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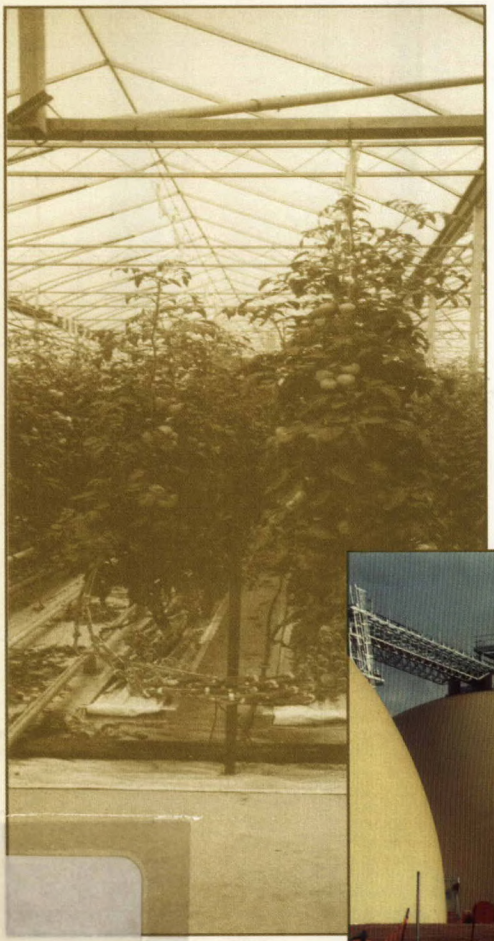
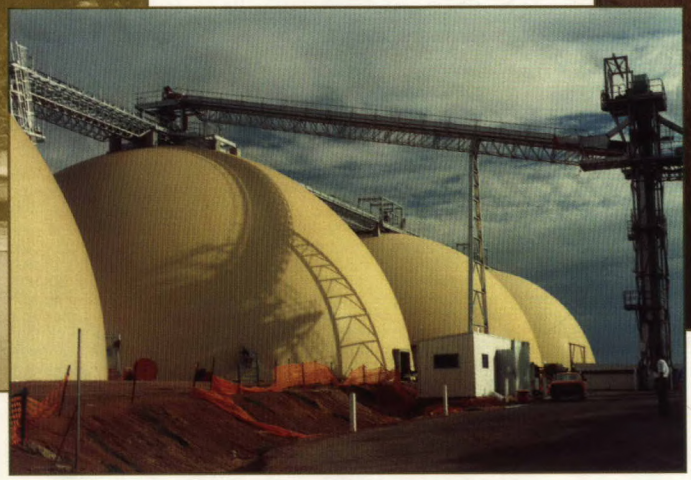
Improving Food and Agriculture Productivity — and the Environment

Canadian Initiatives in Methyl Bromide Alternatives and Emission Control Technologies





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- Corrosive Effects of Phosphine, Carbon Dioxide, Heat and Humidity on Electronic Equipment–1998
- Integrated Pest Management in Food Processing: Working Without Methyl Bromide–1998

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Cover photo: Adalia Preventive Services Ltd.

Improving Food and Agriculture Productivity — and the Environment

Canadian Initiatives in Methyl Bromide Alternatives and Emission Control Technologies

Prepared for the:
Environmental Protection Service
Environment Canada

Research Branch and Environment Bureau
Agriculture and Agri-Food Canada

Environmental Affairs Branch of
the Industry Sector
Industry Canada

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December 1998

Foreword

Canadians believe that sustainable agriculture and food production systems are dependent on a healthy environment. Our unique collaborative approach to problem-solving draws on the resources and expertise of government, institutes, universities, farmers and agri-business.

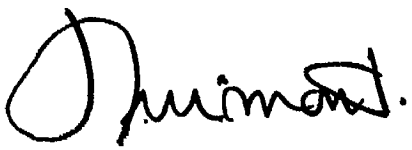
Methyl bromide is an ozone-depleting substance regulated under the Montreal Protocol. The elimination of the use of methyl bromide in agricultural production has been a challenge to the Canadian agri-business. However, in recognition of the fact that prevention of further environmental damage to the ozone layer is paramount — Canada's approach has been to embrace this challenge and work towards ensuring that our agricultural sector develops in an environmentally sustainable manner.

The cooperative relationship between Environment Canada and Agriculture and Agri-Food Canada and the successful partnership that has been developed between government and industry on the issue of methyl bromide are evidence that innovative and alternative practices and technologies can contribute, not only to the protection of the ozone layer, but also to successfully meeting our agricultural and food production goals in an environmentally sustainable manner.

Canadian research and commercial demonstration projects have resulted in the availability of many alternative products, technologies and services which have proven advantageous to the Canadian agriculture and agri-food sector. In addition, Canadian researchers at work in our government agricultural institutes and universities are an excellent source of information exchange and technology transfer. Canadians possess a unique collaborative approach to problem solving and view information as a resource to be shared.

The aim of this document is to provide a comprehensive overview of the alternative solutions that Canadian policy makers, researchers and industry representatives have formulated and tested to date as replacements for the use of methyl bromide.

Adopting methyl bromide alternatives is a worldwide necessity, a necessity that Canada recognized and addressed early on. It is our pleasure, therefore, to share Canada's solutions to the use of methyl bromide with you through this document.



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Assistant Deputy Minister
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Environment Canada

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Policy Branch
Agriculture and Agri-Food Canada

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Acknowledgements

Environment Canada and Agriculture and Agri-Food Canada continue to assist Canadian industry in succeeding with solutions for improving agriculture while respecting the environment. The authors appreciate the collaboration of the companies, research scientists, consultants, and government managers who ensured this publication was as complete as possible. In particular, the members of the Joint Industry-Government Working Group on Methyl Bromide Alternatives should be acknowledged as leaders working together to respond to the challenge of methyl bromide phaseout, and to ensure Canada maintains its edge in the production of safe, high-quality food, products, technologies, and services.

Introduction

Canadians have a uniquely collaborative approach to problem solving and we view information as a shared resource. We see agricultural production and food processing as links in the same chain, dependent on a healthy environment.

