 0.288 to 0.6 kg/ha		
PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) plus CALLISTO (480 g/L)	3 to 4 L/ha 0.3 L/ha	1.2 to 1.6 L/ac 0.12 L/ac	<ul style="list-style-type: none"> Apply when field corn is in the spike to 2-leaf stage and annual grasses are not beyond the 2-leaf stage. Do NOT use on seed or sweet corn. Use high rates for heavy grass infestations.
s-metolachlor/benoxacor/atrazine plus mesotrione	2.16 to 2.88 kg/ha 0.140 kg/ha		

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
PROWL 400 (400 g/L) plus ACCENT (75 DF) plus BANVEL II (480 g/L) or ORACLE (480 g/L) plus non-ionic surfactant	2.5 L/ha 16.7 g/ha 0.625 L/ha 2 L/1,000 L	1 L/ac 6.7 g/ac 0.25 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply early postemergence from the spike to 3 leaf stage of corn. See precautions for PROWL, page 127, ACCENT, page 128 and BANVEL II or ORACLE, page 130. Do NOT use on sweet or seed corn.
pendimethalin plus nicosulfuron plus dicamba plus non-ionic surfactant	1 kg/ha 12.5 g/ha 300 g/ha 0.2% v/v		<ul style="list-style-type: none"> Do NOT apply to corn beyond the 4-leaf stage or annual grasses beyond the 2-leaf stage. Do NOT use on seed corn or sweet corn.
PROWL 400 (400 g/L) plus atrazine (480 g/L)	4.2 L/ha 3.2 L/ha	1.68 L/ac 1.28 L/ac	<ul style="list-style-type: none"> Do NOT apply to corn beyond the 4-leaf stage or annual grasses beyond the 2-leaf stage. Do NOT use on seed corn or sweet corn.
pendimethalin plus atrazine	1.68 kg/ha 1.53 kg/ha		<ul style="list-style-type: none"> Avoid application under adverse growing conditions. See precautions for BANVEL II or ORACLE alone POST, page 130. Do NOT apply to corn beyond the 4-leaf stage or annual grasses beyond the 2-leaf stage. Do NOT apply if temperature exceeds 25°C at application time. Do NOT use on seed corn or sweet corn.
PROWL 400 (400 g/L) plus BANVEL II (480 g/L) or ORACLE (480 g/L)	4.2 L/ha 0.6 to 1.25 L/ha	1.68 L/ac 0.24 to 0.5 L/ac	<ul style="list-style-type: none"> See precautions for BANVEL II alone POST, page 130. Do NOT use on seed corn or sweet corn.
pendimethalin plus dicamba	1.68 kg/ha 0.288 to 0.6 kg/ha		<ul style="list-style-type: none"> See precautions for BANVEL II alone POST, page 130. Do NOT use on seed corn or sweet corn.
PROWL 400 (400 g/L) plus MARKSMAN ((1:2):40) g/L)	4.2 L/ha 3.7 to 4.5 L/ha	1.68 L/ac 1.5 to 1.8 L/ac	<ul style="list-style-type: none"> Apply at the spike to 3-leaf stage of corn. Annual grasses should be no bigger than the 1-2 leaf stage. Apply to medium and fine textured soils with more than 3% organic matter. See precautions for PROWL alone POST, page 127 and SHOTGUN alone POST, page 132.
pendimethalin plus dicamba/atrazine	1.68 kg/ha 1.48 to 1.8 kg/ha		<ul style="list-style-type: none"> Apply when corn is in the 2-7 leaf stage. Apply when the quackgrass is within the 3-6 leaf stage. Apply when temperature, during the 24 hours before and after application, ranges between 5°C and 28°C. Do NOT use on seed corn or sweet corn. Do NOT apply to corn treated with an organophosphate insecticide. SUMMIT EXTRA is a co-pack of SUMMIT and ACCENT See precautions for ACCENT alone, page 128 and SUMMIT alone, page 132.
PROWL 400 (400 g/L) plus SHOTGUN ((2.3:1) 390 g/L)	4.2 L/ha 2.4 to 3.59 L/ha	1.68 L/ac 0.96 to 1.44 L/ac	
pendimethalin plus 2,4-D/atrazine	1.68 kg/ha 0.936 to 1.404 kg/ha		
SUMMIT (47.4 WG) plus ACCENT (75 DF) plus non-ionic surfactant	0.35 kg/ha 25 g/ha 2 L/1,000 L	0.14 kg/ac 10g/ac 2 L/1,000 L	
primisulfuron methyl/dicamba plus nicosulfuron plus non-ionic surfactant	0.166 kg/ha 18.75g/ha 0.2% v/v		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS
ULTIM ((1:1) 75 DF) plus BANVEL II (480 g/L) OR ORACLE (480 g/L) plus non-ionic surfactant	33 g/ha 0.6 L/ha 0.6 L/ha 2 L/1,000 L	13 g/ac 0.24 L/ac 0.24 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Refer to product label(s) for weeds controlled, timing of application, and use precautions. If grass and broadleaf weed growth stages do not coincide, then a sequential application of ULTIM and BANVEL II or ORACLE is required. See precautions for ULTIM alone, page 128 and BANVEL II alone, page 130. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron plus dicamba plus non-ionic surfactant	25 g/ha 0.288 kg/ha 0.2% v/v		
ULTIM (75 DF) plus CALLISTO (480 g/L) plus AATREX LIQUID (480 g/L) plus non-ionic surfactant	33 g/ha 0.21 L/ha 0.58 L/ha 2 L/1,000 L	13 g/ac 0.085 L/ha 0.235 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply from the 3 to 6 leaf stage of corn. Do NOT use on seed or sweet corn. Apply in 100–200 L/ha of water. See precautions for ULTIM alone, page 128 and BANVEL II alone, page 130.
nicosulfuron/irimsulfuron plus mesotrione plus atrazine plus non-ionic surfactant	25 g/ha 0.1 kg/ha 0.28 kg/ha 0.2% v/v		
ULTIM TOTAL ¹ ULTIM ((1:1) 75 DF) + DISTINCT (70 WG) plus non-ionic surfactant plus liquid urea ammonium nitrate (UAN)	33 g/ha + 0.285 kg/ha 2.5 L/1,000 L 12.5 L/1,000 L	13 g/ac + 0.115 kg/ac 2.5 L/1,000 L 12.5 L/1,000 L	<ul style="list-style-type: none"> Apply to active growth stage of seedling broadleaf weeds (less than 5 cm tall). Apply to annual grasses in the 1–6 leaf stage and to quackgrass in the 3–6 leaf stage ULTIM TOTAL is AVAILABLE ONLY as a co-pack of ULTIM + DISTINCT. 1 bag of ULTIM TOTAL treats 10 acres. See precautions for ULTIM alone, page 128 and DISTINCT alone, page 131. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron + diflufenzopyr/dicamba plus non-ionic surfactant plus urea ammonium nitrate	25 g/ha + 0.2 kg/ha 0.25% v/v 12.5 L/1,000 L		
ULTIM ((1:1) 75 DF) plus MARKSMAN ((1:2) 401 g/L) plus a non-ionic surfactant	33 g/ha 2.5 L/ha 2 L/1,000 L	13 g/ac 1 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply up to the 5-leaf stage of corn. Apply one water soluble bag/ha of ULTIM. If grass and broadleaf weed growth stages do not coincide, then a sequential application of ULTIM and MARKSMAN is required. See precautions for ULTIM alone, page 128 and MARKSMAN alone, page 131. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron plus dicamba/atrazine plus non-ionic surfactant	25 g/ha 1.003 kg/ha 0.2% v/v		

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
ULTIM ((1:1) 75 DF) plus PARDNER (280 g/L) or KORIL (235 g/L) plus non-ionic surfactant	33 g/ha 1 L/ha 1.2 L/ha 2 L/1,000 L	13 g/ac 0.4 L/ac 0.5 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply from the 3-6 leaf stage of corn for optimum control. One solupak of ULTIM treats 1 ha (2.5 ac). Refer to product label(s) for weeds controlled, timing of application, and use precautions. If grass and broadleaf weed growth stages do not coincide, then a sequential application of ULTIM and PARDNER is required. Do NOT apply ULTIM to corn treated with organophosphorous insecticides. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron plus bromoxynil plus non-ionic surfactant	25 g/ha 0.28 kg/ha 0.2% v/v		
ULTIM ((1:1) 75 DF) plus PARDNER (280 g/L) or KORIL (235 g/L) plus ATRAZINE 480 (480 g/L) plus non-ionic surfactant	33 g/ha 0.5 L/ha 0.6 L/ha 1.04 L/ha 2 L/1,000 L	13 g/ac 0.2 L/ac 0.24 L/ac 0.42 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply from the 3-6 leaf stage of corn. This treatment provides improved control of larger velvetleaf (up to 6-leaf stage) and common ragweed (up to 8-leaf stage) if grass and broadleaf weed growth stages do not coincide, then a sequential application of ULTIM and PARDNER plus atrazine is required. Note: some hybrids have shown sensitivity to ULTIM. See precautions for ULTIM alone, page 128, PARDNER alone, page 132 and atrazine alone, page 129. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron plus bromoxynil plus atrazine plus non-ionic surfactant	25 g/ha 0.14 kg/ha 0.5 kg/ha 0.2% v/v		
ULTIM (75 DF) plus PEAKPLUS ¹ PEAK (75 WG) + BANVEL II (480 g/L) plus non-ionic surfactant	33 g/ha 13.3 g/ha + 0.3 L/ha 2 L/1,000 L	13 g/ac 5.3 g/ac + 0.12 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply to corn between the 2-6 leaf stage. Do NOT apply to seed corn, popcorn or sweet corn. See precautions for ULTIM alone, page 128 and PEAKPLUS alone, page 132. PEAKPLUS is a co-pack of PEAK and BANVEL II.
nicosulfuron/irimsulfuron plus prosulfuron + dicamba plus non-ionic surfactant	25 g/ha 10 g/ha + 0.14 kg/ha 0.2% v/v		
ULTIM ((1:1) 75 DF) SHOTGUN (2.3:1) 390 g/L plus non-ionic surfactant	33.7 g/ha 2.4 to 3.6 L/ha 2 L/1,000 L	13.4 g/ac 0.96 to 1.44 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Apply as an overall spray from 1-4 leaf stage of corn or 1-6 leaf stage of grasses. See precautions for ULTIM alone, page 128 and SHOTGUN alone, page 132. Do NOT use on seed corn, popcorn or sweet corn.
nicosulfuron/irimsulfuron plus atrazine/2,4-D plus non-ionic surfactant	25 g/ha 0.94 to 1.4 kg/ha 0.2% v/v		

¹Indicates herbicide sold as a co-pack under this trade name.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
Postemergence Grass and Broadleaf Herbicides – for Liberty Link (glufosinate tolerant) hybrids only			
LIBERTY 200 SN (200 g/L)	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY 200 SN. LIBERTY 200 SN can be applied from the 1–8 leaf stage of corn. LIBERTY 200 SN is a contact herbicide and has no residual activity. Consult the product label for rate recommendations for specific weeds and weed stages. Ammonium sulphate can be applied at 6 L/ha (2.4 L/ac) (liquid) or 3.3 kg/ha (1.3 kg/ac) (dry) for improved control of specific weeds. Do NOT add oil or any other surfactants.
glufosinate ammonium	0.3 to 0.5 kg/ha		
LIBERTY 200SN (200 g/L) followed by			
LIBERTY 200SN (200 g/L)	2 L/ha	0.8 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY 200 SN. The first application may be applied on 4–5 leaf corn at the proper growth stage of the weeds. The second application may be made up to the 8-leaf stage of corn to control subsequent flushes of weeds.
glufosinate ammonium	1.25 L/ha	0.5 L/ac	
glufosinate ammonium	0.4 kg/ha		
glufosinate ammonium	0.25 kg/ha		
Postemergence Tank-Mixes – for Liberty Link (glufosinate tolerant) hybrids only			
LIBERTY 200 SN (200 g/L)	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant,* to LIBERTY 200 SN. This tank-mix can be applied up to the 8-leaf stage of corn.
plus ATRAZINE 480 (480 g/L)	1.75 to 2.34 L/ha	0.7 to 0.93 L/ac	
glufosinate ammonium	0.3 to 0.5 kg/ha		
plus atrazine	0.84 to 1.12 kg/ha		
LIBERTY 200 SN (200 g/L)	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY 200 SN. This tank-mix can be applied up to the 8-leaf stage of corn. See precautions for BANVEL II or ORACLE alone POST, page 130.
plus BANVEL II (480 g/L)	0.625 L/ha	0.25 L/ac	
or ORACLE (480 g/L)			
glufosinate ammonium	0.3 to 0.5 kg/ha		
plus dicamba	0.3 kg/ha		
LIBERTY 200 SN (200 g/L) plus	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY 200 SN. This tank-mix can be applied up to the 5-leaf stage of corn. See precautions for BANVEL II or ORACLE alone POST, page 130.
MARKSMAN ((1:2)401 g/L)	2.5 to 3.7 L/ha	1 to 1.5 L/ac	
glufosinate ammonium plus	0.3 to 0.5 kg/ha		
dicamba/atrazine	1 to 1.5 kg/ha		
LIBERTY 200SN (200 g/L)	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY 200 SN. This tank-mix can be applied up to the 4-leaf stage of corn.
PROWL 400 (400 g/L)	2.5 L/ha	1 L/ac	
glufosinate ammonium	0.3 to 0.5 kg/ha		
plus pendimethalin	1 kg/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS

(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Postemergence Grass and Broadleaf Herbicides – for Roundup Ready (glyphosate tolerant) hybrids only

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS
Postemergence Grass and Broadleaf Herbicides – for Roundup Ready (glyphosate tolerant) hybrids only			
glyphosate (360 g/L)	2.5 to 5 L/ha	1 to 2 L/ac	<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as glyphosate tolerant or "ROUNDUP READY CORN". See Table 4-2, page 59, for a list of registered glyphosate products. Apply up to and including the 8-leaf stage of corn. The initial application is recommended between the 2–6 leaf stage (3–5 leaf is optimum timing) to remove early competition. A second application may be applied up to the 8-leaf stage of corn (8-leaf fully expanded). Use 100–200 L/ha (40–80 L/ac) of water.
or glyphosate (480 g/L)	1.875 to 3.75 L/ha	0.75 to 1.5 L/ac	
or glyphosate (540 g/L)	1.67 to 3.34 L/ha	0.67 to 1.34 L/ac	
glyphosate*	0.9 kg/ha		

Postemergence Tank-Mixes – for Roundup Ready (glyphosate tolerant) hybrids only

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS
Postemergence Tank-Mixes – for Roundup Ready (glyphosate tolerant) hybrids only			
GALAXY ¹			<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as glyphosate tolerant or "ROUNDUP READY CORN". Apply spike to the 6-leaf stage corn. Use on corn with corn heat units (CHU) greater than 2500. Water Volume: 140–190L/ha. Symptoms appear after 5–7 days, but may not be noticeable for 2–3 weeks. Provides residual control of fall panicum, green foxtail, lambs-quarters and pigweed spp.
ELIM EP (25 DF) +	50 g/ha +	20 g/ac +	
ROUNDUP WEATHERMAX (540 g/L)	1.67 L/ha	0.67 L/ac	
rimsulfuron + glyphosate	12.5 g/ha + 0.9 kg/ha		<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as glyphosate tolerant or "ROUNDUP READY CORN". Apply up to and including the 5-leaf stage of corn. Atrazine will provide residual control of broadleaf weeds.
glyphosate (360 g/L)**	2.5 L/ha	1 L/ac	
or glyphosate (540 g/L)**	1.67 L/ha	0.67 L/ac	
plus ATRAZINE 480 (480 g/L)	1.56 to 2.1 L/ha	0.63 to 0.85 L/ac	
glyphosate plus atrazine	0.9 kg/ha 0.75 to 1.0 kg/ha		<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as glyphosate tolerant or "ROUNDUP READY CORN". Apply up to and including the 8-leaf stage of corn. CALLISTO and Atrazine will provide residual broadleaf weed control. Refer to Table 9-5, page 149 for a complete list of glyphosate products that can be tank-mixed with CALLISTO plus AATREX LIQUID.
glyphosate (360 g/L)**	2.5 L/ha	1.0 L/ac	
plus CALLISTO (480 g/L)	0.21 L/ha	0.085 L/ac	
plus AATREX LIQUID (480 g/L)	0.58 L/ha	0.235 L/ac	
plus non-ionic surfactant	2 L/1,000 L	2 L/1,000 L	
glyphosate plus mesotrione plus atrazine plus non-ionic surfactant	0.9 kg/ha 0.1 kg/ha 0.28 kg/ha 0.2% v/v		

¹ Indicates herbicide sold as a co-pack under this trade name.

* Numerous products exist, refer to Table 4-1, Herbicides Used in Ontario, page 21 for more information.