This report highlights methyl bromide alternatives in Canada. Some of these were developed as a result of the methyl bromide phaseout, some were in place before the phaseout and some are still under development. Additionally, research resources in government agriculture institutes and in our universities are an excellent source of information and technology transfer partners. Readers will find complete contact information within each section for the companies, associations, researchers and other experts who provide methyl bromide alternative products, technologies and services.

Adopting methyl bromide alternatives is a world-wide necessity; we hope to work with you towards this goal.

1. *Problem-solving Partnership – A Joint Industry/Government Approach*

Immediately after methyl bromide (MeBr) was listed as an ozone-depleting substance under the Montreal Protocol, Environment Canada co-sponsored a conference with the United States government and several United Nations organizations in Washington, DC., in 1994. The scientific reports were thoroughly convincing of the need to eventually phasing out methyl bromide and take immediate action. At the same time, it was apparent that these actions could have significant implications for agriculture and food processing. It was also apparent that there were some alternatives to MeBr use. Clearly, phaseout methyl bromide was going to be difficult, but not impossible.

Within a year, the Canadian government called together growers, food processors, importers and exporters, fumigators, pesticide manufacturers and distributors, research organizations, and environmental experts. A large number of participants reviewed the scientific findings that were creating the sense of urgency, supporting the call for methyl bromide phaseout, the Canadian government policy view, and the alternatives currently available. These formal presentations gave way to concerned discussions on the potential impact on food production and processing by discontinuing the use of methyl bromide. From the point of view of government and nongovernment organizations (NGOs), phasing out methyl bromide was necessary to maintain human and environmental health and fulfil Canada's commitment as a member of the Montreal Protocol. The agriculture and agri-food sector believed, however, that phasing out MeBr was going to cause disruptions in farm productivity, loss of pest control options, and significant economic effects.

If these groups had continued to argue their conflicting views without working together, progress would never have been made.

To the continuing credit of government, industry and environmental activists, we chose to do things differently in Canada. We acknowledged that we had to respond to the environmental necessity and phaseout methyl bromide, but we would do so in a distinctly Canadian way. We developed a collaborative partnership to ensure that agricultural productivity, pest control, and agri-business continued to prosper. We believe our approach works, and offer it as a model for other countries to use, since the protection of the ozone layer requires a global co-operative effort.

Immediately after that first Canadian conference on methyl bromide, a Joint Industry-Government Working Group on Methyl Bromide Alternatives was formed (the "Working Group"). Its purpose was to provide a forum for government to consult with industry and for both groups to provide direction on the effective implementation of Canada's program for the control of methyl bromide, including the adoption of alternatives, research and development, and control strategies. Membership was voluntary and open. Preliminary invitations were issued to growers, end users, fumigators, pesticide manufacturers, research organizations, federal and provincial government departments, alternative product companies, managment consultants, and environmental NGOs. Since then, the Working Group meets three times a year, usually in Ottawa.

Additionally, subcommittees are formed to accomplish specific tasks on behalf of the entire group. These subcommittees planned work,

prepared and reviewed documents, and met before Working Group meetings. One subcommittee drafted the integrated pest management (IPM) document for food processing facilities. Another subcommittee drafted the critical use exemption process to be used by industry and government once methyl bromide is phased out, while another is planning an experiment to test alternatives to methyl bromide fumigation in shipholds. Another subcommittee provided technical advice during a study on the corrosiveness of phosphine. These subcommittees allow fast production of information materials and project planning. Once their work has been completed and accepted by the Working Group, the subcommittees are disbanded.

Most of the original members of the Working Group are still active, and new members continue to join. Membership currently includes:

- growers who used methyl bromide for in field agriculture;
- flour milling and food processing companies, and associations whose members use methyl bromide;
- pest control operators; research scientists from government research institutes;
- companies who market alternative products, services and technologies;
- management consultants active in this area; environmental NGOs; and
- government representatives from Environment Canada, Agriculture and Agri-Food Canada, Industry Canada, the Pest Management Regulatory Agency (PMRA), and the Canadian Food Inspection Agency (CFIA).

The Working Group is jointly managed by two Departments (Environment Canada and Agriculture and Agri-Food Canada) and by industry (an elected position). Environment Canada provides the secretariat function.

1.1 Input to International Negotiations

The Working Group provides a consultative mechanism to discuss, plan, and advise on the negotiation position of the Canadian government concerning methyl bromide phaseout and related issues. While the advice from the Working Group is not binding on government, the positions recommended by this group often become the Canadian position. The group is kept informed of possible issues for future negotiations with sufficient time to discuss the possible impacts and gather member's views. Again, positions recommended by the Working Group have been brought forward at negotiations, giving our government negotiators much valuable information to contribute to meetings of the parties to the Montreal Protocol.

Additionally, two Working Group members are members of the Methyl Bromide Technical Options Committee (MBTOC) under the Montreal Protocol. The MBTOC assesses the technical effectiveness and readiness of methyl bromide alternatives for the Montreal Protocol. Information is gathered from group members before MBTOC meetings to ensure Canadian research, industry situation, technologies and problems are contributed at the meeting. The Working Group usually meets after a MBTOC meeting to allow information to be shared.

A Canada–United States working group, chaired jointly by the Departments of Agriculture, has also been formed to share information, and to discuss and plan collaborative research projects and other initiatives. Members of the Working Group often participate in the two meetings held each per year.

1.2 Input to Domestic Regulation

The Working Group is involved in the development of Environment Canada's amendment to include methyl bromide in the Ozone Depleting Substances regulations. Following the Working Group's extensive work to define, and agree on, critical exemption and emergency exemption processes for methyl bromide, the Canadian government will incorporate the recommendations of the group in regulation. Input from the Working Group has also helped to determine priorities for registration of new pest control products by PMRA.

Issues of regulatory overlap and conflict between different departments have been identified and resolved. As an example, Regulatory guidelines, for example, governing the use of pest control products and technologies conflicted between the newly formed PMRA and the CFIA. Now, as a result, both regulatory agencies are using the same approved list (found on www.cfia-acia.agr.ca). Industry has access to the approved list and conflicting regulatory guidelines have been eliminated.

1.3 Input to Research

Members of the Working Group share research information from government and industry scientists, have access to scientists, agree on priorities, fund research projects, and collaborate on research conducted by group members. The Group has given the work of some scientists more visibility within government and industry, domestically and internationally. For example, the Working Group identified a potential issue with the use of phosphine in food processing facilities. The Canadian and United States governments and the Canadian National Millers Association funded a research project to examine the conditions leading to phosphine corrosion. The technical report (Brigham, 1998) was recently published. In some instances, collaboration between industry and government researchers has led to national recognition awards.

Also, industry members of the group have collaborated on joint research for testing a proposed alternative for food processing facilities on a commercial scale. These projects, are conducted with experimental approval by government, and are published as technical documents by Agriculture and Agri-Food Canada and Environment Canada. Another collaborative project, involving Canadian and US government scientists, used the food processing facility of a Working Group member in a study to examine the commercial scale efficacy of a proposed alternative to methyl bromide for pest control in food processing facilities. Again, the work was published as an industry/technical report for wide distribution.

1.4 Development of Industry Guidelines

Canadian consumers are very disapproving of pests in consumer products. The difficulties of controlling pests in flour mills and other food processing facilities is of concern to those companies, the pest control companies, and the Working Group. Canadian legislation prohibits the export of flour if pests are found in the product or mode of transport. If pests are found in consumer products, actions are triggered at all stages of the marketing channel, with repercussions from distributors and retailers. Using the experience of several members of the Working Group a subcommittee was created, an integrated pest management (IPM) guideline for use in food processing facilities was developed under the guidance of the group member representing the PMRA.

1.5 Industry Promotion Activities

The Working Group organized an international alternatives workshop in 1996 to identify alternatives to users. The Working Group, held a very successful industry demonstration event highlighting methyl bromide alternatives during the 10th Meeting of the Parties to the Montreal Protocol in Montreal,

Canada in 1997. Several industry members demonstrated their products, services, and technologies to a large international audience over two days. In 1998, a tour of Canadian companies with methyl bromide alternatives technologies and expertise was held in southern Ontario for several members of the Multilateral Fund. The tour, organized by Environment Canada's Technology Transfer Office with the Environment Bureau of Agriculture and Agri-Food Canada, allowed several Canadian companies to highlight their products, technologies and services to potential customers and technology transfer partners. Many Canadian companies have made presentations at international and domestic conferences and meetings, and are involved in international projects funded by the Multilateral Fund of the Montreal Protocol.

1.6 Opinions on the Value of the Working Group

Each member of the Working Group came with expectations of what might be accomplished. Since trying to accomplish real objectives through a government committee can be a frustrating experience, some members did not at first consider much would be accomplished. However, as these comments from Working Group members indicate, we have met several important objectives — not that everything has been accomplished yet!

Views from a Pest Control Operator — "At the beginning, discussions were very challenging because everyone was stunned to learn about the phaseout of methyl bromide. We hoped the group would help find alternatives and resolve the problems resulting from the loss of methyl bromide. Over the years we have made progress. We tested some good ideas and did some good research on phosphine and diatomaceous earth for structural pest control. We have done some good work, but we still have lots to do. In general, I'm pretty satisfied." Denis Bureau, Adalia Pest Control Services, Montreal, and industry co-chair of the Working Group.

View from the Flour Milling Industry — "The Canadian flour milling industry is export oriented. Phytosanitary issues, plant hygiene, and related compliance and enforcement measures are very important to us. At first the industry thought Canada's Montreal Protocol commitment did not take into account Canada's technological and investment implications in the absence of alternatives to methyl bromide. After two years of participation, the Canadian National Millers Association (CNMA) is now of the view that the government departments who carry the responsibility for Canada's participation in the Montreal Protocol more fully understand pest control challenges facing flour millers and other food processors. As a consequence, we have now seen the government advocate practical regulatory principles and look forward to seeing these implemented in practice." Gordon Harrison, President, Canadian National Flour Millers Association, Ottawa.

View from a Research Scientist — "At first the Working Group was mostly involved in collecting information, so it wasn't that useful to me. Now, the group is much more interactive and has helped bring soil scientists in Canada and the United States together for research projects. We are now working more directly with growers who use MeBr to find alternatives. Also, several companies learned about my research program as a result of the Working Group and started to fund research. Still, we need to place more emphasis and funding on research, since research really pays the country back in production and industry spin offs. I really hope that the Working Group leads to a joint initiative for long-term funding and collaboration with US research scientists." George Lazarovits, Research Scientist, Agriculture and Agri-Food Canada, London.

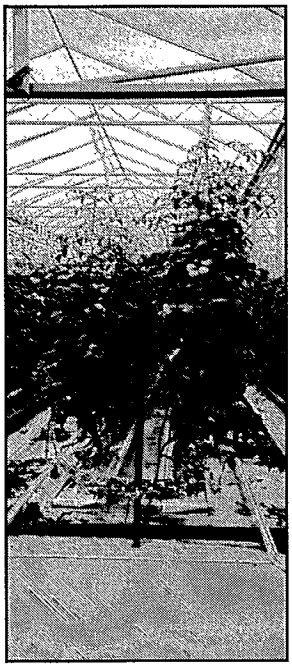
View from Environment Canada — "As regulatory managers we cannot do our jobs without industry consultation, so the Working Group made our lives easier. This way we can develop policy, that makes sense, share information and views on issues, policy, and regulation. The development and acceptance of our new regulation and the critical use

process would have been awfully complicated without the Working Group. Its big advantage is efficiency; having everyone together at the same time means we accomplish a lot." Bernard Madé, Environment Canada, Hull.

View from Agriculture and Agri-Food Canada — "The partnership with industry lets us put industry issues in perspective. This industry is unique in that it pro-actively seeks alternatives rather than simply reacting to international proposals that could negatively affect their business. As a result we see industry spending a lot of money and time to resolve issues and provide solutions. From our perspective, knowing industry issues better allows us to better inform politicians, to prepare better policies, and influence and direct research priorities. The contribution of government scientists on alternatives has been enormous." Sheila Jones, Agriculture and Agri-Food Canada, Ottawa.