** Refer to Table 9-5, Glyphosate Products and "Two-Way" Tank-Mixes, page 149 for a list of registered glyphosate products for this tank-mix.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
glyphosate (360 g/L)** or glyphosate (540 g/L)** plus MARKSMAN ((1:2) 401 g/L)	2.5 L/ha 1.67 L/ha 2.5 to 3.7 L/ha	1 L/ac 0.67 L/ac 1 to 1.5 L/ac	<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as "ROUNDUP READY CORN". Apply up to and including the 5-leaf stage of corn. Marksman will provide residual control of broadleaf weeds. See precautions for BANVEL II or ORACLE applied POST, page 130.
glyphosate plus dicamba/atrazine	0.9 kg/ha 1 to 1.5 kg/ha		
glyphosate (360 g/L)** plus PRIMEXTRA II MAGNUM (1:0.8) 720 g/L)	2.5 L/ha 2.5 L/ha	1.0 L/ac 1.0 L/ac	<ul style="list-style-type: none"> Use ONLY with pedigreed (certified) corn seed designated as glyphosate tolerant or "ROUNDUP READY CORN". Apply up to and including the 6-leaf stage of corn. PRIMEXTRA II MAGNUM will provide residual grass and broadleaf weed control. For tank-mixtures of PRIMEXTRA II MAGNUM plus any of the glyphosate products, to ensure optimum compatibility: Add PRIMEXTRA II MAGNUM to the tank first, then add AGRAL 90, AGSURF or COMPANION at 2.5 L/ 1000 L. Continue agitation and add the glyphosate mix partner. Refer to Table 9-5, page 149 for a complete list of glyphosate products that can be tank-mixed with PRIMEXTRA II MAGNUM.
glyphosate plus s-metolachlor/benoxacor/ atrazine	0.9 kg/ha 1.8 kg/ha		
Directed Postemergence			
LOROX L 480 (480 g/L)	2.4 to 4.5 L/ha	0.96 to 1.8 L/ac	<ul style="list-style-type: none"> Apply in oil water emulsion as directed spray at low pressure with drop nozzles after corn is 30 cm or more in height. The spray must be placed under the corn leaves but on the weeds. Use this treatment as a rescue from weeds escaping a previous treatment and for nutsedge or horsetail top growth burn down. Do not apply linuron after corn is beginning to tassel.
linuron	1.1 to 2.25 kg/ha		
MCPA AMINE (500 g/L)	0.76 to 1.26 L/ha	0.3 to 0.5 L/ac	<ul style="list-style-type: none"> Controls triazine resistant and most other broadleaf weeds. Use the lower rate for small, actively growing weeds and the higher rate for larger weeds or under adverse weather conditions. Top growth of fully developed horsetail (15-25 cm) can be controlled with 1 L/ha (0.4 L/ac) of product; a directed late post application using drop nozzles to avoid corn injury is necessary. Do NOT use on seed corn or sweet corn.
MCPA	0.38 to 0.63 kg/ha		
ULTIM ((1:1) 75 DF) plus PARDNER (280 g/L) or KORIL (235 g/L) plus non-ionic surfactant	33 g/ha 1 L/ha 1.2 L/ha 2 L/1,000 L	13 g/ac 0.4 L/ac 0.5 L/ac 2 L/1,000 L	<ul style="list-style-type: none"> Delay application until 8-leaf stage of corn, when a height differential can be established between the corn and target weeds. Apply before the initiation of corn silking. Direct spray solution below crop canopy. Apply one water soluble bag/ha of ULTIM. Provides later season quackgrass control. Do NOT use on seed corn or sweet corn.
nicosulfuron/trimsulfuron plus bromoxynil plus non-ionic surfactant	25 g/ha 0.28 kg/ha 0.2% v/v		

** Refer to Table 9-5. Glyphosate Products and "Two-Way" Tank-Mixes, page 149 for a list of registered glyphosate products for this tank-mix.

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
ULTIM ((1:1) 75 DF) plus non-ionic surfactant	33 g/ha 2 L/1,000 L	13 g/ac 2 L/1,000 L	<ul style="list-style-type: none"> Delay application until 8-leaf stage of corn, when a height differential can be established between the corn and target weeds. Application should be made before the initiation of silking. Direct spray solution below crop canopy. Apply one water soluble bag/ha of ULTIM. Provides later season quackgrass control. Do NOT use on seed corn or sweet corn.
nicosulfuron/irimsulfuron plus non-ionic surfactant	25 g/ha 0.2% v/v		

Directed Postemergence – for Liberty tolerant hybrids only

LIBERTY 200 SN (200 g/L)	1.5 to 2.5 L/ha	0.6 to 1 L/ac	<ul style="list-style-type: none"> Use ONLY on field and seed corn specially developed to be tolerant to LIBERTY. Application after the 8-leaf stage of corn must be made as a directed spray below the whorl of the corn plant. LIBERTY is a contact herbicide and has no residual soil activity. Consult the product label for rate recommendations for specific weeds and weed stages. Ammonium sulphate can be added at 6 L/ha (2.4 L/ac) (liquid) or 3.3 kg/ha (1.3 kg/ac) (dry) for improved control of specific weeds. Do NOT add oil or any other surfactants.
glufosinate ammonium	0.3 to 0.5 kg/ha		

TABLE 9-3. REGISTERED SOIL APPLIED HERBICIDE TANK-MIXES IN CORN

TRADE NAME	GRASS HERBICIDES			BROADLEAF HERBICIDES						GRASS AND BROADLEAF						
	DUAL II MAGNUM	ERADICANE	FRONTIER	atrazine*	BANVEL II or ORACLE	CALLISTO	CALLISTO + atrazine*	MARKSMAN	LOROX L	LOROX + atrazine*	SENCOR	simazine*	BATTALION ¹	CONVERGE PRO ¹	PRIMEXTRA II MAGNUM	PROWL
Soil Applied Grass Herbicides																
DUAL II MAGNUM	✓			✓	✓	✓	✓	✓	✓	✓				✓		
ERADICANE				✓							✓					
FRONTIER				✓			✓									
Soil Applied Broadleaf Herbicides																
atrazine*	✓	✓	✓		✓	✓	✓	✓	✓							
BANVEL II or ORACLE	✓		✓	✓										✓	✓	✓
CALLISTO				✓											✓	
CALLISTO + atrazine*	✓															
MARKSMAN	✓		✓													✓
LOROX L																
LOROX L + atrazine*	✓			✓											✓	
SENCOR				✓												
simazine*																
Soil Applied Grass and Broadleaf Herbicides																
BATTALION																
CONVERGE PRO ¹	✓															
PRIMEXTRA II MAGNUM					✓	✓	✓	✓	✓							
PROWL					✓	✓	✓	✓	✓							

* Numerous products exist, refer to Table 4-1, page 21 for a complete list of products.

¹ Indicates herbicide sold as a co-pack under this trade name.

✓ Indicates the two matching herbicides can be tank-mixed.

TABLE 9-4. REGISTERED POSTEMERGENCE HERBICIDE TANK-MIXES IN CONVENTIONAL AND "LIBERTY-LINK" CORN (CONT'D)

	GRASS HERBICIDES	BROADLEAF HERBICIDES	GRASS AND BROADLEAF
IMPACT + atrazine*	ACCENT DUAL II MAGNUM FRONTIER OPTION 2.25 OD PROWL ULTIM	2.4-D* 2.4-DB* atrazine* BANVEL II, ORACLE BASAGRAN FORTE BUCTRIL M, BADGE, MEXTROL CALLISTO CALLISTO + AATREX LIQUID DISTINCT IMPACT IMPACT + atrazine* LADDOK MARKSMAN MCPA* MCPB/MCPA* PARDNER, KORIL PARDNER or KORIL + atrazine* PEAKPLUS ¹ PEAKPLUS ¹ + atrazine*	ACCENT-1-PASS ¹ ACCENT TOTAL BATTALION ¹ OPTION 1.2.3. ¹ PRIMEXTRA II MAGNUM PROWL + BANVEL II or ORACLE LIBERTY 200 SN ²
LADDOK			
MARKSMAN	✓		
MCPA *	✓		✓
MCPB/MCPA*	✓		
PARDNER, KORIL	✓		
PARDNER, KORIL + atrazine*	✓		
PEAKPLUS ¹	✓		
PEAKPLUS ¹ + atrazine*	✓		
SHOTGUN	✓		
SUMMIT	✓		
Postemergence Grass and Broadleaf Herbicides			
ACCENT 1-PASS ¹		✓	
ACCENT TOTAL ¹			
BATTALION ¹			
OPTION 1.2.3. ¹		✓	
PRIMEXTRA II MAGNUM		✓	✓
PROWL + BANVEL II or		✓	
ORACLE			
LIBERTY 200 SN ²	✓	✓	✓

* Numerous products exist, refer to Table 4-1, page 21 for a complete list of products.
¹ Indicates herbicide sold as a "co-pack" under this trade name.
² For use on "Liberty Link" corn hybrids.
 ✓ Indicates that the two matching herbicides can be tank-mixed.

TABLE 9-5. GLYPHOSATE PRODUCTS AND "TWO-WAY" TANK-MIXES FOR USE ON GLYPHOSATE TOLERANT OR "ROUNDUP-READY" CORN

GLYPHOSATE PRODUCTS	GLASS & BROADLEAF HERBICIDES		BROADLEAF HERBICIDES										GRASS & BROADLEAF			
	GLASS HERBICIDES	GLASS & BROADLEAF HERBICIDES	BANVEL II or ORACLE	atrazine*	BUCTRL M	CALLISTO + atrazine	DISTINCT	MARKSMAN	MCPA*	IMPACT + atrazine	PEAKPLUS ¹	SHOTGUN	SUMMIT	BATTALION ¹	PROWL	PRIMEXTRA II MAGNUM
DUAL II MAGNUM	ELIM EP ²	FRONTIER		✓												
CREDIT PLUS (360 g/L)				✓				✓								
FACTOR (360 g/L)				✓				✓								
FACTOR 540 GLYPHOSATE (540 g/L)				✓				✓								
ROUNDUP ULTRA2 (540 g/L)				✓				✓								
ROUNDUP WEATHERMAX (540 g/L)				✓				✓								
SHARPSHOOTER PLUS (360 g/L)				✓				✓								
VANTAGE (360 g/L)				✓				✓								
VANTAGE PLUS (360 g/L)				✓				✓								
VANTAGE PLUS MAX (480 g/L)				✓				✓								

* Numerous products exist, refer to Table 4-1, page 21 for a complete list of products.

¹ Indicates herbicide sold as a "co-pack" under this trade name.

² Sold only with ROUNDUP WEATHERMAX in a co-pack called GALAXY.

✓ Indicates that the two matching herbicides can be tank-mixed.

TABLE 9-6. MAXIMUM WEED LEAF STAGES (OR HEIGHT) FOR POSTEMERGENCE HERBICIDE APPLICATIONS IN CORN

TRADE NAME	APPLICATION WINDOW (CORN LEAF-OVER STAGE)	ANNUAL GRASS WEEDS: MAXIMUM LEAF STAGE					ANNUAL BROADLEAF WEEDS: MAXIMUM LEAF STAGE								PERENNIALS			
		barnyard grass	crabgrass	fall panicum	green foxtail	witchgrass	proso millet	buckwheat, wild	cocklebur	jimsonweed	lady's-thumb	lamb's-quarters	wild mustard	nightshade		pigweed	ragweed	velvetleaf
Postemergence Grass Herbicides																		
ACCENT	1-8 leaf	6	-	6	6	6	6	-	-	-	-	-	-	-	-	-	-	
DUAL II MAGNUM	PRE - 3 leaf	1	1	1	1	1	1	-	-	-	-	-	PRE	PRE	-	-	-	
FRONTIER	PRE - 3 leaf	1	1	1	1	1	1	-	-	-	-	-	PRE	PRE	-	-	-	
ULTIM	1-6 leaf	6	-	6	6	6	6	-	-	-	-	-	-	6	-	-	3-6	
Postemergence Broadleaf Herbicides																		
atrazine	tolerant at all stages	-	-	-	-	-	-	-	PRE	-	10 cm	10 cm	10 cm	10 cm	10 cm	7-10 cm	5-10 cm	
BANVEL II OR ORACLE	up to 5 leaf	-	-	-	-	-	-	-	4	4	4	4	4	4	4	4	4	
BUCTRIL M OR BADGE OR MEXTROL	4-6 leaf	-	-	-	-	-	-	-	8	4	-	4	8	8	-	4	8	4
CALLISTO + atrazine	3-8 leaf	-	-	-	-	-	-	-	8	4	4	8	8	-	8	6	8	-
DISTINCT	2-6 leaf	-	-	-	-	-	-	-	6	6	6	6-8	6	6	6	6	6	-
IMPACT + atrazine	1-7 leaf	4	-	-	4	-	-	-	-	5	-	8	8	8	8	8	8	-
MARKSMAN	up to 5 leaf	-	-	-	-	-	-	-	4	4	4	4	4	4	4	4	4	-
PARDNER OR KORIL	4-8 leaf	-	-	-	-	-	-	-	8	4	-	4	8	4	-	4	4	-
PARDNER OR KORIL + atrazine	4-8 leaf	-	-	-	-	-	-	-	8	4	-	4	8	4	-	6	8	6
PEAKPLUS ¹	up to 6 leaf	-	-	-	-	-	-	-	-	6	5	4	6	12	-	6	8	6
SHOTGUN	spike-4 leaf	-	-	-	-	-	-	-	6	-	-	6	6	6	-	6	6	-
SUMMIT	2-7 leaf	-	-	-	-	-	-	-	-	-	5	-	6	7	-	8	6	4

¹ Indicates herbicide sold as a "co-pack" under this trade name.

² For use only on glyphosate tolerant (Roundup Ready) corn hybrids.

— indicates that either the weed is not controlled by the corresponding herbicide, or not enough data is available to specify a maximum leaf stage. Expressed as leaf stages except as indicated.

TABLE 9-6. MAXIMUM WEED LEAF STAGES (OR HEIGHT) FOR POSTEMERGENCE HERBICIDE APPLICATIONS IN CORN (CONT'D)

TRADE NAME	APPLICATION WINDOW (CORN LEAF-OVER STAGE)	ANNUAL GRASS WEEDS: MAXIMUM LEAF STAGE										ANNUAL BROADLEAF WEEDS: MAXIMUM LEAF STAGE						PERENNIALS		
		barnyard grass		crabgrass	fall panicum	green foxtail	witchgrass	proso millet	buckwheat, wild	cocklebur	jimsonweed	lady's-thumb	lamb's-quarters	wild mustard	nightsshade	pigweed	ragweed		velvetleaf	quackgrass
Postemergence Broadleaf and Grass Herbicides																				
ACCENT 1-PASS ¹	1-7 leaf	6	-	6	6	6	6	6	6	6	6	6	6	12	-	6	8	6	6	3-6
ACCENT TOTAL ¹	2-8 leaf	6	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3-6
BATTALION ¹	PRE - 3 leaf	3	PRE	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	3
GALAXY ^{1,2}	1-6 leaf	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
glyphosate ²	up to 8 leaf	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	-
IMPACT + FRONTIER + atrazine	1-7 leaf	4	-	-	4	-	-	-	-	-	-	-	-	-	5	-	8	8	8	8
LIBERTY	up to 8 leaf	5	5	4	5	4	5	4	5	4	5	4	5	-	4	-	6	6	4	1-4
OPTION 2.250D	up to 8 leaf	6	-	4	5	4	5	4	5	4	5	4	5	-	-	-	8	7	5	7
PRIMEXTRA	PRE - 3 leaf	2	2	2	2	2	2	2	2	2	2	2	2	PRE	-	2	2	2	2	2
ULTIM TOTAL	2-6 leaf	6	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3-6

¹ Indicates herbicide sold as a "co-pack" under this trade name.

² For use only on glyphosate tolerant (Roundup Ready) corn hybrids.

- indicates that either the weed is not controlled by the corresponding herbicide, or not enough data is available to specify a maximum leaf stage. Expressed as leaf stages except as indicated.

TOMATOES



TOMATOES

Production Requirements

Tomatoes perform well on a wide range of mineral soil types, but good drainage is essential. Lighter soils produce earlier crops and facilitate mechanical harvesting. A soil pH range of 6.0–6.8 is optimal.

In Ontario, tomatoes are established using greenhouse-produced transplants. Fresh-market varieties grown in Ontario require 58–80 days from transplanting to harvest. Processing varieties require from less than 100 to over 130 days. Harvest begins 6–10 weeks after pollination.

Average Yields

Crop	per acre	per hectare
Fresh market	8–14 tons	18–31 tonnes
Cherry tomatoes	2.5–3.5 tons	5.5–8 tonnes
Processing	32–40 tons	72–90 tonnes

Cultivars

Fresh-market tomato growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix D, *Vegetable Seed Suppliers*, on page 229. Growers of tomatoes for processing must grow varieties specified by the processor.

See the section *Transplanting*, on page 39, for information on producing tomato transplants.

Plasticulture

Fresh-market tomatoes respond well to plastic mulch, row covers and drip irrigation. However, keep in mind that tomatoes are sensitive to low temperatures. Row covers may not provide significant frost protection. Monitor the temperature inside the row cover regularly and ventilate when it reaches 35°C (95°F) or higher. Remove the cover once conditions are favourable for good growth and prior to pollination. To control weed growth under the mulch, choose a mulch that blocks most light transmission, such as black, white on black, or infrared-transmitting mulch. High tunnels are another option to extend the field tomato production season. For more information, see the section *Season Extension*, on page 34.

Plant Spacing

Table 9–101, *Tomato Plant Spacing*, right, shows spacing for both fresh-market and processing types of tomatoes.

Table 9–101.
Tomato Plant Spacing

Type	Row Spacing	In-Row Spacing	Bed Centres
Fresh Market			
Large vined (indeterminate)	1.5–1.8 m (5–6 ft)	50–70 cm (20–27 in.)	
Small vined (determinate and semi-determinate)	0.9–1.5 m (3–5 ft)	30–60 cm (12–24 in.)	
Processing (Machine Harvest)			
Twin row system	45 cm (18 in.)	38–45 cm ¹ (15–18 in.)	1.5–1.65 m (5–5.5 ft)
Single row system	75 cm (30 in.)	38–45 cm ¹ (15–18 in.)	

¹ For small-vined, early-season processing varieties, in-row spacing can be reduced to 33–38 cm (13–15 in.).

Machine harvest varieties may be grown in twin or single rows, with or without raised beds, depending on the harvest equipment. The improved air circulation associated with single rows may help to reduce foliage and fruit disease.

Fertility

Nitrogen

FRESH-MARKET TOMATOES

For non-fertigated fresh market tomatoes, apply nitrogen according to Table 9–102, *Non-Fertigated Tomato Nitrogen Recommendations*, below. Avoid late side-dress applications. They may prune the roots and trigger blossom-end rot.

Table 9–102.
Non-Fertigated Tomato
Nitrogen Recommendations

	Actual N	
	kg/ha	lb/acre
Fresh-Market		
Preplant	35–50	31–45
Side-dress (applied after the first fruit are set)	35–50	31–45
Processing – Hybrid		
Coarse sand and sandy loams <2% organic matter	160–180	142–160
Loams, silt loams and sandy loams >2% organic matter	90–120	80–107
Processing – Open-Pollinated		
Coarse sand and sandy loams <2% organic matter	100–120	89–107
Loams, silt loams and sandy loams >2% organic matter	70–90	62–80

**Table 9-103.
Fertigated Tomato
Nitrogen Recommendations**

Timing	Actual N	
	kg/ha	lb/acre
Fresh Market Tomatoes – on all soils		
Processing Tomatoes – on all soils (except coarse-textured soils containing less than 3.2% organic matter)		
Preplant (broadcast)	35–50	31–45
Transplanting to fruit set	2.5/week	2.2/week
Fruit sizing to harvest	5/week	4.5/week
Harvest	2.5/week	2.2/week
Processing Tomatoes – on coarse-textured soils containing less than 3.2% organic matter only		
Preplant (broadcast)	85–120	77–107
Week 1–3 (transplant to first bloom)	no fertigation	
Week 4 (beginning of fruit set)	20–25/week	18–22/week
Week 5–7 (beginning of fruit sizing)	25–35/week	22–31/week
Week 8–9	20–25/week	18–22/week
Week 10	continue irrigation, no fertigation	
Week 11 to harvest	no irrigation/fertigation	
Do not exceed 300 kg/ha (270 lb/acre) total nitrogen applied during the season.		

For fertigated fresh market tomatoes, apply nitrogen according to the schedule in Table 9-103, *Fertigated Tomato Nitrogen Recommendations*, above.

PROCESSING TOMATOES

The nitrogen rate will vary greatly, according to variety, soil type, crop rotation, organic matter and soil management.

For tomatoes that are not fertigated, apply nitrogen as a preplant broadcast application according to the recommendations in Table 9-102, *Non-Fertigated Tomato Nitrogen Recommendations*, on page 197.

For fertigated tomatoes, broadcast and incorporate the recommended preplant nitrogen. Apply the remainder of the nitrogen according to Table 9-103, *Fertigated Tomato Nitrogen Recommendations*, above.

The nitrogen rate for fertigated processing tomatoes on coarse textured soils with organic matter levels of 2.5%–3.2% is very specific to these soils. The supporting research was conducted near Harrow, on Granby sandy loam and Granby loamy sand soils. There is no research showing a benefit of this higher fertigation rate on other soil types. All other soils should use the alternative fertigation recommendation.

Timely establishment of cover crops is recommended following the harvest of vegetable crops, to manage residual soil nitrogen and nitrogen release from plant residue.

**Table 9-104.
Fertigated Tomato
Potassium Recommendations**

Timing	Actual K ₂ O	
	kg/ha	lb/acre
Preplant	35–50	31–45
Transplanting to fruit set	2.5/week	2.2/week
Fruit sizing to harvest	5/week	4.5/week
Harvest (fresh market)	2.5 /week	2.2/week

Alternatively, potassium can be applied 100% preplant, according to Table 1-12, on page 15.

Phosphorus

Test the soil to determine phosphorus requirements. Where the soil test values are 61 mg P per L soil (ppm) or higher, tomatoes are unlikely to respond to additional phosphate applications. For soils testing lower than 61 mg P per L soil (ppm), see Table 1-10, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 12.

All phosphorus should be broadcast preplant. When fertigating, never apply phosphorus through the drip line.

Potassium

Test the soil to determine potassium requirements. Where the soil test values are 181 mg K per L soil (ppm) or higher, fresh-market and paste tomatoes are unlikely to respond to additional potash applications. For whole-pack tomatoes, use a higher threshold of 250 mg K per L soil (ppm).

For soils testing lower than the threshold values listed above, see Table 1-12, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15. For fertigated tomatoes, potash can be applied 100% preplant, or split between preplant and fertigated, according to the recommendations in Table 9-104, *Fertigated Tomato Potassium Recommendations*, above.

STARTER SOLUTION (ALL TOMATOES)

Apply a high-phosphorus starter fertilizer in the transplant water when transplanting tomatoes. Starter fertilizer is especially important when planting in cool soils.

**Table 9-105.
Tomato Starter Solution Recommendations**

Soil Temperature	Starter Concentration ¹
<18°C (64°F)	Use full label rate as recommended.
18°C–27°C (64°F–81°F)	Use half of recommended rate.
>27°C (81°F)	Starter not normally required.

¹ Under high temperature or dry conditions or in sandy soils with less than 2% organic matter, use half the recommended rates.

Table 9-106.
Tomato Nutrient Sufficiency Ranges

Plant Part	Time of Sampling	N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu
		Percent (%)							Parts Per Million (ppm)			
Most recently mature leaf	5-leaf stage	3-5	0.3-0.6	3-5	1-2	0.3-0.5	0.3-0.8	40-100	30-100	25-40	20-40	5-15
	First flower	2.8-4	0.2-0.4	2.5-4	1-2	0.3-0.5	0.3-0.8					
	Early fruit set	2.5-4	0.2-0.4	2.5-4	1-2	0.25-0.5	0.3-0.6	40-100	30-100	20-40	20-40	5-10
	First ripe fruit	2-3.5	0.2-0.4	2-4	1-2	0.25-0.5	0.3-0.6					
	During harvest period	2-3	0.2-0.4	1.5-2.5	1-2	0.25-0.5	0.3-0.6					

Adapted from Maynard, D.N., and G.J. Hochmuth. 2007. *Knott's Handbook for Vegetable Growers*. 5th edition. John Wiley & Sons, Inc. New York.

TOMATOES

Starter fertilizers are available in several forms, including liquids (10-34-0 or 6-24-6), soluble, or granular materials (10-30-20 or 10-52-10). Apply according to the recommendations in Table 9-105, *Tomato Starter Solution Recommendations*, on page 198.

Magnesium

A magnesium deficiency may occur on tomatoes. The usual symptoms are yellowing of older leaves while the veins remain dark green. Excessive potash applications may induce a magnesium deficiency. Reduce potassium fertilizer rates on soils testing less than 100 ppm magnesium. Adjust the potassium rate proportionally to a minimum of 50% at 50 ppm Mg. See the section *Micronutrients*, on page 17, and Table 1-13, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

Plant Analysis

When used in conjunction with a soil analysis, plant analysis is a useful tool for diagnosing crop problems or for evaluating a fertilizer program. The objective of a good fertilizer program is to maintain tissue nutrient concentrations on the lower side of the sufficiency range. Attempting to bring the nutrient analysis up to the higher end of the range could possibly result in over-fertilization and may not be economical. For more information see the section, *Plant Analysis*, on page 3.

Only use sufficiency ranges as a reference and a guideline. Plant analysis does not replace soil testing or a sound soil fertility program. See Table 9-106, *Tomato Nutrient Sufficiency Ranges*, above.

Integrated Pest Management Transplant Production — Disease Management

Bacterial spot is a serious disease of tomatoes. Talk to your seed supplier to ensure that proper seed treatment prevention methods have been used. A greenhouse spray program with a fixed copper fungicide can greatly reduce

the field infection rate later in the season. Apply every 5 days, starting 2 1/2 weeks after seeding. Use low water volumes — wet the foliage, but not to excessive runoff. Ensure foliage is dry when shipping plants.

Fungicides registered for greenhouse transplant production are listed in Table 9-107, *Greenhouse Tomato Transplant Production Disease Control Recommendations*, on page 200. See also the section *Bacterial Disease Control With Copper Fungicides*, on page 202. For more information on vegetable transplant production, see Chapter 5, *Seeding and Transplanting*, on page 37.

Diseases

ANTHRACNOSE

Identification: Fruit symptoms appear as small, sunken, water-soaked, circular spots. Lesions gradually expand to 20 mm (3/4 in.) in diameter, developing a pattern of concentric rings. The lesions darken, and small black fungal structures appear in the centre. Anthracnose lesions on leaves are inconspicuous.

Development: Infections can take place under a wide range of temperatures from 10°C–30°C (50°F–86°F). Rapid development occurs during periods of prolonged leaf wetness. While symptoms appear only on ripe fruit, infection can be initiated on green fruit. It is critical that green fruit be adequately protected with a fungicide program.

Thresholds: See the section *TOMcast*, on page 200. There is little tolerance for anthracnose in processing crops, where fruit must be held in the field and the taste of the product can be affected. Do not delay initial fungicide applications beyond July 11 (July 18 for very late plantings).

Management Notes: Follow a minimum 3-year rotation with non-solanaceous crops. Control weeds that can act as hosts. Use disease-free or treated seed. Properly timed fungicide sprays are effective at reducing losses to this

Table 9-107.
Greenhouse Tomato Transplant Production Disease Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	Notes
DAMPING-OFF, ROOT ROT					
phthalimide (group M3)	captan	Maestro 80 DF	1.25 kg/1,000 L of water.		Soil drench treatment. 48-hr re-entry.
		Supra Captan 80 WDG	Apply 50–85 L of solution per 100 m ² (1,076 ft ²).		
dithiocarbamate (group M2)	oxine benzoate	No-Damp	10 mL/L of water		Damping off. Soil treatment.
BOTRYTIS GREY MOULD					
hydroxanilide (group G3)	fenhexamid	Decree 50 WDG	1.5 kg	607 g	Maximum 2 applications per crop cycle. 60 day pre-harvest interval. 4-hr re-entry.
BACTERIAL DISEASE					
inorganic (group M1)	copper hydroxide	Kocide 2000	3.2 kg	1.3 kg	Apply every 5 days, when warranted, to a maximum of 5 applications over a 4-week period prior to transplanting. Apply in low water volumes. 24-hr re-entry.

disease. See Table 9-108, *Tomato Fungal Disease Control Recommendations*, on page 201.

EARLY BLIGHT

Identification: Circular spots with dark, concentric rings (target spots) develop on the older foliage. Severe infections spread to younger leaves. Fruit infections are not common, but may appear as a blackened area at the stem-end.

Development: Early blight overwinters in infected crop residue. Spores are present throughout the growing season and may be carried long distances in the wind. Temperatures of 17°C–24°C (63°F–75°F) and extended leaf wetness favour early blight development.

Thresholds: See the section *TOMcast*, right.

Management Notes: Reduce early blight inoculum by following a 3- to 4-year crop rotation. Ensure transplants are healthy and free of disease. Cultivars vary in tolerance to early blight. See Table 9-108, *Tomato Fungal Disease Control Recommendations*, on page 201.

SEPTORIA LEAF SPOT

Identification: Lower leaves become peppered with small, dark, circular spots up to 5–6 mm (1/4 in.) in diameter. Spots have a dark margin with a lighter centre. Tiny, black fungal structures (pycnidia) are visible in the centre of the lesions. Rapid defoliation may occur if left untreated.

Development: Plants are most susceptible after fruit set. Septoria leaf spot prefers warm temperatures of 20°C–25°C (68°F–77°F) and extended periods of leaf wetness caused by overhead irrigation, rain or heavy dews.

Thresholds: See the section *TOMcast*, below.

Management Notes: Ensure disease-free seed and transplants. Rotate crops and control solanaceous weeds, such as nightshade. See Table 9-108, *Tomato Fungal Disease Control Recommendations*, on page 201.

TOMcast

The TOMcast program is available in some growing areas to help field tomato growers determine the optimum time to apply foliar fungicides for the control of early blight, septoria leaf spot and anthracnose.

A network of weather stations monitors conditions affecting disease development. The weather data is used to calculate disease severity values (DSVs) throughout the growing season. Growers are advised to spray when a critical number of DSVs have accumulated since planting or since the last fungicide application. For more information, contact Weather Innovations Incorporated at 519-352-5334 or see their website at www.weatherinnovations.com.

If the TOMcast service is unavailable, begin a preventative spray program when the first fruits are about walnut size. Repeat sprays as necessary. Repeat at 5–7-day intervals during continuous moist weather. Extend the schedule to 12–14 days in warm, dry weather if diseases are under control. Applications should continue until close to harvest. Anthracnose lesions can appear on unprotected fruit within 5–6 days in favourable conditions.

Table 9-108.
Tomato
Fungal Disease Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
ANTHRACNOSE, EARLY BLIGHT, LATE BLIGHT, SEPTORIA LEAF SPOT						
chloronitrile (group M4)	chlorothalonil	Bravo 500	2.4–4.0 L	0.97–1.62 L	1	48-hr re-entry.
dithiocarbamate (group M2)	mancozeb	Dithane DG	1.1–3.25 kg	0.45–1.3 kg	7	Early blight, anthracnose, late blight only.
		Manzate Pro-Stick	1.75–3.25 kg	0.7–1.3 kg	7	
		Penncozeb 80 WP	1.1–3.25 kg	0.45–1.3 kg	7	
	metiram	Polyram DF	2.25–3.25 kg	0.9–1.3 kg	7	Low rate for early and late blight; high rate for anthracnose and septoria leaf spot.
Qol (group 11)	azoxystrobin	Quadris Flowable	300–500 mL	120–200 mL	1	Early blight, anthracnose only. Maximum 3 applications/yr. Do not apply for 21 days after transplanting. Do not apply for 6 days before or after using metribuzin.
	pyraclostrobin	Cabrio EG	560–840 g	226–340 g	0	Use up to 1 kg/ha (400 g/acre) for late blight. Maximum 6 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
carboxamide (group 7)	boscalid	Lance WDG	175–315 g	70–126 g	0	Early blight only. Maximum 5 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group. 4-hr re-entry.
Qol + acetamide (group 11 + group 27)	famoxadone + cymoxanil	Tanos 50 DF	560–840 g	226–340 g	3	Early blight and late blight only. 24-hr re-entry. Do not apply sequential applications of any Qol fungicide or of any tank-mix containing a Qol fungicide.
inorganic + dithiocarbamate (group M1 + group M2)	copper hydroxide + mancozeb	Parasol Flowable + Dithane DG	2.3 L + 1.75–2.25 kg	0.9 L + 0.7–0.9 kg	7	Septoria leaf spot, early blight and late blight only. Apply at 7–10-day intervals.
		Parasol Flowable + Manzate Pro-Stick	2.3 L + 1.75–2.25 kg	0.9 L + 0.7–0.9 kg	7	Early blight and septoria leaf spot only. Use the high rate for early blight. Apply at 7-day intervals.
inorganic (group M1)	copper hydroxide	Kocide 2000	2.24–2.52 kg	0.91–1.0 kg	1	
phthalimide (group M3)	captan	Maestro 80 DF	2.75–4.25 kg	1.1–1.7 kg	2	Anthracnose and septoria leaf spot only. Use high rate on mature plants or for severe infections. 48-hr re-entry.
		Supra Captan 80 WDG	2.75–4.25 kg	1.1–1.7 kg	2	
BOTRYTIS GREY MOULD						
carboxamide (group 7)	boscalid	Lance WDG	420 g	168 g	0	Maximum 5 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group. 4-hr re-entry.

¹ PHI = Pre-Harvest Interval.

BACTERIAL SPOT AND BACTERIAL SPECK

Identification: It can be difficult to distinguish between these two diseases. Small, dark lesions develop on the leaves. The infected tissue of either disease may exhibit a

yellow halo. Lesions also occur on stems and flower buds. Severe infections may cause defoliation.

Table 9-109.
Tomato
Bacterial Disease Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
inorganic + dithiocarbamate (group M1 + group M2)	copper hydroxide + mancozeb	Kocide 2000 + Dithane DG	3.2 kg + 1.75–2.25 kg	1.3 kg + 0.7–0.9 kg	7	Only effective if applied 7 days after transplanting and repeated at 7-day intervals for at least 3 applications. Apply more frequently under wet conditions. If wet conditions persist, applications may be continued until early bloom. 24-hr re-entry.
		Parasol Flowable + Dithane DG	2.3 L + 1.75–2.25 kg	0.9 L + 0.7–0.9 kg	7	
		Parasol Flowable + Manzate Pro-Stick	2.3 L + 1.75–2.25 kg	0.9 L + 0.7–0.9 kg	7	

¹ PHI = Pre-Harvest Interval.

These diseases initiate lesions on green fruit. Bacterial spot-infected fruit develop small, raised, dark spots. Young lesions may have a white halo, similar to bacterial canker. Spots increase in size to 4–6 mm (1/4 in.) in diameter and develop brown, corky centres.

Bacterial speck fruit lesions are small (<2 mm in diameter), black, slightly raised and often surrounded by a narrow, green-to-yellow halo. Speck lesions on the fruit are usually superficial and can be scraped off.

Development: Bacterial spot prefers warm temperatures of 24°C–30°C (75°F–86°F). Bacterial speck favours cooler weather — 18°C–24°C (64°F–75°F). Abundant rainfall and high humidity aid infection of both diseases.

Thresholds: None established. Tolerance for either disease is low in fresh-market or processing tomatoes (wholepack and diced) due to marketability and peeling issues.

Management Notes: All tomato seed should be disinfected by the supplier, using acid or chlorine treatment. Do not plant diseased transplants. Copper fungicides may be effective in slowing bacterial spot development, but only if applied early and often. Bacterial speck populations in Ontario show resistance to copper. See Table 9-109, *Tomato Bacterial Disease Control Recommendations*, above.

Note: Avoid working in fields when foliage is wet. Wash machinery with a high-pressure hose after working in contaminated fields. If possible, schedule overhead irrigation early in the day to allow the foliage time to dry before nightfall or consider a drip irrigation system.

BACTERIAL CANKER

Identification: Early (systemic) infections from infected seed or seedlings are of greatest concern. They cause the plant to wilt, often on only one side. Streaking or open cankers may appear on the stems and a light, reddish-brown discoloration may be seen in the vascular tissue, just above the soil line.

The more common, and less severe, secondary infections show up later in the season. Leaves develop brown-to-black margins with a thin, yellow border. Leaflet edges usually curl upwards.

Infected fruit may develop “bird’s-eye” spots — small lesions with light brown centres and a greasy white halo.

Bacterial Disease Control With Copper Fungicides

In the greenhouse, apply 4–5 applications of a registered fixed copper product, every 5 days, starting 16–18 days after seeding. Use low water volumes. Wet the foliage, but do not soak the plug media. Apply fungicides after the last watering of the day. Ensure foliage is dry when shipping plants.

In the field, apply a copper spray within 7 days of transplanting; within 5 days if the weather is wet (rain, fog, dews) or the greenhouse program was not followed.