2. Canadian Greenhouse Operations

2.1 Focus on Canada



Canadian growers have adapted to extreme climatic conditions by developing one of the most advanced greenhouse industries in the world (Vandenberg and Rattray, 1997). Strong ties with the research community have enabled Canadian greenhouse growers to maintain a competitive advantage. Development of integrated pest management systems (IPM) has played a key role in the industry's success. The development of computerized management and fertilization and irrigation systems that improve efficiency and quality has been integral to IPM. Disease and pest outbreaks, generally enhanced in the greenhouse environment, are also prevented through the development and use of biological control methods using predator insects. Over the years, scientists and the industry have realized the use of methyl bromide is not necessary and does not contribute to the sustainability desired by the industry. As a result, methyl bromide has been phased out of most Canadian greenhouse operations, with the exception of a small proportion of soil-based facilities.

In 1997, 12 889 000 m^2 of greenhouse production was operated by 4 655 companies in Canada (Statistics Canada, 1998). Approximately 2/3 of Canadian greenhouse production was under plastic and the rest was under glass. Total sales exceeded $1 billion. Flowers and plants accounted for 75% of this total and vegetables accounted for the remainder. Roses and carnations are the most common cut flowers while geraniums and tropical plants are the main potted plants. Because of greenhouse production, tomatoes and cucumbers are no longer seasonal crops but can be grown year round, thus increasing yields substantially. Production value and export sales of all greenhouse crops have been increasing steadily in recent years. Improved facilities and an emphasis on quality products are key elements in the industry.

According to Agriculture and Agri-Food Canada's Horticultural and Special Crops Division, greenhouse tomatoes are one of the fastest growing horticultural products in Canada and one of five Canadian products with a farm gate value of more than $100 million. Greenhouse tomatoes are also one of Canada's fastest growing export commodities in the agricultural sector.

The *Canadian Agricultural Products Act* ensures produce, such as greenhouse grown tomatoes, meet quality and food safety standards (Vandenberg and Rattray, 1997). The Canada Food Inspection Agency inspects the growers or packers that oversee grading, providing safeguards to meet the required standards. Pesticide residues are monitored regularly. Pesticide use in Canada is already significantly lower than in other countries; IPM techniques and biological control agents are allowing growers to reduce pesticide use to an even greater extent so residue problems are becoming less of an issue.

Canada is a large nation with extremely variable growing conditions, so the greenhouse industry, and agriculture as a whole, has needed to be highly versatile. Canadians are equipped to undertake technology transfer programs under very diverse conditions.

2.2 *Production Trends*

Greenhouse vegetable production is centred around various hydroponic systems, most using soilless culture. Rock-wool slabs are the preferred growing medium although the use of "no-growing medium" is increasing (Vandenberg and Rattray, 1997). Most vegetables are produced in these soilless systems, with the exception of Ontario tomatoes that are still often produced in soil (40–50%). British Columbia's floriculture greenhouses are approximately 50% soilless. Cut flowers tend to be grown in soil beds while potted plants are grown in soilless media.

In southern Ontario, greenhouses are most often made of plastic or double plastic film. Plastic film is generally less costly and better able to control the extreme light and heat conditions of the summer. In addition, it tends to experience less damage when exposed to hail or freezing rain. British Columbia's greenhouse industry, located as it is in a mountainous area, experiences high wind conditions. Glass is better able to withstand windy conditions than plastic and allows more light to pass through to the plants.

Approximately 15 years ago, the BC greenhouse vegetable industry started using biological controls for insect pests. This move was stimulated by increasing consumer opposition to pesticides and a lack of acceptable and effective chemicals available for use. Currently almost all insect pest problems in vegetable greenhouses can be controlled using biological control agents. When it comes to biological pest control, BC greenhouse growers are leaders in the world.

Use of biocontrol agents has been less successful in the floriculture industry than the vegetable industry. The sale of products such as cut flowers depends on the aesthetic appeal of both the foliage and blooms. Therefore, any level of insect or disease damage is considered unacceptable.

2.3 *Integrated Pest Management in Soilless Greenhouse Systems*

Integrated pest management touches on all aspects of greenhouse production. The climate control system, greenhouse design, pest monitoring, biological control agents, spot treatments when indicated, and sanitation all contribute to pest control and higher quality produce. Adaptations are made to contend with local conditions, but the key elements remain the same.

2.3.1 Climate control

Effective climate control removes the conditions for growth of diseases, and makes the establishment of pest populations difficult. Involving the manipulation of several factors including temperature and humidity, good climate control requires an in-depth knowledge of plant growth needs. Some greenhouses also enrich the atmosphere with CO_2, to increase sugar levels in the leaf. (The preferred level is 600–700 ppm; ambient atmosphere is 350 ppm; the health and safety limit is 3000 ppm.) Early in the development of soilless systems, simple timers and inexpensive equipment were used, but later replaced by imported equipment. Now, Canadian computerized climate control systems have been developed to suit local conditions and needs.

2.3.2 Controlled delivery of nutrients

Water-based fertilizer systems have been designed to deliver sufficient quantities of the nutrients to the plants, depending on their stage of growth and market conditions. Water use in soilless systems is high; approximately 10 L/m^2 litres/square meter may be needed in summer months. The industry's new challenge is recirculating the fertilizer water through the development of closed loop systems that reduce or eliminate the wastewater from greenhouse operations. Growers using recirculating water systems have reduced fertilizer use by 50%.

2.3.3 Soilless media

Most greenhouse growers use locally produced products, such as sawdust, to physically anchor plant roots in hydroponic systems. Plants are grown in free-standing rockwool blocks that are supported in sawdust bags. As they grow, the roots are supported in the sawdust. Cocoa husks and rice hulls can also be used for this purpose where available locally.