Repeat copper applications at 7-day intervals for at least 3 applications. Continue applications until early fruit set if wet conditions prevail or if plants are under stress. Bacterial speck populations in Ontario show resistance to copper.

Research has shown that tank-mixing mancozeb with copper enhances bacterial disease control.

Development: Warm, wet weather conditions with temperatures of 24°C–32°C (75°F–90°F) favour the spread of this disease.

Management Notes: Use disease-free or disinfected seed and disease-free transplants. Copper fungicides may slow canker development. See the section *Bacterial Disease Control With Copper Fungicides* and Table 9–109, *Tomato Bacterial Disease Control Recommendations*, on page 202.

For more information on bacterial diseases, see the OMAFRA Factsheet, *Bacterial Diseases of Tomato: Bacterial Spot, Bacterial Speck, Bacterial Canker*, Order No. 05-069.

LATE BLIGHT

Identification: Late blight causes rapid and severe defoliation. Pale green-to-brown water-soaked spots develop on the leaves. Lesions enlarge rapidly and become brown to purplish-black. A grey-to-white mouldy growth may develop on the underside of infected leaves, especially under conditions of high humidity. Brownish cankers on leaf petioles and stems may girdle and kill the plant. Fruit lesions are firm and greasy-looking, with greyish-green or brown blotches.

Development: The late blight fungus prefers temperatures from 15°C–21°C (59°F–70°F). Cool nights and warm days, with moist weather, are ideal for disease development.

Thresholds: No tolerance. This disease is easily spread by wind and can rapidly destroy the crop.

Management Notes: Preventative fungicide sprays for early blight, septoria and anthracnose also protect against late blight. If the disease is present in the area, follow a 5–7-day fungicide schedule, using fungicides recommended specifically for late blight control. For more information about management practices for reducing late blight, see the section *Late Blight*, on page 157. See also Table 9–108, *Tomato Fungal Disease Control Recommendations*, on page 201.

VERTICILLIUM WILT

Identification: Yellow, V-shaped lesions develop on the lower leaves. Symptoms often appear only on one side of the plant or one side of the leaf. The vascular tissue becomes brown and discoloured, causing infected plants to wilt, especially during the hot part of the day.

Development: *Verticillium* wilt is present all season. However, symptoms are often more severe after fruit set or during dry periods. The presence of plant parasitic nematodes may increase the severity of *verticillium* wilt.

Thresholds: Soil *Verticillium*, root knot and root lesion nematode counts, available from the Pest Diagnostic Clinic, University of Guelph, will help determine the need for control measures. See Appendix G, *Diagnostic Services*, on page 233.

Management Notes: Follow a 4–6-year crop rotation. Do not rotate with related crops, strawberries or raspberries. Keep fields clean of host weeds such as nightshades. Cultivars tolerant to *verticillium* wilt are available. Soil fumigation may be required if *Verticillium* and nematode counts are high. See the section *Nematodes*, on page 63.

VIRUSES (CUCUMBER MOSAIC, TOMATO MOSAIC, STREAK, TOMATO SPOTTED WILT)

Identification: Symptoms vary between viruses, cultivars and conditions. Interaction between viruses may occur, complicating visual diagnosis.

Period of Activity: Cucumber mosaic is spread by aphids. Thrips are a vector for tomato spotted wilt. The presence of these diseases usually follows periods of high aphid/thrips activity. Tomato mosaic and the streak viruses are spread mechanically.

Management Notes: Control weed hosts in and around the field. Pigweeds, nightshades and related weeds, milkweed, purslane, chickweed and many other plants are alternative hosts to the cucumber mosaic virus. See the section *Aphids*, on page 60. Tomato spotted wilt virus is rarely of economic concern.

Insects

CUTWORMS, TARNISHED PLANT BUG, WIREWORM, APHIDS

For identification and management information on these common vegetable insects affecting tomatoes, see Chapter 8, *General Diseases and Insects of Vegetable Crops*, on page 59, Table 9–110, *Tomato Aphid and Colorado Potato Beetle Control Recommendations*, on page 205, and Table 9–111, *Tomato Insect Control Recommendations*, on page 206.

COLORADO POTATO BEETLE

Identification: Adults are orange with 10 black stripes on the wings. Larvae are red-to-orange with two rows of black spots along their sides.

Period of Activity: Feeding damage is mainly a concern early in the season when plants are small.

Thresholds: 0.5 adults or larvae per plant in the first 2 weeks after transplanting or 1 adult or larvae per plant later in the season.

Management Notes: Rotate crops and avoid planting tomatoes adjacent to beetle overwintering sites (previous year's tomato, eggplant or potato fields). Chemical controls are most effective when applied to small larvae. For more information, see the section *Colorado Potato Beetle*, on page 163. See Table 9-110, *Tomato Aphid and Colorado Potato Beetle Control Recommendations*, on page 205.

Warning

In a number of counties and regions, Colorado potato beetles have developed a strong resistance to certain insecticides. To slow development of further resistance, it is essential to rotate between chemical groups each time a spray is applied.

TOMATO OR TOBACCO HORNWORM

These hornworms are large, smooth, green caterpillars. Mature larvae measure 8 cm (3.5 in.) in length. The hornworm has seven or eight conspicuous white V-shaped markings down each side and a prominent spike (horn) on its rear end. The hornworm feeds on the leaves, stems and fruit of tomato plants.

If populations exceed one larvae per 30 plants, apply one of the products listed in Table 9-111, *Tomato Insect Control Recommendations*, on page 206.

CABBAGE LOOPER

The cabbage looper is a sporadic pest of tomatoes. Use a spray threshold of 15 larvae per 30 plants. For complete identification and management information, see the section *Imported Cabbageworm, Cabbage Looper, Diamond-back Moth Caterpillar*, on page 90. Also see Table 9-111, *Tomato Insect Control Recommendations*, on page 206.

STINK BUG, TARNISHED PLANT BUG

Stink bugs feed on tomato fruit. Their piercing mouthparts sting the fruit, producing a yellowish blotch and corky tissue beneath the skin. Damaged fruit does not peel well during processing. Tarnished plant bug causes similar damage. Stink bugs often move into tomatoes from wheat fields or weedy areas as they dry out in mid-summer.

SAP BEETLES

Sap beetles are attracted to damaged or rotting fruit. Establish roadways or dedicated spray rows in the field at suitable intervals to minimize damage caused by farm equipment. Avoid crushing of fruit at picking time.

For processing crops, harvest as close as possible to time of delivery to the factory. If loaded wagons are not delivered immediately, leave them exposed to air circulation.

Birds

Bird-feeding damage on tomato fruit results in reduced yields and quality, as well as increased sorting costs. Noisemakers, such as propane cannons and digital distress calls may be successful deterrents. Use more than one type of scare device. Regular changes to the noise frequency pattern and distribution of these scare tactics will improve their efficacy. Start control measures early, before birds get accustomed to feeding in your field. See the section *Birds*, on page 64.

Overall population control is not feasible. Gulls, crows, cowbirds, starlings, grackles and blackbirds are protected under the Wildlife Conservation Act. However, growers may acquire a permit to use a firearm to scare or shoot birds causing damage to crops. For a permit, call the Enforcement Coordinator, Canadian Wildlife Service, Environment Canada, 905-336-4464.

Physiological Disorders

Blossom-End Rot (BER)

Blossom-end rot is a localized calcium deficiency in the blossom end of the fruit. It occurs when dry soil conditions reduce the amount of water movement into the plant, thus reducing the movement of calcium to the fruit. Calcium is an important component of cell development. BER is caused primarily by dry soil conditions, not by a deficiency of calcium in the soil.

Side-dressing with calcium nitrate will not prevent BER if adequate moisture is not available. Foliar sprays of calcium are also ineffective. Foliar-applied calcium is taken up and fixed in the leaves, and very little reaches the fruit. Avoid deep cultivation, which can prune roots and reduce water uptake. Blossom-end rot can be minimized by properly scheduled irrigation, ensuring steady movement of water and calcium into the plant. (See the section *Irrigation*, on page 27.)

Table 9-110.
Tomato
Aphid and Colorado Potato Beetle Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
APHIDS						
neonicotinoid (group 4)	acetamiprid	Assail 70 WP	56–86 g	22.4–34.4 g	7	Maximum 2 applications/yr. Alternate applications with other insecticide groups. 12-hr re-entry.
chlorinated cyclodiene (group 2A)	endosulfan	Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Thionex 50 WP	1.1 kg	0.45 kg	2	
organophosphate (group 1B)	diazinon ²	Diazinon 50 W	1.1–1.75 kg	0.45–0.71 kg	1	
		Diazinon 500 E	1.1–1.7 L	0.45–0.69 L	1	
	dimethoate	Cygon 480	0.55–1.1 L	0.22–0.45 L	7	
		Lagon 480	0.55–1.1 L	0.22–0.45 L	7	
	malathion ²	Malathion 25 W	2.75–4.25 kg	1.1–1.7 kg	3	Not effective below 20°C (68°F).
		Malathion 500 E	1.5–2.0 L	0.6–0.8 L	3	24-hr re-entry.
acephate	Orthene 75 SP	1.2 kg in 2,000 L of water	0.48 kg in 180 gal of water		Based on 14,000 plants/ha. Transplanting water treatment only. Caution: Temporary plant damage may occur on light sandy soils or if the rate used is too high.	
carbamate (group 1A)	methomyl	Lannate TNG	270–540 g	109–218 g	1	24-hr re-entry.
COLORADO POTATO BEETLE						
Transplant treatment						
neonicotinoid (group 4)	imidacloprid	Admire 240 F	7–10 mL per 100 m of row	2–3 mL per 100 ft of row		Apply in-furrow at transplanting. Consult the label for application details. Do not apply foliar imidacloprid in the same season as a soil application.
		Alias 240 EC	7–10 mL per 100 m of row	2–3 mL per 100 ft of row		
organophosphate (group 1B)	acephate	Orthene 75 SP	1.2 kg in 2,000 L of transplant water	0.48 kg in 180 gal of transplant water		Based on 14,000 plants/ha. Caution: Temporary plant damage may occur on light sandy soils or if the rate used is too high.
Foliar treatment						
biological (group 11)	<i>Bacillus thuringiensis</i>	Novodor	4.0–8.0 L	1.6–3.2 L	0	Field scouting is essential for timing of sprays.
neonicotinoid (group 4)	imidacloprid	Admire 240 F	200 mL	80 mL	7	Maximum 2 foliar spray applications at least 5 days apart may be made per year. Do not make a foliar application following a transplant application of imidacloprid in the same crop. 24-hr re-entry.
		Alias 240 EC	200 mL	80 mL	7	
	acetamiprid	Assail 70 WP	40–80 g	16–32 g	7	Maximum 2 applications/yr. Alternate applications with other insecticide families. 12-hr re-entry.
pyrethroid (group 3)	cyhalothrin-lambda	Matador 120 EC	83–125 mL	34–51 mL	7	Use the higher rate for larger instars or higher populations of larvae. 24-hr re-entry.
		deltamethrin	Decis 5 EC	100–150 mL	40–60 mL	3
	cypermethrin	Ripcord 400 EC	85 mL	34 mL	3	
	permethrin	Pounce 384 EC	180–260 mL	73–105 mL	0	
naturallyte (group 5)	spinosad	Success 480 SC	83 mL	34 mL	1	Use only on small larvae and low infestations. Maximum 3 applications/yr. Maintain a spray water pH of 6 or greater.
		Entrust 80 W	50 g	20 g	1	

¹ Pre-Harvest Interval.² Control of aphids with diazinon and malathion has been inconsistent in many areas.

Table 9-111.
Tomato
Insect Control Recommendations

Group (Group #)	Common Name	Trade Name	Rate per Hectare	Rate per Acre	PHI ¹	Notes
CUTWORMS						
pyrethroid (group 3)	cyhalothrin-lambda	Matador 120 EC	83 mL	34 mL	7	Apply in the late evening or at night. Do not disturb the soil for 5 days after application. 24-hr re-entry.
	permethrin	Pounce 384 EC	180-260 mL	73-105 mL	0	Apply in the late evening or at night.
carbamate (group 1A)	carbaryl	Sevin XLR	45 mL/100-m row	14 mL/100-ft row	2	
	methomyl	Lannate TNG	270-540 g	109-218 g	1	Use the high rate on large larvae (2.5-3.0 cm). 24-hr re-entry.
organophosphate (group 1B)	acephate	Orthene 75 SP	1.2 kg in 2,000 L of water	0.48 kg in 180 gal of water		Also controls wireworm. Based on 14,000 plants/ha. Transplanting water treatment only. Caution: Temporary plant damage may occur on light sandy soils or if the rate used is too high.
TARNISHED PLANT BUG						
pyrethroid (group 3)	cyhalothrin-lambda	Matador 120 EC	83 mL	34 mL	7	24-hr re-entry.
organophosphate (group 1B)	dimethoate	Lagon 480	0.55-1.1 L	0.22-0.45 L	7	
carbamate (group 1A)	carbaryl	Sevin XLR	5.25-6.4 L	2.1-2.6 L	2	
HORNWORM						
biological (group 11)	<i>Bacillus thuringiensis</i>	Thuricide HPC	0.75-1.5 L	0.3-0.6 L	0	Most effective against small larvae.
		Dipel 2X DF	140-275 g	56-110 g	0	
		Biprotec CAF	0.65-1.1 L	0.26-0.44 L	0	
pyrethroid (group 3)	permethrin	Pounce 384 EC	180-260 mL	73-105 mL	0	
carbamate (group 1A)	carbaryl	Sevin XLR	2.5-5.25 L	1.0-2.1 L	2	
chlorinated cyclodiene (group 2A)	endosulfan	Thiodan 4 EC	1.5-2.75 L	0.6-1.1 L	2	
		Thionex 50 WP	1.1 kg	0.45 kg	2	
DROSOPHILA (FRUIT FLY)						
organophosphate (group 1B)	diazinon	Diazinon 50 W	1.1-1.75 kg	0.45-0.7 kg	1	
		Diazinon 500 E	1.1-1.7 L	0.45-0.69 L	1	
	naled	Dibrom	1.1 L	0.44 L	4	
CABBAGE LOOPER						
microbial (group 11)	<i>Bacillus thuringiensis</i>	Thuricide HPC	2.0-4.25 L	0.8-1.7 L	0	Most effective against small larvae.
		Dipel 2X DF	275-550 g	110-220 g	0	
		Biprotec CAF	1.4-2.8 L	0.56-1.12 L	0	

¹ Pre-Harvest Interval.

Chemical Fruit Ripening

Ethephon (Ethrel) is used on processing tomatoes to trigger uniform ripening for once-over harvest. It will also enhance ripening in the late cultivars or during late seasons. For best results, apply ethephon to healthy fields. If plants are under moisture or disease stress, avoid use of ethephon or apply it at reduced rates.

Ethephon is only effective on mature green fruit. Mature green fruit contain a gelatinous pulp surrounding the seeds. Time applications for when 5%–20% of the fruit are showing red colour development.

Good spray coverage on fruit and foliage is essential for maximum effectiveness. Use the higher label rates when day temperatures are below 18°C (64°F) or when plant growth is dense. Excessive rates of ethephon will cause defoliation, reduce fruit quality and shorten field holding ability. Cool temperatures will delay colour development and extend the duration between treatment and harvest. Generally, fruit is ready to harvest 14–21 days after treatment.

Ethrel is not recommended for use on fresh-market tomatoes.

Harvest and Storage

Mature-green fresh-market tomatoes may be stored at 13°C–21°C (55°F–70°F) for 1–3 weeks. Firm, ripe tomatoes should be stored at 8°C–10°C (46°F–50°F) for no more than 4–7 days. Maintain storage at a relative humidity of 90%–95%.

For more information, see Chapter 6, *Food Safety and Storage*, on page 45.

A cover crop should be seeded after harvest is completed; this will protect soil and reduce erosion. In addition, the cover crop will absorb and tie up left-over nitrogen fertilizer and reduce leaching.

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

TOMATOES TRANSPLANTED

Weed control in tomatoes usually consists of a combination of chemical weed control and cultivation. Crop rotation is also beneficial in the control of weeds. Cultivation should be shallow to prevent bringing untreated soil to the surface, which may result in another flush of weeds. When tomatoes are grown on raised beds and beds are reshaped during the course of the season, it may be necessary or useful to apply another herbicide treatment to areas between the rows to prevent a new weed infestation from interfering with harvesting. Do not exceed the total recommended rate per season of any herbicide applied more than once per year. Band treatment of herbicides over the row will reduce the cost by one-half to two-thirds depending on the width of the band compared to the row spacing. Shallow inter-row cultivation will be required for weed control between the rows.

Perennial weeds may be partially controlled by cultivation. Controlling them in crops other than tomatoes when grown in rotation is the best approach to perennial weed control. Perennials are easily spread with cultivators or tillage equipment. Till areas of perennial weeds last. Machinery sanitation is important when moving from between fields.

Site Preparation Before Planting – See Chapter 6, *Special Methods of Weed Control*, page 78.

Apply all treatments in 150–300 L/ha (60–120 L/ac) water unless otherwise specified.