2.3.4 Biological control measures

Biological controls rely on monitoring and early detection. Rows of vegetables are tagged with sticky yellow pest monitoring flags; the levels of pests trapped are regularly checked. Light traps are used for moths and pheromone traps are used for both monitoring and to disrupt mating patterns. The efficacy and the value of the predators makes the use of pesticides very infrequent; they are only used in response to an extreme problem. Manual pest removal is also practiced. The industry makes major investments in predators to control common pests (approximately CDN$ 900 000 in 1994). Approximately 20 species of predators are commercially available to the greenhouse industry. Packages of locally reared predators are placed throughout the greenhouse and released. The use of natural bacteria to control plant diseases is not yet allowed in Canada, but the industry believes some of the research and some of the new products being developed are promising.

2.3.5 Sanitation measures

At the end of harvest, the spent plants and sawdust are composted. Plastic from the sawdust bags and the floor coverings is currently dumped, but research is being conducted to develop reusable plastics. Some growers are already using reusable plastic floor coverings. Thorough steam cleaning of ceiling, walls, and floors is conducted to control diseases. Mild bleach solutions or antifungal solutions are used to clean the greenhouse structure at the end of the season. Labour changes also work to control diseases. Pollination is now done by bumblebees, instead of by hand. Workers moving from plant to plant for pest control or during harvesting dip their hands in skim milk to prevent the spread of plant viruses.

2.4 Industry Resources

1. Ag Biologicals, Agrium, Inc.

Ag Biologicals, Agrium, Inc. is in the process of registering two biocontrol products for use in forestry and horticulture. FTG is a bacterial-based biofungicide developed for use on seedlings of coniferous and deciduous trees and shrubs. FTG suppresses damping-off and root rot diseases caused by *Fusarium*, *Rhizoctonia,* and *Armillaria* and increases root and shoot growth of transplanted seedlings. The second product, AtEze, is an easy-to-use liquid inoculant containing a beneficial bacteria. It can effectively control root/stem rot diseases caused by *Rhizoctonia solani*, *Phythium* spp. and *Fusarium oxysporum* on many ornamental and vegetable crops including poinsettia, impatiens, geranium, chrysanthemum, cyclamen, cucumber, and tomato. Enhanced vigour and growth have been observed repeatedly on tomato, cucumber, poinsettia, geranium, and celery, with improved crop yield and quality. In research trials where moderate amounts of pathogens were incorporated, AtEze consistently performed as effectively or more effectively than standard soil fungicides.

Contact: Louise Nelson, Ag Biologicals,
Agrium, Inc., 402-I5 Innovation Blvd.,
Saskatoon, SK, S7J 5B7
Tel: (306) 975-3850 Fax: (306) 975-3750

2. Applied Bio-Nomics Ltd.

Applied Bio-Nomics was formed in 1980 to research, develop, and market live biological control agents for pest control. Over the past 18 years they have pioneered the commercial use of a number of control agents for aphids, thrips, spider mites, fungus gnats, and whitefly. Applied Bio-Nomics products are used in greenhouses, zoos, conservatories, and gardens throughout North America and Europe. In 1988, they were given the Award of Excellence by the Professional Pest Management Association of BC for outstanding contributions in promoting the concepts and use of biological control in pest management.

Contact: Don Elliott, Applied Bio-Nomics Ltd.,
11074 West Saanich Rd., Sidney, BC, V8L 5P5
Tel: (250) 656-2123 Fax: (250) 656-3844
E-mail: bug@islandnet.com

3. Climate Control Systems Inc. (CCS): Fertigation Technology

Climate Control Systems Inc. (CCS) designs and manufactures computer controlled Drip Fertigation Systems for greenhouse vegetable and flower crops. The "fertigation manager," a computer controlled injection system, allows growers of flower crops, vegetable crops, vineyards, nursery crops, and field crops to achieve higher levels of profitability by increasing crop yields and quality, at the same time decreasing fertilizer, water, and labour costs. The user-friendly software allows the growers to deliver fertilizer formulas with great accuracy and simplicity.

Contact: Eric Labbate, 509 Hwy. 77, R.R. #5,
Leamington, ON, N8H 3V8
Tel: (519) 322-2515 Fax: (519) 322-2215
E-mail: climatecontrol@mnsi.net
Internet: www.climatecontrol.com

4. Nature's Alternative Insectary Ltd.(NAI)

Nature's Alternative Insectary Ltd. (NAI) has been producing biological predators for over 10 years. Commonly used by larger greenhouse growers in BC, NAI's products provide the most effective pest control when used in conjunction with other cultural control practices. Beneficial parasitic nematode strains supplied by NAI are particularly effective against fungus gnats and will aid in the control of pupating thrips. Their nematode strains are reared in such a way that those with the best reproductive, searching and killing ability are collected. NAI's nematodes are shipped throughout North America. NAI also produces a fungus gnat predatory mite, *Hypoaspis*, that controls fungus gnats in cucumbers, tomatoes, peppers, bedding plants, and flowers. Used in conjunction with thrips predatory mites (*A. cucumeris*) and pirate bugs (*Orius insidiosus*), *Hypoaspis* will also help control thrips.

Contact: Jessica Dawe, Production Manager,
Nature's Alternative Insectary Ltd., 1636 E. Island Hwy., Nanoose Bay, BC, V9P 9A5
Tel: (250) 468-7911 Fax: (250) 468-7912
Toll-free: 1 (800) 668-3367
E-mail: nai@bcsupernet.com

5. Phero Tech Inc.

Phero Tech Inc. manufactures and distributes a wide variety of products for environmentally sound management of insects and mammals. Their product line includes insect control strategies for the forestry, agricultural, greenhouse, and structural pest control sectors. Products such as insect pheromone trapping systems allow for more informed pest management decisions. Product quality and valuable technical support are among Phero Tech's strengths.

Contact: Julie McCarthy, Phero Tech Inc.,
7572 Progress Way, Delta, BC, V4G 1E9
Tel: (604) 940-9944 Fax: (604) 940-9433
Toll-free: 1 (800) 665-0076
E-mail: sales@pherotech.com
Internet: http://www.pherotech.com/

6. Plant Products Co. Ltd. and Morse Grower's Supplies Inc.

Plant Products Co. Ltd. is principally a manufacturer of water-soluble fertilizers for the horticultural industry. These fertilizers are sold in 18 countries throughout the world. In conjunction with its joint venture partners, Westgro Sales Inc. and Morse Grower's Supplies Inc., Plant Products Co. Ltd. is the leading distributor of horticultural products to approximately 20 000 commercial growers in Canada. In business for over 50 years, Plant Products Co. Ltd. is dedicated exclusively to the horticulture, high value crop marketplace and is interested in supplying their products and expertise abroad to assist developing countries in reducing their requirements for methyl bromide.

Contact: Plant Products Co. Ltd.,
314 Orenda Road, Brampton, ON, L6T 1G1
Tel: (905) 793-7000 Fax: (905) 793-9157 (sales)
(905) 793-9632 (administration)
Morse Grower's Supplies Inc., 50 Hazelton St.,
Box 33, Leamington, ON, N8H 3W1
Tel: (519) 326-9037 Fax: (519) 326-9290

7. B.C. Hot House Foods Inc.

B.C. Hot House Foods Inc. is a British Columbia marketing co-operative representing many provincial growers of tomatoes, peppers, cucumbers, and lettuce. They have a distribution system extending into the rest of Canada and the United States. B.C. Hot House promotes their products as being high quality and herbicide free. They operate a centralized grading facility and a traceback system to the farm.

Contact: B.C. Hot House Foods Inc.,
5355 152nd St., Surrey, BC, V3S 8E7
Tel: (604) 576-8525
Internet: http://www.bchothouse.com/

8. Ontario Greenhouse Vegetable Producer's Marketing Board

This is the largest marketing organization in Canada for greenhouse vegetables. Established by provincial legislation, it includes all Ontario greenhouse vegetable growers and has been a strong contributor to marketing successes in Canada and for exports to the United States.

Contact: Denton Hoffman, Ontario Greenhouse Vegetable Producer's Marketing Board,
139 Oak St. West, Leamington, ON, N8H 2B8
Tel: (519) 326-2604 Fax: (519) 326-7842
E-mail: denton@ontariogreenhouse.com
Internet: www.ontariogreenhouse.com

9. United Flower Growers' Co-operative Association

The United Flower Growers' Co-operative Association is a grower-owned and operated co-operative established in 1963. It plays a significant role marketing British Columbian floral products and has become a major distribution centre for Canada's multimillion dollar floriculture industry. By shipping through the association's auctions, that take place four to five times weekly depending on the season, members can take advantage of reduced marketing and promotional costs and improved payment security. The co-operative currently has 100 members, 30 full-time staff and 50 growers and wholesalers classified as guest shippers.

Contact: United Flower Growers' Co-operative Association, 4085 Marine Dr., Burnaby, BC,
V5J 5E2, Tel: (604) 430-2211
Fax: (604) 430-6659 E-mail: info@ufgca.com
Internet: www.ufgca.com

2.5 University Resources

1. Laval University

Scientists at Laval University have been working in conjunction with Plant Products Co. Ltd. and researchers at other university and government facilities to develop a biofungicide to control powdery mildew in greenhouses. Powdery mildew is one of the few diseases that prevents complete non-chemical pest control production of greenhouse vegetables. An effective biocontrol agent could reduce or eliminate fungicide use. Sporodex^{TM} is being prepared for submission for registration to the Pest Management Regulatory Agency and if approved could become the first biofungicide registered for use in Canada.

Contact: Richard Bélanger, Département de Phytologie, Centre de Recherche en Horticulture, Université Laval, Québec, QC, G1K 7P4
Tel: (418) 656-2758 Fax: (418) 656-7856
E-mail: richard.belanger@plg.ulaval.ca

2. McGill University

Researchers at Macdonald Campus of McGill University are conducting studies to understand the mechanisms of biological control of pythium damping-off by the bacterium *Pseudomonas putida*. Present research is focusing on the mechanism of nutrient competition between the pathogen and bacterium for carbon substrates produced by germinating seeds. In other studies, scientists are working to develop methodologies and formulations to apply bacteria (*Pseudomonas* spp.) to peat products for controlling root rot diseases in greenhouse and ornamental plants. They are seeking to understand the mechanisms of biocontrol by the bacteria, including characterizing antibiotic production, induced resistance, studies of

colonization and nutrient competition. The intent is to develop a formulated peat growing mixture that would be suppressive to these diseases, and lead to better production with less reliance on fungicides. The group has recently discovered and characterized a novel antibiotic from *Pseudomonas aureofaciens* effective against several fungi.

Contact: Tim Pawlitz, Macdonald Campus of McGill University, Faculty of Agricultural and Environmental Sciences, 21-111 Lakeshore Road,
Ste-Anne-de-Bellevue, QC, H9X 3V9
Tel: (514) 398-7851 Fax: (514) 398-7897

3. Simon Fraser University

The Centre for Pest Management at Simon Fraser University has several faculty members working on biological control methods using agents including nematodes, bacteria, fungi, and yeasts. Research on various organisms has been undertaken in order to understand how they, or their products, can be used to control plant diseases as part of an environmentally acceptable biological control program.

Contact: Dr. Z. K. Punja, Centre for Pest Control, Department of Biological Sciences,
Simon Fraser University, Burnaby, BC, V5A 1S6
Tel: (604) 291-3705 Fax: (604) 291-3496
E-mail: punja@sfu.ca

4. University of Guelph

Scientists at the University of Guelph are establishing optimal environmental algorithms for computer-controlled growth facilities and commercial greenhouses. Safe and effective pest control combined with high yield is a goal. Carbon dioxide gas is being assessed for effectiveness as an alternative to pesticides.