PREPLANT INCORPORATED (PPI) – Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/hr) or vibrating shank S-tine cultivator (10–13 km/hr) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

Tomatoes (Transplanted) – Soil Applied Grass Herbicides

	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	
DUAL II MAGNUM (915 g/L)			<ul style="list-style-type: none">• Apply PPI. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing tomato roots.• Use ONLY on transplanted tomatoes grown for processing.• Do NOT use on muck, peat, high organic matter soils.• Do NOT use on soils with less than 1% organic matter.• Use the higher rate for heavier weed populations, Eastern black nightshade and yellow nut sedge.
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		
TREFLAN EC (480 g/L)	1.25 to 2.3 L/ha	0.5 to 0.92 L/ac	<ul style="list-style-type: none">• Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplant roots.
or RIVAL EC (500 g/L)	1.2 to 2.2 L/ha	0.48 to 0.94 L/ac	<ul style="list-style-type: none">• Use ONLY on transplant tomatoes grown for processing.
or BONANZA 400 (400 g/L)	1.5 to 2.75 L/ha	0.6 to 1.1 L/ac	<ul style="list-style-type: none">• Cool, wet weather may delay transplant establishment but yield is not usually affected.• Do NOT apply to peat or muck soils (> 15% organic matter).• Do NOT apply to soils with < 2% organic matter.• Do NOT apply to fields spread with manure within the last 12 months.• Do NOT apply by air.
trifluralin	0.6 to 1.105 kg/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRODUCT RATE
PER ACRE

PRECAUTIONS
(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

Tomatoes (Transplanted) – Soil Applied Grass and Broadleaf Herbicides

DEVINOL DF (50 DF)	2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplant roots. Registered for use on field seeded and transplanted tomatoes. Use the lower rates on light textured soils. Do NOT apply to soils with over 10% organic matter. Damage to subsequent cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected.
<i>napropamide</i>	1.12 to 2.25 kg/ha		
DUAL II MAGNUM (915 g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplants roots. Use ONLY on transplant tomatoes grown for processing. Do NOT use on muck, peat, or high organic matter soils. Do NOT use on soils with < 2% organic matter. Use the higher rate of DUAL II MAGNUM for heavier weed populations, Eastern black nightshade and yellow nut sedge. Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin. Do NOT exceed total maximum rate of metribuzin recommended for your soil type.
SENCOR 480 F (480 g/L)	0.5 to 1.4 L/ha	0.2 to 0.56 L/ac	
<i>s-metolachlor/benoxacor</i>	1.14 to 1.6 kg/ha		<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplant roots. Use ONLY on transplant tomatoes grown for processing. Do NOT use on muck, peat or high organic matter soils (>15% OM). Use the lower rates on light textured soils. Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin. Do NOT exceed total maximum rate of metribuzin recommended for your soil type. Cool, wet weather may delay establishment, but yield is not usually affected. For Eastern black nightshade, use the higher rate of DUAL II MAGNUM. Preharvest interval is 60 days.
<i>plus metribuzin</i>	0.25 to 0.7 kg/ha		
TREFLAN EC (480 g/L)	1.1 to 2.1 L/ha	0.44 to 0.84 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplant roots. Use ONLY on transplant tomatoes grown for processing. Do NOT use on muck, peat or high organic matter soils (>15% OM). Use the lower rates on light textured soils. Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin. Do NOT exceed total maximum rate of metribuzin recommended for your soil type. Cool, wet weather may delay establishment, but yield is not usually affected. For Eastern black nightshade, use the higher rate of DUAL II MAGNUM. Preharvest interval is 60 days.
<i>plus s-metolachlor/benoxacor</i>	1.05 to 1.38 L/ha	0.42 to 0.56 L/ac	
<i>plus trifluralin</i>	0.5 to 1 L/ha	0.2 to 0.4 L/ac	
<i>plus s-metolachlor/benoxacor</i>	0.528 to 1.008 kg/ha		
<i>plus metribuzin</i>	0.96 to 1.260 kg/ha		
	0.25 to 0.5 kg/ha		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
TREFLAN EC (480 g/L)	1.25 to 2.3 L/ha	0.5 to 0.92 L/ac	<ul style="list-style-type: none"> Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide treated zone and developing transplant roots. Use ONLY on transplant tomatoes grown for processing. Do NOT apply to peat or muck soils (> 15% organic matter). Do NOT apply to soils with < 2% organic matter. Do NOT apply to fields spread with manure within the last 12 months. Use lower rates on sandy soils or soils with low organic matter. Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin. Do NOT exceed total maximum rate of metribuzin recommended for your soil type. Cool, wet weather may delay establishment, but yield is not usually affected.
OR RIVAL EC (500 g/L)	1.2 to 2.2 L/ha	0.48 to 0.94 L/ac	
OR BONANZA 400 (400 g/L)	1.5 to 2.75 L/ha	0.6 to 1.1 L/ac	
plus SENCOR 480 F (480 g/L)	0.5 to 1.4 L/ha	0.2 to 0.56 L/ac	
trifluralin	0.6 to 1.105 kg/ha		
plus metribuzin	0.25 to 0.7 kg/ha		

Tomatoes (Transplanted) – Postemergence Grass Herbicides

POSTEMERGENCE – Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there needs to be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant, see the product label for more details. Always use appropriate drift management technology.

EXCEL SUPER (80.5 g/L)	0.67 L/ha	0.27 L/ac	<ul style="list-style-type: none"> Apply POST when annual grasses are in the 1–6 leaf stage and volunteer corn is up to 25 cm tall. Use ONLY on transplant tomatoes grown for processing. Annual grasses emerging after application will not be controlled. Do NOT apply other herbicides within 4 days of EXCEL SUPER application. Do NOT apply by air. Do NOT use flood jet nozzles or controlled droplet application equipment. Spray tips angled forward 45° will give better coverage. Do NOT apply if rain is expected within one hour after application. Preharvest interval is 55 days. Apply POST to actively growing grasses. For annual grass, use 0.32 L/ha. Apply at the 1–6 leaf stage (2–5 is optimum). For volunteer grains, use 0.47 L/ha. Apply at the 1–6 leaf stage (2–5 is optimum). For quackgrass, use 1.1 L/ha. Apply up to the 3 leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. Use 100–200 L water/ha (40–80 L water/ac). Grasses emerging after application will not be controlled. Do NOT apply any other chemicals within 4 days of POAST ULTRA application. Spray tips angled forward 45° will give better coverage. Do NOT use flood jet or hollow cone nozzles. Do NOT apply if rain is expected within one hour after application. Preharvest interval is 60 days.
fenoxaprop-p-ethyl	0.054 kg/ha		
POAST ULTRA (450 g/L)	0.32 to 1.1 L/ha	0.13 to 0.45 L/ac	
plus MERGE	1 to 2 L/ha	0.4 to 0.8 L/ac	
sethoxydim	0.15 to 0.5 kg/ha		
surfactant/solvent	1 to 2 L/ha		

TRADE NAME (Concentration) active ingredient	PRODUCT RATE PER HA active rate per ha	PRODUCT RATE PER ACRE	PRECAUTIONS (For more information, see Chapter 4, page 21 and Chapter 5, page 67).
VENTURE L (125 g/L)	0.6 to 2 L/ha	0.24 to 0.8 L/ac	<ul style="list-style-type: none"> Apply POST to actively growing grasses before tillering. Apply at 0.6 L/ha (0.24 L/ac) at 2-5 leaf stage of volunteer corn. Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of volunteer wheat and barley. Apply at 1 L/ha (0.4 L/ac) at 2-5 leaf stage of annual grasses (2-4 leaf for foxtails). Apply at 2 L/ha (0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly.
fluzifop-p-butyl	0.075 to 0.25 kg/ha		<ul style="list-style-type: none"> Thorough preplant tillage, fragmenting quackgrass rhizomes improves control. Apply in a maximum volume of 300 L/ha (120 L/ac). Do NOT cultivate for 5 days after application. Do NOT apply other herbicides within 3 days of VENTURE L application. Do NOT apply if rain is expected within 2 hours after application. Preharvest interval is 60 days.

Tomatoes (Transplanted) – Postemergent Broadleaf Herbicides			
AIM EC (240 g/L)			<ul style="list-style-type: none"> Hooded Application ONLY, refer to Chapter 6, page 80 for precautions and rates. Do NOT apply closer than 1 day to harvest.
PINNACLE (75% DF) plus AGRAL 90	5.5 to 8.0 g/ha 2 L/1000 L water	2.2 to 3.2 g/ac 2 L/1000 L water	<ul style="list-style-type: none"> Apply 3 weeks after transplanting to weeds less than 10 cm tall. Add PINNACLE to the spray tank and agitate, then add AGRAL 90. Do NOT apply in less than 100 L water/ha. Do NOT apply if rain is expected within several hours. Apply ONLY once per year. Do NOT apply to tomatoes that are stressed. Do NOT apply within 45 days of harvest.
thifensulfuron methyl plus non-ionic surfactant	4.125 to 6.0 g/ha 0.2% v/v		

Tomatoes (Transplanted) – Postemergent Grass and Broadleaf Herbicides			
PRISM (25DF) plus AGRAL 90 or AG-SURF	60 g/ha 2 L/1000 L water	24 g/ac 2 L/1000 L water	<ul style="list-style-type: none"> Apply POST when hairy nightshade is up to the 4-leaf stage, quackgrass is in the 3-6 leaf stage (less than 10 cm tall), annual grasses are in the 1-6 leaf stage and redroot pigweed is at the 4-6 leaf stage. Apply ONLY once per year. Do NOT apply if rainfall is expected within 2 hours of application. Preharvest interval is 30 days. May be used on processing and fresh market tomatoes.
rimsulfuron plus non-ionic surfactant	15 g/ha 0.2% v/v		
SENCOR DF (75 DF)	0.32 to 1.1 kg/ha	0.13 to 0.44 kg/ac	<ul style="list-style-type: none"> Apply POST at least 3 weeks after transplanting before weeds exceed 4 cm in height. Use ONLY on transplant tomatoes grown for processing. Apply ONLY once per season. Direct spray to bottom one-third of tomato plants to reduce risk of crop injury. Do NOT apply when crop is under stress due to cool, wet, cloudy weather or excessively hot temperatures. Do NOT use on muck soils. Do NOT use on soils with < 2% organic matter. Use lower rates on sandy soils, higher rates on clay soils. Preharvest interval is 60 days.
metribuzin	0.25 to 0.85 kg/ha		

TRADE NAME
(Concentration)
active ingredient

PRODUCT RATE
PER HA
active rate per ha

PRECAUTIONS

(For more information, see Chapter 4, page 21 and Chapter 5, page 67).

SENCOR 480 F (480 g/L)

0.3 L/ha

0.12 L/ac

- Apply up to 4 POST applications per season.
- Apply before the weeds are 2.5 cm in height.
- Use **ONLY** on transplant tomatoes grown for processing.
- BRAVO 500 fungicide (chlorothalnil) may be tank-mixed with this treatment at 2.4–4.8 L/ha (1.2–2.4 kg/ha active). Control of annual grasses may be reduced.
- **Do NOT** apply when crop is under stress due to cool, wet, cloudy weather or excessively hot temperatures.
- **Do NOT** use on muck soils.
- **Do NOT** use on soils with < 2% organic matter.
- **Do NOT** exceed the maximum total rate of metribuzin recommended for your soil.
- Preharvest interval is 30 days.

metribuzin

0.15 kg/ha

Tomatoes (Transplanted) – Postemergent Tank-Mix Options

PRISM (25DF)
plus PINNACLE (75% DF)
plus AGRAL 90

60 g/ha
5.5 to 8.0 g/ha
2 L/1000 L water

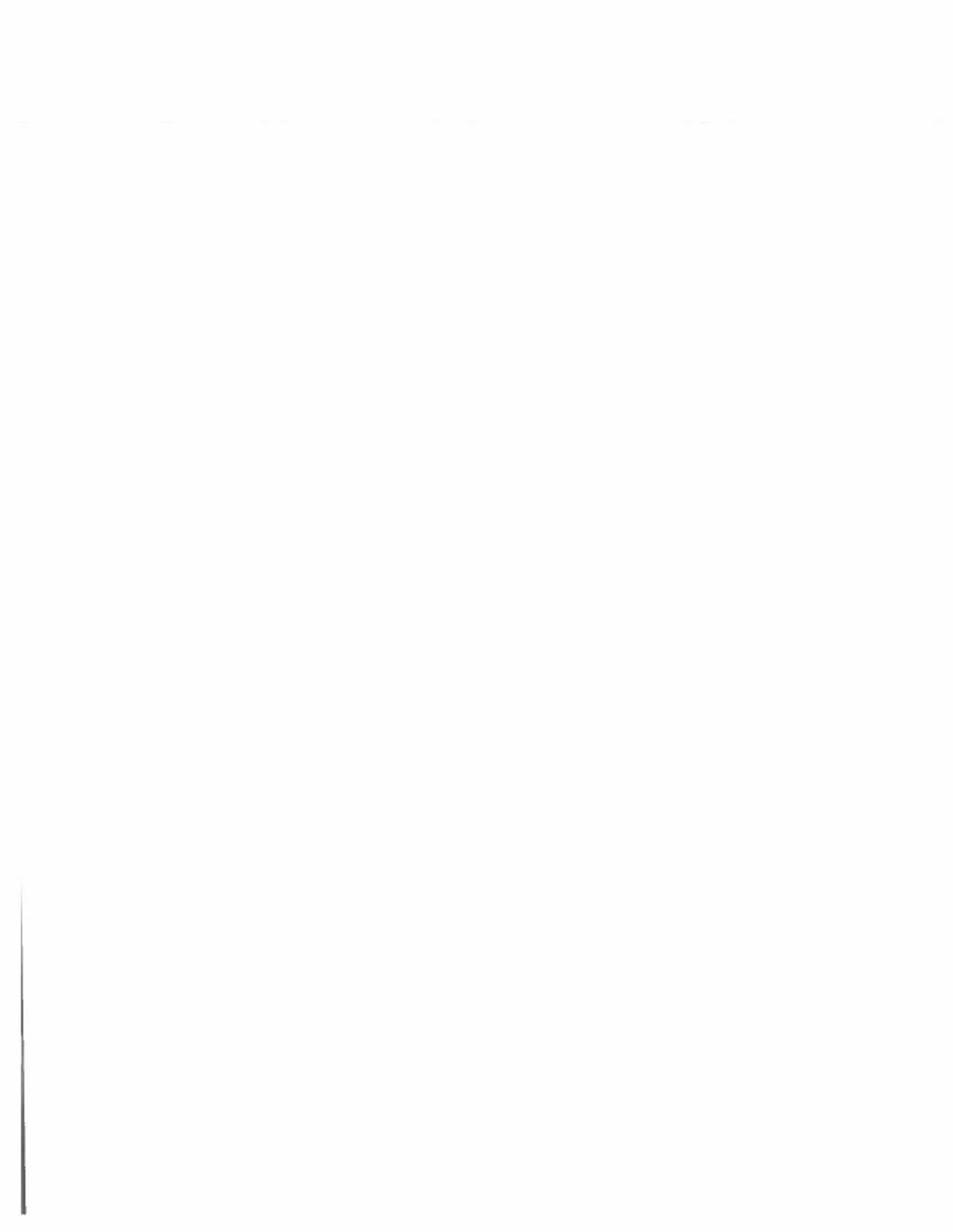
24 g/ac
2.2 to 3.2 g/ac
2 L/1000 L water

rimsulfuron
plus thifensulfuron methyl
plus non-ionic surfactant

15 g/ha
4.125 to 6.0 g/ha
0.2% v/v

- Apply POST when hairy nightshade is up to the 4-leaf stage, quackgrass is in the 3–6 leaf stage (less than 10 cm tall), annual grasses are in the 1–6 leaf stage and redroot pigweed is at the 4–6 leaf stage.
- May be used on processing tomatoes.
- Apply 3 weeks after transplanting to weeds less than 10 cm tall.
- **Do NOT** apply in less than 200 L water/ha.
- **Do NOT** apply if rain is expected within 2 hours of application.
- **Do NOT** apply to tomatoes that are stressed.
- **Do NOT** apply within 45 days of harvest.