Contact: B. Grodzinski, Department of Plant Agriculture, University of Guelph, Guelph, ON, N1G 2W1, Tel: (519) 824-4120

2.6 Government Resources

1. Alberta Department of Agriculture and Food

The Greenhouse Crops Program at the Crop Diversification Centre South (CDCS) at Brooks, AB is working to support the continuing development of the industry. The research greenhouses at the Centre are managed in a industrial fashion utilizing the same cultivars and growing techniques as commercial growers. This allows for direct transfer of technology and management systems. The research greenhouses are also operated on environmentally sustainable principles, there being no pesticides used in the production of the vegetable crops grown at the Centre. The program at CDCS operates co-operatively with the Greenhouse Crops Program at the Crop Diversification Centre North in Edmonton, AB to meet the research and extension needs of greenhouse growers throughout the province. A monthly newsletter for the greenhouse industry called *Greenhouse Coverings* is published jointly by both centres. This newsletter is available on Alberta Agriculture's Internet site: www.agric.gov.ab.ca
Contact: Jim Calpas Tel: (403) 362-1312.

Studies at the Crop Diversification Centre North in Edmonton, Alberta are looking at the epidemiology and control of powdery mildew of greenhouse-grown tomatoes. In addition to identifying the causal organism, they are identifying environmental factors that affect disease spread and identification of fungicides that control powdery mildew that could be registered for minor use on tomato.

Contact: P. S. Bains, Alberta Department of Agriculture, Food and Rural Development, Plant Industry Division, Crop Diversification Centre North, R.R. #6, Edmonton, AB, T5B 4K3
Tel: (403) 422-1789 Fax: (403) 422-6096

2. The British Columbia Ministry of Agriculture and Food

The British Columbia Ministry of Agriculture and Food supports several greenhouse integrated pest management projects through its Industry Innovations Program 1997/1998. Projects include control of cabbage loopers in greenhouse vegetables using biological control and IPM, management of *Fusarium* crown and root disease of greenhouse tomatoes, management of stem end rot of greenhouse cucumbers, and a survey of pest species in vegetable greenhouses. Each of these projects is being done in conjunction with either the BC Greenhouse Vegetable Council or the Greenhouse Vegetable Growers' Committee.

For more information: http://www.agf.gov.bc.ca/croplive/cropprot

3. Greenhouse and Processing Crops Research Centre — Agriculture and Agri-Food Canada —Harrow, Ontario

The Greenhouse and Processing Crops Research Centre is the most southerly of the 18 research facilities of Agriculture and Agri-Food Canada. The Centre develops and transfers new technologies for production of greenhouse vegetables (tomatoes, cucumbers, and peppers) that will result in improved greenhouse vegetable production efficiency and marketability, in a sustainable, environmentally safe production system.

The research team at the Greenhouse and Processing Crops Research Centre are looking at several aspects of pest control in an integrated management environment. Researchers are investigating major fungal and bacterial root diseases in greenhouse vegetables with a view to developing control measures to minimize economic losses due to these diseases. Others are developing cost-effective pest control technologies with the emphasis on non-chemical control measures for insect and mite pests.

Contact: Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Hwy. 18, Harrow, ON, N0R 1G0
Tel: (519) 739-2251 Fax: (519) 738-2929
E-mail: harweb@em.agr.ca
Internet: http://res.agr.ca/harrow/

Dr. Tom Papadopoulos, researcher at the Greenhouse and Processing Crops Research Centre, has produced a publication entitled "Growing Greenhouse Seedless Cucumbers in Soil and Soilless Media"; a comprehensive guide to all aspects of production. This manual (Publication 1902/E) is available in English and French from the Communications Branch, Agriculture and Agri-Food Canada, Ottawa, ON, K1A 0C7.

Greenhouse production technology has advanced substantially in sophistication and automation over the recent years. Computerized climate control and fertigation systems are now widely used. Dr. Papadopoulos has also been involved in the development of the "Harrow Fertigation Manager," a fertilizer injection system guided by an expert information system designed for local conditions and climate. This was a joint project with Climate Control Systems (see industry resources).

Contact: T. Papadopoulos, Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Hwy. 18,
Harrow, ON, N0R 1G0
Tel: (519) 739-2251 Fax: (519) 738-2929
E-mail: papadopoulost@em.agr.ca
Internet: http://res.agr.ca/harrow/

The Greenhouse and Processing Crops Research Centre of Agriculture and Agri-Food Canada has also developed a decision support system that assists the user in solving pest and production problems, as well as improving overall management of greenhouse operations. This system

has been named the Harrow Greenhouse Crop Manager (HGCM). The user-friendly computer software assists the grower in accessing, assimilating, and integrating the latest production and control practices into their own operations. A data base also helps the user to record, tabulate, and present graphical and tabular reports on the efficacy of different greenhouse tasks, yield data, pest monitoring, material purchases, and employee records. The end-result is improved fruit yield and quality while at the same time reduced energy consumption by optimizing greenhouse environment and fertilizer application, and by the elimination of up to 90% of pesticide use through non-chemical control strategies. The system was developed to complement the Harrow Fertigation Manager and other computerized greenhouse control systems.

Contact: Dr. Les Shipp, Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Hwy. 20, Harrow, ON, N0R 1G0
Tel: (519) 738-2251 ext. 431 Fax: (519) 738-2929
E-mail: shippl@em.agr.ca

To order contact : Enermodal Canada,
650 Riverbend Drive, Kitchener, ON, N2K 3S2
Tel: (519)743-8777 Fax: (519)743-8778
E-mail:office@enermodal.com
Internet: http://www.enermodal.com/agri_index1.html

4. The Southern Crop Protection and Food Research Centre — Agriculture and Agri-Food Canada — London, Ontario

The Southern Crop Protection and Food Research Centre has as part of its mandate the development of alternative and environmentally acceptable technologies for the protection of tree fruits, vegetables, field, and ornamental crops from disease and insect pests.

Pheromone-based monitoring and mating disruptions systems are being developed for situations where the adoption rate is likely to be high or where insect resistance to currently used pesticides has developed rendering chemical control ineffective.

Contact: J. Potter, Agriculture and Agri-Food Canada, Southern Crop Protection and Food Research Centre, 1391 Sandford St., London, ON, N5V 4T3
Tel: (519) 457-1470 Fax: (519) 457-3997
Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

Scientists are also investigating rational and environmentally acceptable methods for control of diseases caused by soilborne fungal pathogens including *V. dahliae, R. solani, and P. sojae*. They are looking at methods based on disruption of infection processes, reduction of pathogen populations in the soil and by identification and exploitation of natural biological, chemical, and physical processes that accelerate the death of the pathogens. Better diagnosis of disease will allow growers to make better decisions as to cultivars to plant and disease control procedures to implement.