Section B



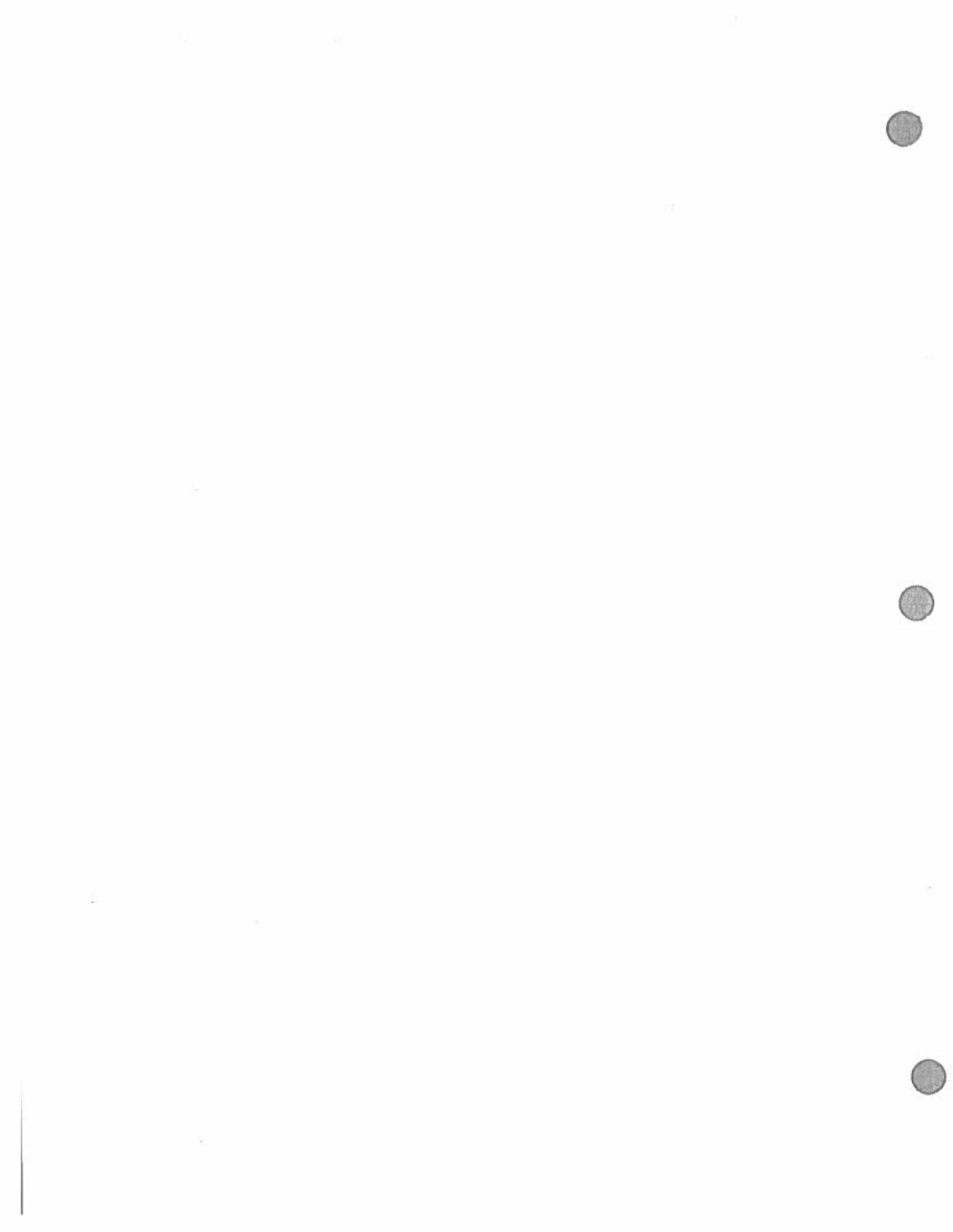
Processing Tomato Industry

Pesticide Management Protocol

Ontario Processing Vegetable Growers

Ontario Food Processors Association

July, 2008

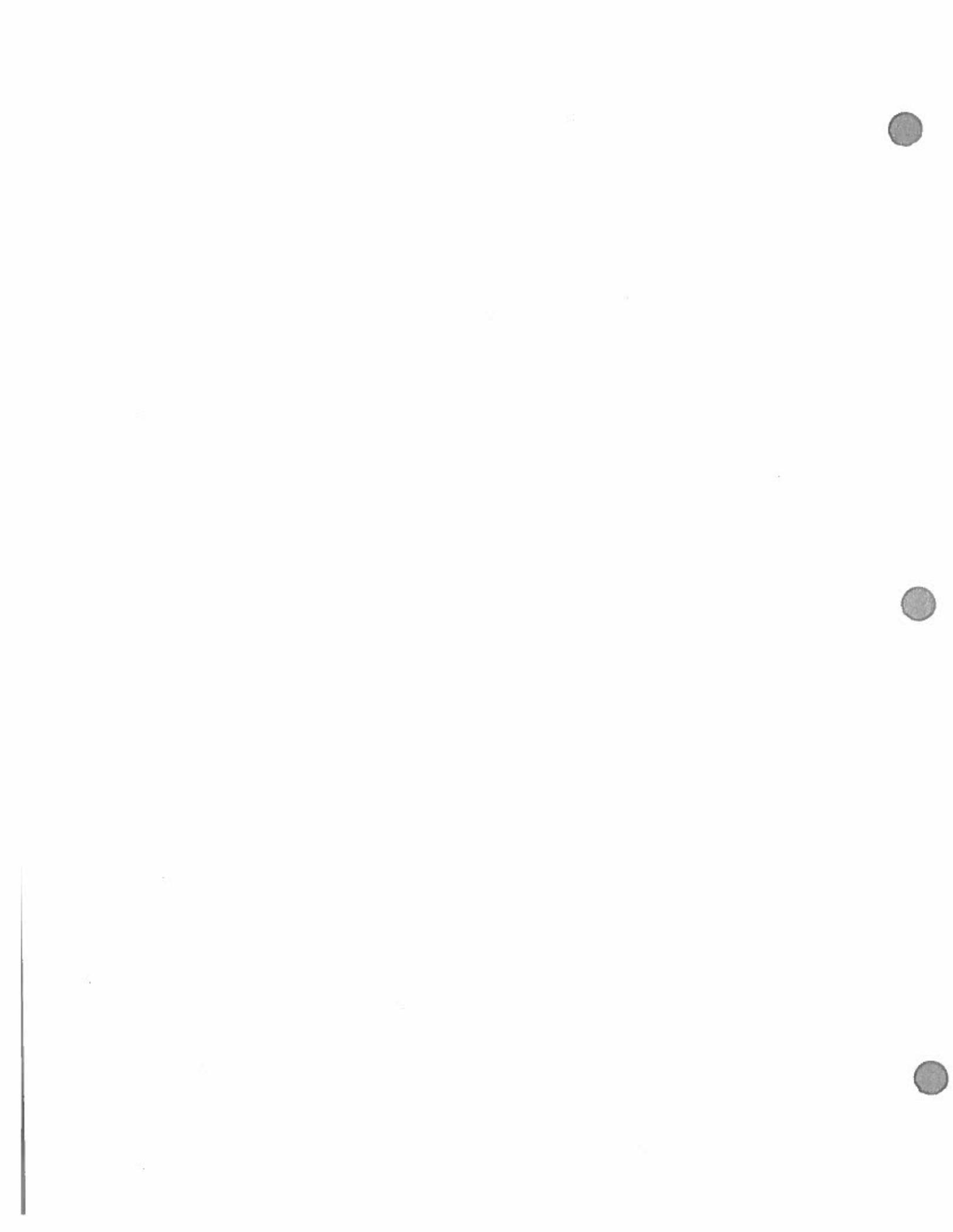


Processing Tomato Industry Pesticide Management Protocol

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2. General Procedures
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 - Any spray recommendations/spray schedules (to be included by individual processors if necessary)
3. Pesticide Management Records (Pesticide Application Form)
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5. Communications
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 - Negotiated Agreements (specified wording in Agreements related to grower/processor obligations and any penalties)
7. Appendix
 - Guidelines for Pesticide Residue Sampling Program for Processing Tomatoes in the Field

July, 2008



Section 1 - General Policy

- The Pesticide Management Protocol detailed in the following report has been developed by, and is supported by, growers and processors (herein referred to as the industry) in the processing tomato industry.
- The industry places significant importance on the health and safety of the food that we grow and process.
- Pesticide Management is a key area in the realm of food safety.
- The industry believes that the development of the Pesticide Management Protocol will provide added assurance of the industry's commitment towards safe food products.
- As an industry, we must ensure that only those pesticides registered in Ontario are being used and being used in accordance with the prescribed procedures. The annual negotiated Agreements shall govern processor/grower obligations with respect to pesticide usage.

Section 2- General Procedures

Processors with specific production recommendations and requirements must provide these to the grower at the time of contracting.

In the absence of such recommendations and/or requirements, growers are referred to OMAFRA publications 363-Vegetable Production Recommendations and 75-Guide to Weed Control, included in appendix 1 of the Processing Vegetable On Farm Food Safety Handbook.

Section 3 - Pesticide Management Records

1. Growers will be required to sign and submit, as required, a completed Pesticide Application Form, provided by the processor. (Form 4 outlined in the Agreement.)
2. All Processors will collect pesticide records on the Pesticide Application Form (attached) from all of their contracted tomato growers. Growers will receive blank copies of these forms from the processor at the time of contracting.
3. Processors shall, at the time of contracting, make clear the responsibilities of the grower regarding pesticide reporting.
4. Processors shall keep all Pesticide Application Forms submitted by the grower, for a minimum of two years, and provide access to regulatory officials to review such records, as requested.
5. For all raw product procurement, processors shall require written statements from the growers or brokers that they used only pesticides registered for that crop, in accordance with recommended procedures.
6. The OFPA shall monitor processor compliance regarding the collecting of Pesticide Application Forms.

Section 4 - Industry Residue Sampling and Testing Procedures

- A Third Party Contractor ("TPC") will collect samples to be analyzed for pesticide residues.
- The Ontario Processing Tomato Advisory Committee (OPTAC) will choose which pesticides to sample and test for each year.
- Individual companies have the right to conduct their own sampling and testing programs for any pesticide residues, however, all processors and growers shall be participants in the industry Pesticide Management Protocol.
- Based on the pesticide residue(s) chosen to sample and test, OPTAC will need to determine the timing for the sampling and testing.
- Random pesticide residue sampling and testing shall target a minimum of 10% of the total grower population.
- For every 10 growers contracted to a processor, one grower will be randomly selected to be sampled and tested for the selected pesticide residues. For example, where a processor has 30 growers, 3 growers will be selected at random for sampling analysis. If the number of growers contracted to the processor falls between a multiple of 10, the number of growers selected for sampling and testing will be rounded up or down at the break point. All processors shall have at least one grower sampled for each pesticide being tested for.
- The cost of the random sampling and testing program will be shared 50% by processors and 50% by growers. The individual processors' portion will be determined based on the actual number of growers contracted to that processor that were sampled and tested.
- Growers shall provide the TPC with access to any fields, as requested, for collecting the samples.
- All sampling and testing will be conducted and results made available prior to harvesting the field where the sample was taken. A sampling and testing schedule will be developed by the TPC and the lab depending upon residues being tested.
- One pre-harvest sample will be taken per selected grower.
- All positive samples will be confirmed by a second test.

- Additional sampling and testing may be conducted, as determined, based on a decision by OPTAC.
- Test results will be filed with the OPVG and OFPA. Processors shall have access to the sample results of their growers and growers shall be notified of their test results.
- A positive sample will result in immediate notification to the grower and the grower's processor(s).
- The processor is responsible to act on the results based on the authority outlined in the Agreement with the OPVG.
- Where additional sampling and testing is required and approved by the Ontario Processing Tomato Advisory Committee, that cost will also be split 50% by the processors and 50% by the growers.
- Consideration will be given to accommodate specific sampling and testing requests from an individual processor or grower, however the cost will be paid by the processor or grower making the request. The OFPA and OPVG will be notified of individual requests and the results of any tests and subsequent actions will be according to the provisions of the negotiated Agreement.
- Costs of the program are dependent upon the residue being sampled and tested, the frequency of sampling and testing, the organization doing the sampling and testing.

Section 5 - Communications

Growers:

- OPVG to reinforce with growers the importance of compliance with pesticide regulations.
- Obligations through Agreement - records, penalties.
- Complete the Pesticide Application Form as required and return it to the processor.

Processors:

- Communicate, in writing, the Pesticide Management Protocol at time of contracting with growers.
- Provide sufficient Pesticide Application Forms for completion by the grower.
- Detail any specific company programs/policies with respect to the use of pesticides (provide a copy).
- Review wording in the contract with the grower.
- Review obligations in the Agreement.
- Ensure company staff is aware of the Pesticide Management Protocol.

Dealers:

- Processors and growers to inform pesticide dealers of the Pesticide Management Protocol and the importance of their due diligence in not selling unregistered pesticides for a specific crop.
- Request support from pesticide dealers for the industry's Pesticide Management Protocol.
- Processors to supply a copy of the recommended list to the dealer.

Section 6 - Commitment

Negotiated Agreement

Clause 12 of the Tomato Agreement states as follows:

12. a) A Processor shall have the right as a condition of contract to require that all tomatoes contracted to be grown for delivery to the processor, shall be sprayed for pest control following a spray program using only spray materials registered for use on tomatoes in Canada. In addition, the grower may be restricted from using specified spray materials provided they are clearly identified in the written contract between the grower and processor.
- (b) No processor shall require as a condition of contract any grower to purchase fertilizer or chemicals from such processor or any agent, servant or employee of such processor nor may the processor require any grower to use the services of a specific spray operator.
- (c) The grower shall keep complete records of pesticide applications and shall forward a completed Form 4 to the processor in accordance with the schedule clearly identified in the written contract between the grower and the processor.
- (d) The processor may refuse to schedule delivery of tomatoes in accordance with the agreement in the event that all records of pesticide application in Form 4 have not been provided in accordance with the written requirements.
- (e) As a condition of contract, the processor shall provide written assurance to the grower that transplants have been treated only with pesticides registered for use on greenhouse tomatoes in Canada. Third party random sampling and testing of all tomato transplants shall be conducted prior to shipment to growers.
- (f) Both the grower and the processor shall provide any and all information necessary to facilitate third party random sampling and residue testing in the field. Where third party testing has determined that illegal residues have been discovered, the processor may refuse to accept delivery of tomatoes from the field in question. A confirmatory test shall be conducted in order to rule out the possibility of a false positive in the initial test result.

APPENDIX - Guidelines for the Pesticide Residue Sampling Program for Processing Tomatoes in the Field

Location:

- Each processor shall have at least one grower sampled and tested.
- For every 10 growers contracted to a processor, Third Party Contractor (TPC) will randomly sample 1 grower for the selected pesticide residues. If the number of growers contracted to a processor falls between a multiple of ten, the number of growers selected for sampling and testing will be rounded up or down at the break point.
- TPC will identify the location of the grower's field where the samples were taken.
- TPC will identify on a map of the grower's field the exact locations where the samples were taken (TPC to develop a procedure identifying the locations of the samples taken).

Timing:

- One pre-harvest sample will be taken per selected grower.
- All sampling and testing will be conducted and results made available prior to harvesting the field where the sample was taken.

Procedures:

- TPC will collect a five pound sample throughout the grower's field. One pound will be sent to the lab for testing and one pound will be retained by TPC. Both samples shall be clearly identified for future reference and retrieval, if necessary.
- TPC will identify on a map of the grower's field, the exact locations where the samples were taken.
- TPC shall notify the grower prior to taking the samples. Growers shall provide access to any fields by TPC for the collecting of samples for residue testing.
- The sample shall be sent to the lab for testing and the other half shall be stored by TPC - the samples shall be sent to the lab on the day they were taken so they are received by the lab the following day - this should produce a lab result by the following morning.
- The lab will test the samples for the pesticides requested.
- According to the lab's own procedures, if a positive sample is found, a second test will be run on the sample.
- If the lab confirms a positive sample, then TPC will send the reserved half of the original sample for a retest.
- The same procedures will be performed by the lab on the reserved sample.

Records and Reporting:

- TPC shall keep a record of the growers whose fields have been tested.
- The processor will be notified of the grower(s) being tested and the results of the test, whether positive or negative, should be provided to the processor by the middle of August. Growers shall also be notified of their specific test results.
- All tests will be filed with the OPVG and OFPA.

Actions:

- Where a positive sample is found and confirmed, the processor shall not harvest the field of tomatoes where the sample was taken.
- Further, the processor may request, on their own initiative, to conduct further sampling.

Costs:

- The cost of the random sampling and testing program shall be shared by processors and growers. The individual processor's portion will be determined based on the actual number of growers contracted to that processor that were sampled.
- The costs of additional sampling requested by the processor shall be paid outside of the program.

SECTION C



Instructions for the Proper Application of Pesticide Products (Required for Schedule 5 Pesticide Products) - To Be Filled out by Certified Grower

Farm:	
Trained Assistant:	
Certified Grower:	
Contact Number:	Alternate Contact Number:

In Case of an Emergency:
• Call Certified Grower at: _____

In Case of a Leak or Spill:
• Protect yourself first
• Shut off all equipment
• Tell Certified Grower & GET HELP
• Stop the spill from spreading

In Case of a Poisoning:
• Call for help right away - call the Certified Grower
• Keep victim comfortable until help arrives

Re-entry Period: _____

Pre-Harvest Interval: _____

Amounts of Pesticides to Add into the Tank				Tractor/Sprayer
Product:	PCP #:	Schedule #:	Amount:	
1				Sprayer:
2				Tractor:
3				Gear:
4				Speed:
				Pressure:
Water to Add to Tank	--	--		RPM:

Number of Tanks: _____

Spray Area: _____

Crop: _____

Start Time: _____

Finish Time: _____

Date: _____

**When you mix,
you must wear: (✓)**

- Coveralls
- Long pants and shirt with long sleeves
- Gloves, chemical resistant
- Boots, chemical resistant
- Water repellent hat
- Apron, chemical resistant
- Respirator
- Goggles
- Face Shield
- Waterproof rain suit with hood

**When you apply,
you must wear: (✓)**

- Coveralls
- Long pants and shirt with long sleeves
- Gloves, chemical resistant
- Boots, chemical resistant
- Water repellent hat
- Apron, chemical resistant
- Respirator
- Goggles
- Face Shield
- Waterproof rain suit with hood

Trained Assistant Signature

Supervising Certified Grower Signature, Certificate #

This form was developed by the Ontario Ministry of the Environment in partnership with Ridgeway College, University of Guelph, OMAFRA, AGCare, and Ontario Grower Groups.

Section 2

APPENDIX 2 - SCHEDULE A

FORM 1 PESTICIDE REPORTING FORM

MONTH/YEAR: _____ GROWER: _____

CROP: _____ ACRES: _____

INSTRUCTIONS:

- INCLUDE ALL HERBICIDES, INSECTICIDES, FUNGICIDES, FUMIGANTS AND GROWTH REGULATOR TREATMENTS APPLIED BY THE GROWER.
- COMPLETED FORM MUST BE SIGNED BY THE GROWER AND RETURNED TO THE PROCESSOR AS SPECIFIED BY THE TERMS OF THE AGREEMENT AND AWARD.

PLEASE PRINT PESTICIDE HISTORY				
INCLUDE - HERBICIDES, INSECTICIDES, FUNGICIDES AND GROWTH REGULATORS				
FIELD LOCATION	APPLICATION DATE	ACRES SPRAYED	PESTICIDE INCLUDING FORMULATION	PRODUCT RATE PER ACRE
EXAMPLE Field #1 (Smith's)	36284	12.5	Sencor (500 g/L)	.25 L/acre

THE UNDERSIGNED HEREBY AFFIRMS THAT ALL MATERIALS APPLIED TO THE CROP ARE LISTED ABOVE AND THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

Grower's Signature Date

THE UNDERSIGNED HEREBY AFFIRMS THAT ONLY MATERIALS REGISTERED FOR USE ON SWEET CORN HAVE BEEN APPLIED TO THIS CROP.

Grower's Signature Date



Section 3

Jan 27, 2008

wellwise *helping well owners make wise decisions about their wells*

Main Menu

- About Us
- Contact Us
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- Water Testing
- Soil Testing
- Well Upgrades
- Decommissioning
- Water Treatment
- Publications
- Articles
- Order Books Here
- Links
- Home

Water Testing Packages

A survey conducted in 1991/92 of 1200 rural wells in Ontario found:

- 14% high for nitrate
- 34% high for bacteria
- 6 wells exceeded for pesticides

Fact Why test your water?



To order water testing packages, please call 905-983-9911. Online ordering will be available in the near future.

Rural Well Owner Test Package: \$50 *

Well Wise recommends the Rural Well Owner Test Package to all well owners. We developed this package to assess the most common impurities found in well water, plumbing and other nuisance compounds often treated by well owners. We have worked hard to make this package the best possible value so that well owners adopt a routine of testing for this package regularly. This package offers well owners the best value for testing their well water for pH, turbidity, nitrate N, phosphorus, potassium, magnesium, calcium, chloride, sulphate, electrical conductivity, bicarbonate, sodium, total dissolved solids, hardness, zinc, manganese, copper, iron, boron, silicon and lead.

We recommend that well owners test for bacteria with their local health units according to MOH guidelines (3 times per year) and test the parameters in this package once a year so that you can have confidence and a greater understanding of your well water quality.

Bacterial Test Package: \$50 *

For many well owners, the only routine test performed to assess well water quality is the bacterial test offered through local health units. The MOH bacterial test package informs well owners of the number of coliform and E. Coli bacteria present in 100 ml of your water. Well owners should conduct this test three times a year. There are no additional analyses performed on samples submitted to the Ministry of Health.

For some well owners, bacteria are present in their well water on a regular basis. It is very important to try to figure out where this bacteria is coming from so that you can solve the problem and remove the source of bacteria impacting your water supply. The bacterial package offered through Well Wise assesses Total coliform, E. Coli, Fecal Streptococci and Pseudomonas aeruginosa. The reason we added these two additional bacterial tests is to guide you to a potential source to help you take action.

Fuels and Solvents Package: \$295 *

This package is a useful package if you live near a gas station, if you have underground fuel storage or industrial uses nearby or if you have any reason to suspect they may be an issue with fuels or solvents in your water supply. This package assesses 40 different compounds and includes: Benzene, Vinyl chloride, acetone, chloroform and methylbromide.

Metals, Minerals and Salts Package: \$130 *

The Metals, Minerals and Salts Package comprehensively assesses more than 40 different parameters. It provides well owners with a detailed understanding of impurities that may be in their water because of rock or surrounding land uses. It includes most of the parameters included in the Rural Well Owner Test Package but it also analyzes a broader range of metals and minerals. This package is intended for those who want a general water quality test package. A comprehensive list of the parameters assessed is posted on our website.

Pesticides Package: \$275 *

Why test for pesticides? The Pesticides Package analyzes well water for a broad range of organochlorine and organophosphorous pesticides. These are the most commonly used pesticides in Ontario over the last 30 years.

This package is a good package to assess to screen your water initially and again every few years to keep an eye on your water supply. If there are any changes in the land use around you or if you are concerned, test to rule out all possibilities. This testing package is more expensive because the analysis is much more complex. The turn around time for these packages is also longer. Testing will provide you with confidence in your water supply and it is important that well owners feel confident that they are using a reliable water supply.

Well Wise works with two laboratories for the analysis in our program. The Rural Well Owner Test Package and soil analysis are performed by Agri-food Labs. The Metals, Minerals and Salts, Fuels and Solvents, and Pesticides packages are analyzed by Maxxam Labs. For more information on these laboratories, please see our website at [wellwise.ca](http://www.wellwise.ca).

* Shipping and administration are in addition to the fees listed above.

Section 4

Appendix 4

SAMPLE LETTER OF GUARANTEE

DATE

PRODUCER TO WHOM ADDRESSED:

We, the undersigned *product* supplier, do hereby guarantee that any and all *product* supplied by us for the purposes of processing vegetable production, to the premises designated by the above vegetable producer, will not knowingly be contaminated. Furthermore, certificates of analyses will be supplied to the above named producer at each formulation change.

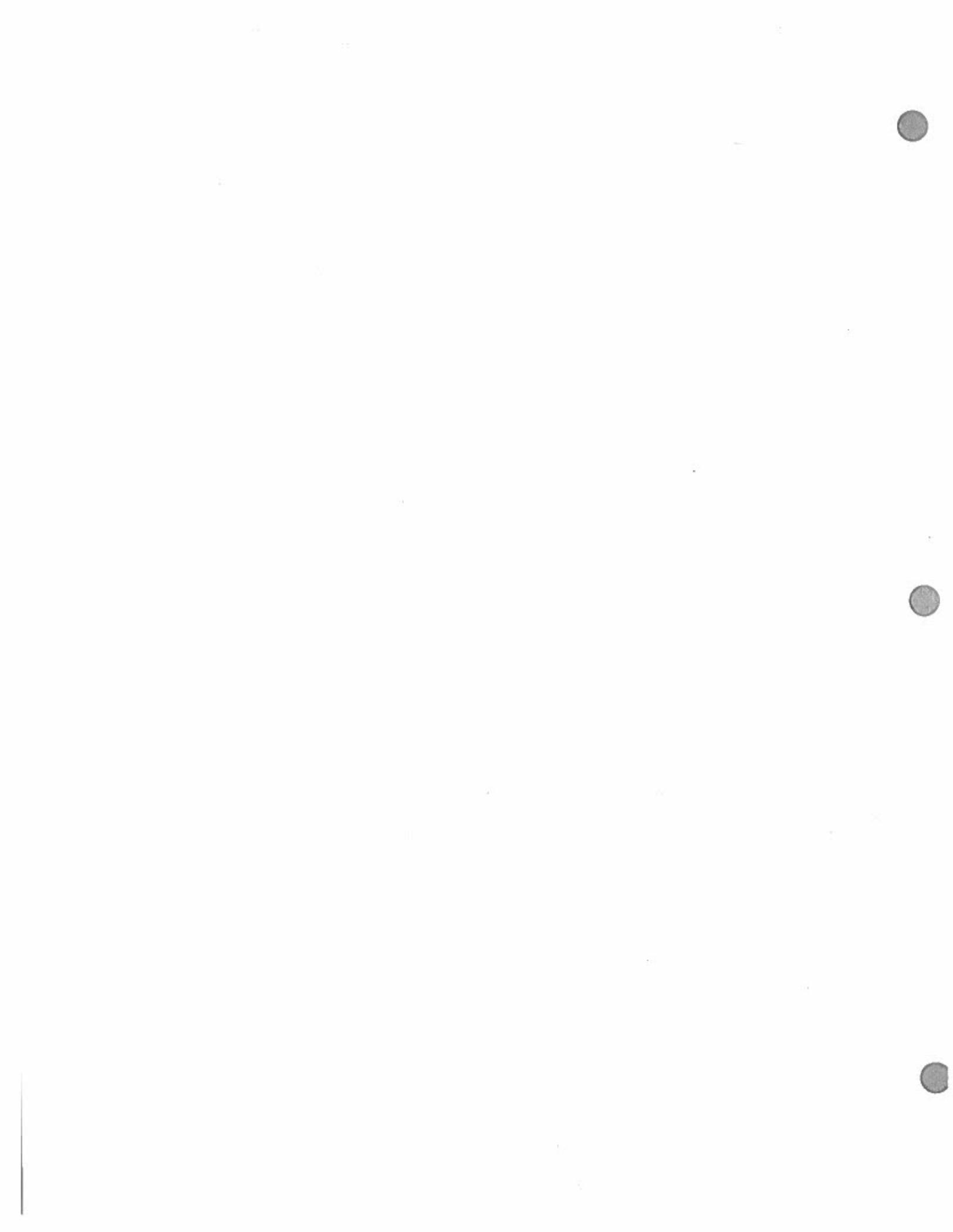
PRODUCT SUPPLIER NAME, ADDRESS, AND TELEPHONE NUMBER

Signed on behalf of the supplier,

Section 5

APPENDIX 5

Many processors specifically do not permit the application of sewage biosolids on land to be used to produce vegetables for processing. As such, refer to your grower contract or check with your processor if you are planning to utilize sewage biosolids. Use of sewage biosolids requires the submission of an Application for a Certificate of Approval to Spread Sewage and Other Biosolids on Agricultural Lands. The following factsheet outlines some of the issues to be considered if you are contemplating the use of sewage biosolids.



FACTSHEET SOILSOrder No. 95-069
NOVEMBER 1996
AGDEX 540

Ontario Ministry of Agriculture, Food and Rural Affairs

**LAND APPLICATION OF SEWAGE BIOSOLIDS
FOR CROP PRODUCTION**

Agriculture and Rural Division

(Replaces Factsheet No. 85-093 "How and Where to Use Sewage Sludge in Crop Production")

The utilization of sewage biosolids on agricultural land is becoming a more attractive choice for farmers in Ontario. The material provides nutrients for plant growth and is a source of organic matter for the soil. Sewage biosolids can reduce fertilizer costs and improve the tilth of the soil.

Improvements in municipal sewage treatment systems have increased the amount of sewage biosolids available for agricultural use. The practice also reduces the disposal of this material in landfill sites, saving valuable landfill space.

WHAT IS SEWAGE SLUDGE?

Sewage sludge results from the decomposition and settling at a sewage treatment plant. This material usually contains considerable amounts of organic matter, and can contain about 0.1 % to 0.3% total nitrogen, and large amounts of plant available phosphorous. Other nutrients such as magnesium, zinc, copper and boron are also present. Since the inputs into sewage sludge may vary considerably, chemical analysis is required to determine the nutrient and heavy metal content and calculate an application rate.

SEWAGE BIOSOLIDS

Before sewage sludge can be considered a sewage biosolid and used for land application, it must satisfy the criteria outlined in the "Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land". Only stabilized sewage sludges with low metal concentrations are suitable for land application and are designated sewage biosolids. Sewage sludge that does not meet the beneficial use criteria remains designated as sewage sludge.

Sewage sludge must be stabilized before it can be considered a sewage biosolid. Stabilization is accomplished by digestion or other acceptable means such as adding lime. The two basic types of digestion are anaerobic and aerobic.

Digestion reduces the number and types of pathogens (viruses, bacteria, fungi and parasites), reduces the volume of material, and stabilizes organic matter thereby reducing the potential for odours.

Once a sewage sludge meets the guidelines to become biosolids, a proposal is submitted to the Ontario Ministry of the Environment and Energy (MOEE) for land application. When the site criteria have been met, a Certificate of Approval is issued for individual fields.

LIMITS TO LAND APPLICATION**Nutrients**

The APPLICATION rate of sewage biosolids is based on its nitrogen content and on the amount of nitrogen required by the crop to be grown at the application site. For anaerobically digested sewage biosolids, the application rate is limited to 135 kg of nitrogen per hectare per five year period. For aerobically digested and dewatered or dried sewage biosolids, applications are limited to 8 t of solids per hectare per five year period.

The guidelines limit sewage biosolid application to fields with a soil test of less than 60 mg/L or parts per million (ppm) of available phosphorous in the top 15 cm, as measured by the Olsen sodium bicarbonate method.

Soils with a pH of less than 6.0 should not receive sewage biosolids unless the material contains enough lime to raise the soil pH to or above 6.0. Another option is to lime the field raising the soil pH above 6.0, to allow for sewage biosolid application.

Heavy Metals

The major factor in determining the acceptability of sewage sludge for land application is the presence and concentration of heavy metals. There are eleven heavy metals in sewage sludge that are of concern to agriculture.

These are:

- arsenic
- chromium
- copper
- mercury
- nickel
- zinc
- cadmium
- cobalt
- lead
- molybdenum
- selenium

Sewage biosolid quality and application rate are determined by the: (1) amount of available nitrogen, and (2) quantities of metals.

Therefore, limiting the amount of nitrogen supplied by the material for the crop to be grown, in turn limits the amount of heavy metals applied to the soil. For anaerobically digested sewage biosolids, minimum ammonium plus nitrate nitrogen to metal ratios have been developed as quality standards to ensure that heavy metals are limited (Table I, Column IV).

Table I — Metal Criteria For Fluid¹ Anaerobically Digested Sewage Biosolids

I	II	III	IV
Metal	Maximum Permissible Metal Content in Soil ($\mu\text{g/g}$)	Maximum Permissible Metal Addition to Soil (kg/ha)	Minimum Ammonium plus Nitrate Nitrogen to Metal Ratios Required in Sewage Biosolids
Arsenic	14	14	100
Cadmium	1.6	1.6	500
Chromium	120	210	6
Cobalt	20	30	50
Copper	100	150	10
Lead	60	90	15
Mercury	0.5	0.8	1500
Molybdenum	4	4	180
Nickel	32	32	40
Selenium	1.6	2.4	500
Zinc	220	330	4

¹Dewatered and dried anaerobic sludges are to meet the Column IV criteria prior to dewatering and drying.

*Based on dry weight at 100°C. The term $\mu\text{g/g}$ represents parts per million (ppm) on a dry weight basis.

**Values in Column II apply to soils of average metal content.

Aerobic sewage biosolids are low in ammonium plus nitrate nitrogen and normally do not meet the nitrogen to metal ratios required for anaerobic sewage biosolids. For

this reason, aerobic sewage biosolids are limited by total metal concentrations rather than a nitrogen/metal ratio (Table 2).

Table 2 — Metal Criteria for all Aerobic Sewage Biosolids and for all Dried and Dewatered Anaerobic Sewage Biosolids

Metal	Maximum Permissible Metal Concentration ($\mu\text{g/g}$ of solids)
Arsenic	170
Cadmium	34
Chromium	2800
Cobalt	340
Copper	1700
Lead	1100
Mercury	11
Molybdenum	94
Nickel	420
Selenium	34
Zinc	4200

Physical Limitations

The maximum depth of a fluid sewage biosolid that can be spread at any one time is 1.3 cm. This depth is equivalent to an application rate of 130 m^3/ha . Additional applications can continue only when the preceding application has dried.

The guidelines limit application of sewage biosolids on frozen or ice covered soil. This is to minimize movement of material off the application site. Winter spreading of sewage biosolids is recommended only when there is little or no frost in the soil or the surface is lightly snow covered. Such conditions allow liquids to percolate into the soil. However, the guidelines restrict application if there is potential for snow melt to cause surface runoff.

Sewage biosolids may be applied to "mineral" soils but not to "organic" soils. Organic soils are defined as those containing 17% or more organic carbon by weight and which have a depth of 0.4 m of unconsolidated organic material.

Site characteristics determine separation distances and the timing of sewage biosolid applications. Separation distances are the area between the sewage biosolid spreading zone and the conflicting use, which do not receive sewage biosolids. The distances are determined in part by soil texture, slope, drainage, application methods, and neighbouring land use. These limitations are further outlined in the "Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Lands," available from MOEE and OMAFRA.

Other Limitations

Waiting periods developed for specific crops and livestock species are outlined in Table 3. Access to fields is limited for a period of time after sewage biosolid application to protect human and livestock health. The waiting periods are necessary to further reduce the number of pathogenic organisms (viruses, bacteria, fungi and parasites) that remain in sewage biosolids after stabilization.

Table 3 — Sewage Biosolid Spreading Restrictions Related to Public Health and Pathogens

Crop	Waiting Period after Sewage Biosolid Application
Hay and haylage	3 weeks before harvest
Pasture for horses, beef or dairy cattle	2 months before grazing
Pasture for swine, sheep or goats	6 months before grazing
Commercial sod	12 months before harvest
Small fruits	15 months before harvest
Tree fruits and grapes	3 months before harvest
Vegetables	12 months before harvest
Tobacco	Application not recommended
Home lawns and gardens	Application not recommended
Golf courses and recreational land	Application recommended only if further stabilization in addition to digestion is used to reduce content

It is the responsibility of the farmer to enforce the appropriate waiting periods between sewage biosolid spreading and cropping, pasturing or human access. (See Table 4 for more cropping limitations.)

Table 4— Information about Sewage Biosolid Application for Specific Crops

Crop	Comments
Field corn, hay, haylage, pasture, commercial sod	These crops are well suited to using nitrogen supplied by sewage sludge. Nutrients such as nitrogen should be applied within crop recommendations.
Cereals	Spring applications of sewage sludge containing more nitrogen than is recommended may result in the crop lodging or falling down before harvest.

Perennial legumes and soybeans	Soybeans and hay crops containing more than one-half legumes do not require added nitrogen. However, sludge can be used to supply phosphorous and organic matter. Some sludges may cause some management concerns. For example viable tomato seeds can pose a weed problem in a soybean crop.
Tree fruits and grapes	Sewage sludge may be applied in late fall. Early fall applications may cause nitrogen to be released at the wrong time causing poor fruit quality, delayed hardening of trees or vines and winter injury.
<p>Notes:</p> <ol style="list-style-type: none"> 1. The maximum applications rate per hectare for anaerobically digested sludges is 135 kg/ha of ammonium + nitrate nitrogen per 5 years (4 years for commercial sod); for aerobic, dewatered or dried sludges, the application rate is 8 tonnes of solids per hectare per 5 years. 2. The maximum depth of sludge applied to land at one time is 1.3cm (130 m³/ha). 3. Nitrogen application rates for individual crops should not be exceeded. Refer to OMAFRA publications 296, 360, 363 and 384 for the recommended nutrient application rates. 	

APPLICATION/SPREADING

Sewage biosolids should be spread only when the soil is dry enough to carry the application equipment. Spreading when soil is wet results in rutted fields and soil compaction. Use of flotation tires on spreading vehicles can increase the number of days when sewage biosolids may be spread but it does not eliminate the possibility of soil compaction.

Injection of fluid sewage biosolids into the soil using a self-propelled or drag hose system can greatly reduce the chance of runoff, odours, and nitrogen loss. Another method of application is surface spreading or broadcasting by means of a splash plate using a self-propelled or drag hose system. Applying the material by spray irrigation (irrigation gun) decreases the potential for soil compaction, but increases the potential for odour complaints, runoff, and nitrogen loss. Also, if wind conditions are not favourable there is increased potential for wind-drift and overspray onto surrounding land uses.

The nitrogen in sewage biosolids is used most effectively when the material is applied in the spring, using soil injection or worked into the soil within 24 to 48 hours. Delaying incorporation will result in nitrogen loss to the atmosphere. Therefore, supplemental fertilizer rates should be adjusted to compensate for the loss of nitrogen.

The importance of uniform application of sewage biosolids cannot be overemphasized. Higher than recommended application rates may result in:

- excessive nitrogen, phosphorous and metal additions to the soil
- poor utilization of the nutrients by crops
- possible decreases in crop yields
- poor crop quality.

Equally important to uniform application is applying fertilizer to separation areas such as the field edges, where sewage biosolids cannot be applied. These separation areas must be fertilized to provide for more even crop growth. For more information on separation distances see the guidelines.

APPLICATION RATES

The application rate of sewage biosolids is based on the nitrogen fertilizer recommendations in the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Publications 296, 360, 363 and 384. The rate of available nitrogen (ammonium and nitrate nitrogen), permitted to be supplied by sewage biosolids is limited to 135 kg N/ha every five years. For commercial sod production, this amount may be applied every four years.

Depending on the nitrogen fertilizer recommendations, one application of 135 kg N/ha from sewage biosolids may be made in one year. However, sewage biosolids cannot be applied to that site until the remainder of the five year period has lapsed. If the amount of applied sewage biosolid nitrogen is less than 135 kg/ha, sewage biosolids may be applied to the site again as long as the total rate does not exceed 135 kg N/ha for the five year period.

Aerobic sewage biosolids contain substantial amounts of phosphorous and organic matter, but are lower in nitrogen than anaerobic sewage biosolids. Therefore, aerobic sewage biosolids will not likely supply the entire amount of nitrogen required for crop production and the site may need to be supplemented with other sources of nitrogen.

The nitrogen content of sewage biosolids are reported in milligrams/litre or parts per million (ppm) of ammonium plus nitrate nitrogen. This is an approximate measure of nitrogen, which is readily available to plants. See Figure 1, to determine the fertilizer nitrogen equivalent of sewage biosolids.

Figure 1 — Estimating the Fertilizer Nitrogen Equivalent of Sewage Biosolid

$$\text{Nitrogen (kg/ha)} = \frac{\text{Ammonium + Nitrate Nitrogen content of sewage biosolid (mg/l)} \times \text{Sewage biosolid application rate (m}^3\text{/ha)}}{1000}$$

Sewage biosolids contain large amounts of plant available phosphorous. This phosphorous is estimated to be about 40% as available as that of commercial fertilizer. The phosphate (P₂O₅) fertilizer equivalent of the sewage biosolid can be estimated using the equation in Figure 2.

Figure 2 — Estimating the Phosphate Fertilizer Equivalent of Sewage Biosolids

$$\text{Phosphate (P}_2\text{O}_5\text{) (kg/ha)} = \frac{\text{Sewage biosolid phosphorous (P) content (mg/L)} \times \text{Sewage biosolid application rate (m}^3\text{/ha)}}{1000}$$

RESPONSIBILITIES

Operating Agencies

The operating agencies are responsible for:

1. keeping records of all fields receiving sewage biosolids:
 - location
 - amount applied
 - sewage biosolid analysis
2. submitting samples for analysis (frequency determined by MOEE)
3. monitoring application rates
4. preparing contingency plans for when the sewage biosolid cannot be land applied
5. reviewing acceptability of sewage biosolids, implementing corrective measures when necessary and informing farmers in the event of material quality deviating from the standards.

Sewage Biosolid Haulers and Spreaders

The hauler/spreader must apply the sewage biosolid uniformly on land at the rate, and using the method required by the farmer. The rates of actual nitrogen applied (kg/ha) and/or sewage biosolid applied (m³/ha) must not exceed those specified in the Biosolid Guidelines or by MOEE.

The hauler/spreader must maintain all required separation distances and comply with other site requirements as specified on the Certificate of Approval. A report outlining the nutrients applied must be provided to the farmer after completing the sewage biosolid application to any field.

The rights of the farmer must be respected with regard to timing, method and rate of application of the sewage biosolid.

Farmers

Farmers, the sewage biosolid hauler/spreader and the sewage treatment plant operator should work together to develop a utilization program for individual fields. Farmers have the right and the responsibility to insist on program flexibility, so that the sewage biosolid application rates may be adjusted to suit the nitrogen and phosphorous requirements of the crop, as long as the adjusted rate does not exceed that specified in the guidelines or by MOEE.

The farmers have the right to discontinue sewage biosolid spreading at any time if soil compaction or environmental damage is likely or if timing interferes with soil and crop practices on the farm.

Farmers have the responsibility to enforce the appropriate waiting periods between sewage biosolid spreading and cropping, pasturing or human access.

OBTAINING SEWAGE BIOSOLIDS

Evaluate your situation to determine if sewage biosolids have a place in your farm management system and site location. If you are interested in using sewage biosolids as a soil amendment, contact your local MOEE office.

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Section 6

APPENDIX 6

ONTARIO MINISTRY OF AGRICULTURE,
FOOD AND RURAL AFFAIRS

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MANURE CHARACTERISTICS

H. Fraser, Agricultural Engineering Service

NUTRIENT VALUE

The main value of manure is in its plant nutrient content, and the amount of organic matter that it contains. The fertilizer nutrients in manure come entirely from the feeds consumed by the animal. Animals use only about 25% of the nutrients contained in feeds, with the remaining 75% of the original content of nitrogen (N), phosphorus (P), and potassium (K) excreted as manure and urine. See Table 1 below.

Table 1. Approximate Percentage of Intake Nutrients Excreted in Manure

	N	P	K
Beef Steer	80	61	93
Dairy Cow	71	73	90
Feeder Hog	65	69	86
Chicken Broiler	61	69	80
Laying Hen	70	68	87

About half of the nitrogen and two-thirds of the potassium in manure is found in the liquid portion. Almost all the phosphorus is contained in the solids. Thus, the liquid portion markedly affects the nutrient value and is well worth conserving. Nutrients in the liquid portion are water soluble and highly available for crop use. Nutrient content varies between livestock and poultry. See Table 2.

Table 2. Nitrogen, Phosphorus and Potassium Excreted over a 365 Day Period

LIVESTOCK NUMBERS	N (kg of N)	P (kg of P ₂ O ₅)	K (kg of K ₂ O)
1 Dairy Cow (545 kg)	64	30	80
1 Beef Feeder (182-500 kg)	32	15	40
1 Feeder Hogs (14-90 kg)	11	6	4.5
1 Sow and Litter to Weaning	16	9	5.5
1 Caged Layer Hen (2.3kg)	0.53	0.42	0.23
1 Broiler (0-1.8kg)	0.35	0.16	0.14
1 Sheep (Ewe)	7.3	2.6	6.2
1 Horse	45	18	33

AVAILABILITY OF NUTRIENTS

1. Nitrogen (N)

Nitrogen, in freshly excreted manure, is in the organic form, which is converted to ammonium-nitrogen during storage or after application to the soil. Since ammonium is held firmly to the surfaces of soil particles (adsorbed), it does not leach easily but may, under certain conditions, be converted to volatile ammonia gas. This happens to manure lying on top of the soil, particularly in dry, warm, windy weather.

Certain soil microbes convert ammonium-nitrogen to nitrate-nitrogen, which is not adsorbed to soil and can be leached from the root zone depending on soil water movement. It can also be lost when other microorganisms convert it to free nitrogen (denitrification) when oxygen is limited in soils. Therefore, in wet soils, nitrate may be leached away with excess soil water or become volatile as a result of denitrification.

Crops generally have higher requirements for N than for other major elements. Both ammonium-nitrogen and nitrate-nitrogen are taken up by plants.

2. Phosphorus (P)

Phosphorus is available to plants in mineral phosphates, from weathering of the soil's parent material, addition of fertilizer P, or from mineralization of organic P. P in manure may be inorganic or organic; the organic component mineralizes slowly in soil, so not all is immediately available for plant use.

Phosphates, unlike nitrates, are virtually immobile in soils because, if not used by plants, they form insoluble compounds in combination with calcium, iron or aluminum. A small proportion of the soil P is normally available to plants.

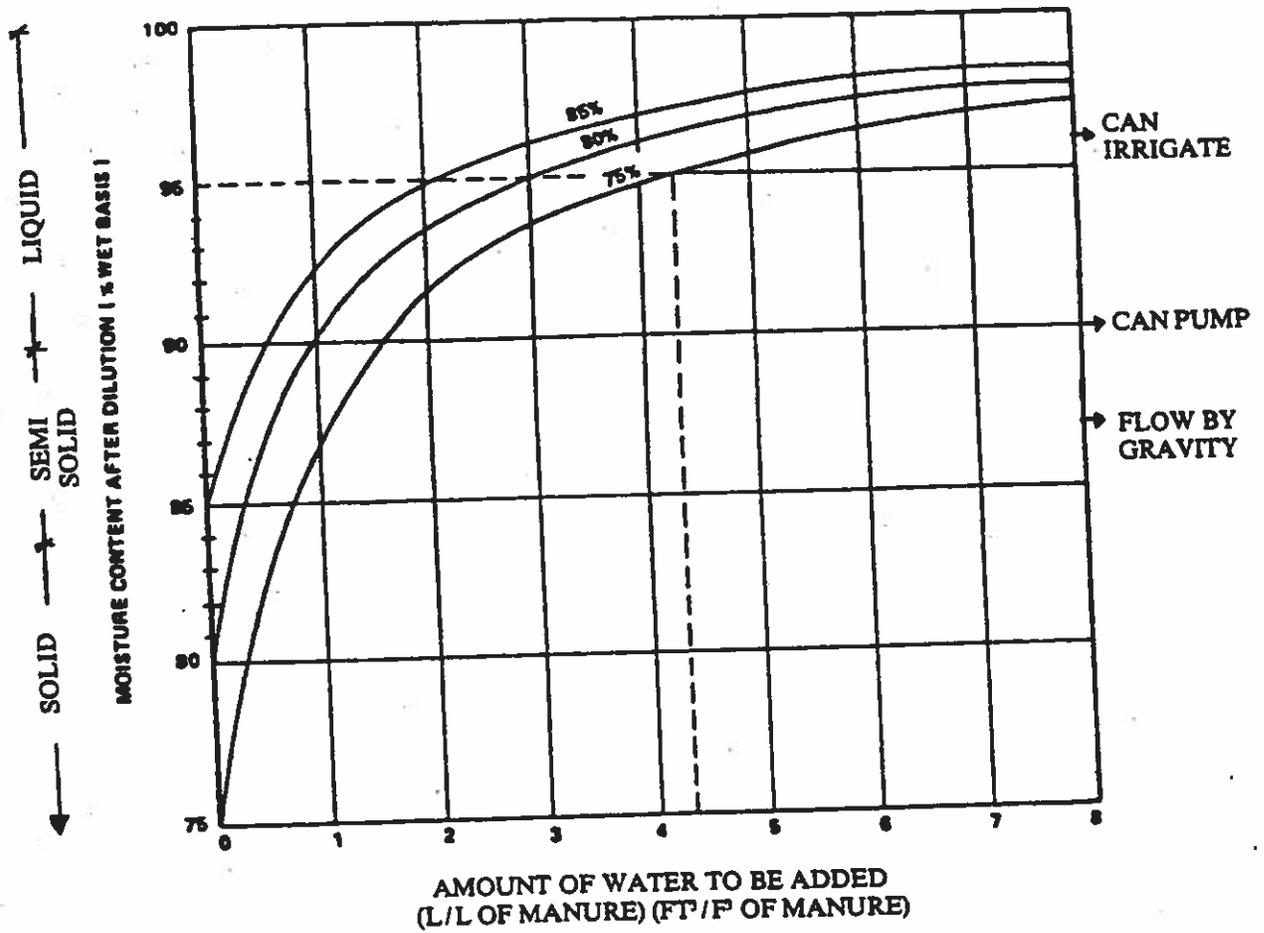
3. Potassium (K)

Soils generally have large stores of K, up to 10 times as much as N or P. Much is unavailable at any time, however, some release brings this element into the soil solution, from which it can leach or be used by the plants. Most manure K is readily available, and during the first season, is either used by the crop or adsorbed on the soil to become available later. K is not subject to conversions and losses like N or fixed as firmly in insoluble compounds as P.

MOISTURE CONTENT AND MANURE TYPE

The moisture content of manure has an important effect on its consistency and on the selection of handling equipment and facilities. It is influenced by the type of animal, feed used, type and amount of bedding, and amount of dilution water added. Where bedding is restricted, liquid manure is produced with a thin consistency by adding water intentionally or from leaking waterers. Some liquefaction also occurs when liquid manure is stored anaerobically. At about 87% moisture content or greater, liquid manure will flow by gravity from deep horizontal gutters; at about 90% can be pumped easily; and at about 96% can be successfully irrigated. Figure 1 is a useful graph to determine the amount of dilution water required to change moisture content.

Figure 1. Volume of Dilution Water Required to Change Manure Moisture Content



EXAMPLE: To bring manure that has 75% moisture content up to 95% moisture, 4 1/4 liters of water must be added to each litre of manure.

Between moisture contents of about 84-90%, the resulting consistency is called semi-solid manure. Generally, this consistency results when bedding or natural air drying is limited. It will not stack, so requires retention walls in storage, nor will it pump without addition of water. In dairy manure, additions of less than 8% bedding can produce semi-solid manure.

Solid manure will stack, has a moisture content under about 84% and generally has 8% or more bedding added.

MANURE PRODUCTION AND CONTENT

The size of manure storage depends on the type and number of animals, the length of time that manure is stored, and with liquid manure, the volume of dilution-water added. The daily volumes of fresh manure produced by different animals are shown in Table 3.

Table 3. Animal Manure Characteristics (Nominal Values for Urine and Feces as Voided)

Animal	Volume of manure /animal* (L/day)	Volume of manure and bedding (L/day)	Undiluted manure moisture (%)	Urine in manure (%)	DOB/animal (g/day)
Cattle					
Beef of dairy calf (0-3 mo)	5.4				
Beef or dairy calf (3-6 mo)	7.1				
Beef feeder or dairy heifer (6-15 mo)	14.2	17.0		35	
Beef feeder or dairy heifer (15-24 mo)	21.2	22.6			
Beef cows (545 kg)	28.3	34			
Dairy cow (545 kg)	45.3		87	30	900
Open pen loose housing		56.6			
Free stall loose housing		48.1			
Tie stall		50.9			
Swine					
20-90kg(8-22wk)	5.1		91	45	135
5-10kg(3-6 wk)	1.1				
11-20 kg (6-9 wk)	2.3				
21-35 kg (9-12 wk)	3.4				
36-55 kg (12-16 wk)	5.1				
56-80 (16-20 wk)	7.4				
81-90 kg (20-22 wk)	9.1				
Sow	11.3	13.6			
Chicken					
Broiler (0-1.8 kg)	0.08	0.14	litter-25		
Laying hen (1.8 kg)	0.14		77		9
Turkey					
Broiler (0-14 wk)	0.13				
Growing hen (0-22 wk)	0.18				
Growing tom (0-24 wk)	0.28				
Breeder	0.34				
Rabbit (doe & litter)	0.71				
Ewe Sheep	2.8	4.2	75	50	40
Horses	26.0	56.6	80	20	
Mink (female & kits)	0.2				

* Adapted from Canadian Farm Building Code, Associate Committee on the National Research Council of Canada, Building Code, National Research Council of Canada, Ottawa

There is a considerable variance of nutrient and moisture content between similar farm operations. Table 4 outlines the results of some manure analyses.

Table 4. Nutrient and Moisture Content of Manure Samples*

Department of Land Resource Science, University of Guelph, May 1977 - April 1981						
Manure	No. of Samples		%N	%P	%K	% Moisture
Dairy (solid)	80	Average	.55	.13	.44	81.7
		Minimum	.27	.05	.15	66.0
		Maximum	.80	.34	1.44	86.9
Dairy (liquid)	124	Average	.28	.06	.21	92.7
		Minimum	.04	.01	.02	88.1
		Maximum	.61	.11	.58	99.9
Beef (solid)	48	Average	.58	.13	.51	76.6
		Minimum	.21	.02	.14	65.0
		Maximum	1.00	.28	1.22	87.7
Beef (liquid)	29	Average	.24	.06	.17	95.1
		Minimum	.07	.01	.05	89.9
		Maximum	.45	.15	.30	99.9
Swine (solid)	20	Average	.68	.33	.29	71.8
		Minimum	.13	.01	.10	48.7
		Maximum	1.35	.62	.75	85.3
Swine (liquid)	141	Average	.37	.09	.15	96.7
		Minimum	.01	.01	.01	88.5
		Maximum	.78	.33	.49	99.9
Poultry (solid)	68	Average	2.2	.96	1.06	48.1
		Minimum	.19	.02	.09	9.9
		Maximum	5.55	2.1	2.3	87.0
Poultry (liquid)	4	Average	.72	.28	.28	92.2
		Minimum	.42	.07	.13	89.4
		Maximum	.90	.48	.39	97.3

* Adapted from paper by T.H. Lane and T.E. Gates, University of Guelph.

OTHER CHARACTERISTICS

Water Quality can be affected in several ways when manure is applied to the soil. The most direct contamination occurs when manure is applied to frozen ground and washed directly to a watercourse during the spring thaw.

Occasionally, similar effects may result when heavy rains occur immediately after application to unfrozen soil.

Manure in water enhances algae growth and/or submerged plant growth because of the increased nutrients. It creates a demand for dissolved oxygen as organic matter decomposes, and introduces potentially pathogenic bacteria to the water.

Excess application of manure over a long-term can build up the nutrient content of the soil far beyond crop requirements. Sediments eroded from soils high in P cause the greatest pollution because it is a critical nutrient in aquatic systems. Nitrate contamination of groundwater or surface water is potentially toxic to animals and infants when used for a water supply. High concentrations of nitrate in forages and corn may occur if nitrate levels far exceed the crop requirements. High nitrate forages have been implicated in illness or death of cattle. In silage corn, it leads to dangerous accumulations of silo gas in newly filled silos where nitrate is reduced to nitrogen oxides.

Anerobic decomposition of manure can produce considerable quantities of potentially hazardous gases, particularly ammonia and hydrogen sulfide. The most common complaint of livestock facilities is the bad odors they can produce.

Manure is an ideal breeding ground for insects including flies, and tends to attract birds and rodents. All can be disease carriers.

Dust can be a problem, particularly in total confinement of poultry on deep litter or with finishing hogs.

The uniqueness of each animal production unit must be stressed; no two operations are identical, and neither are their manure characteristics. Although different operations may have several common features, the best way to utilize the manure as a resource while minimizing its environmental hazards, is to examine the management options available in each case.