Contact: G. Lazarovits, Agriculture and Agri-Food Canada, Southern Crop Protection and Food Research Centre, 1391 Sandford St., London, ON, N5V 4T3
Tel: (519) 457-1470 Fax: (519) 457-3997
Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

5. Pacific Agri-Food Research Centre (PARC) — Agriculture and Agri-Food Canada — Agassiz, BC and Summerland, BC

PARC conducts research on horticultural and field crop production and protection, including greenhouse vegetables.

The Agassiz Research Station is looking at introducing biological controls and Integrated Pest Management systems into the Canadian greenhouse industry on a commercial basis. The purpose is to reduce dependence on chemical pesticides and at the same time reduce economic losses caused by invasions of insects and mites, particularly spider mites and cabbage loopers. IPM techniques and biological controls are essential both to food safety and to the ability of the Canadian industry to compete aggressively in international markets. Technology developed by Agassiz researchers, in

conjunction with provincial insectary companies, will be introduced first into the BC greenhouse vegetable industry before expanding throughout Canada and beyond our borders.

At the Summerland Research Station, studies are underway to investigate factors that limit yield and quality in greenhouse crops grown in soilless culture and to develop new methodology for improved management practices in environmentally sustainable systems. Population ecology and biological control of arthropod pests are being investigated to develop improved sampling protocols, economic or action thresholds, population modelling systems, biological control methods, and computerized systems for pest management.

Contact: G. Neish, Agriculture and Agri-Food Canada, Research Branch, PARC,
4200 HWY 97, Summerland, BC, V0H 1Z0
Tel: (250) 494-6355 Fax: (250) 494-0755
E-mail: parc@em.agr.ca
Internet: http://res.agr.ca/summer/parc.htm

3. Soils

3.1 Focus on Canada

Canada, with it's abundance of rich agricultural land has become one of the world's fore-most agricultural nations. To continue to produce high yields of superior quality crops, Canada's soils must be kept free from fungal, bacterial, and insect pests. Nematodes, soil diseases, insects, and weeds can cause annual losses of hundreds of millions of dollars.

Soil fumigation for the control of a wide range of soil pest problems is integral to the production of many crops. Although Canada is not a large user of methyl bromide for soil fumigation, compared to the global consumption rate, we have put a lot of effort into identifying MeBr alternatives for soil use to maintain our strong economic activity. The need for environmental sustainability has led scientists to investigate alternatives to rid the soil of damaging insects and diseases.

3.2 Industry Resources

1. AgroSpray Ltd.

AgroSpray Ltd. provides specialized crop protection products, equipment, and service to horticultural and specialty crop producers throughout eastern Canada. Specializing in soil fumigation, AgroSpray handles a complete line of soil fumigant products and designs and manufactures equipment to supply these products safely and effectively. A pioneer of bulk delivery of agricultural chemicals to growers, AgroSpray prides itself on its rapid customer service response and high standards for safety.

Contact: Paul Martin, Sales Marketing Manager, AgroSpray Ltd., 85 Spruce St., Box 130, Tillsonburg, ON, N4G 4H3
Tel: (519) 842-8408 Toll-free: 1-800-640-2476
Fax: (519) 688-0456 Internet: www.agrospray.com

3.3 Government Resources

1. Southern Crop Protection and Food Research Centre — Agriculture and Agri-Food Canada — London, Ontario

One of the goals this centre of the Southern Crop Protection and Food Research Centre is the maximization of profitability, competitiveness and sustainability of Ontario cropping systems, and the improvement of soil and water quality, by developing superior soil management practices and technologies for pest control and nutrient management. Soil scientists work with partners in fruits, new crops, field crops, and vegetables to integrate pest control technologies into sustainable production and management systems. The intention is to provide recommendations and working models to growers and extension personnel on many aspects of production, including pest control.

Contact: J.W. Potter, Southern Crop Protection and Food Research Centre, Agriculture and Agri-food Canada, 1391 Sandford Street, London, ON, N5V 4T3
Tel: (519) 457-1470 Fax: (519) 457-3997
Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

3.4 *The Use of Marigolds to Control Nematodes*

Parasitic nematodes attack a wide variety of crops causing significant economic losses. Nematodes can reduce crop yield and quality both by direct damage and by facilitating the movement of pathogenic fungi into plant roots. As yet, nematode resistant cultivars are not widely available. Control methods include crop rotations and chemical nematocides, the latter generally being highly toxic and ozone-depleting in nature. Alternative nematode control methods are being investigated.

The Soil and Environmental Quality Team (Agriculture and Agri-Food Canada) has demonstrated that marigolds can suppress soil-inhabiting pathogenic nematodes (such as *Pratylenchus penetrans* and *Meloidogyne* sp.), replacing chemical fumigants (Topp *et al.*, 1998). While the use of marigolds to control nematodes is not yet commercialized, several years of positive field data have been obtained and a number of seed companies have expressed interest in the project. The team has identified two constraints. Firstly, the marigold seed is difficult to work with because its weight and shape do not lend it to mechanised handling and second, marigolds are not a commercial crop. Studies are currently underway looking at the possible commercial use of marigolds for pigment production.

Contact: Ed Topp, Southern Crop Protection and Food Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ON, N5B 4T3, Tel: (519) 457-1470 ext. 235
Fax: (519) 457-3997 E-mail: toppe@em.agr.ca
Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

3.5 *The Replacement of Chemical Fumigants with Organic Amendments*

The Southern Crop Protection and Food Research Centre is looking at the potential to replace chemical soil fumigants by composts and organic by-products from seafood, livestock, and vegetable processing industries. Soilborne pathogens can have major effects on the production of many crops including tomatoes, potatoes, and strawberries. Alternatives to soil fumigation are being sought because the use of herbicides and pesticides is becoming less acceptable.

Deregulation of methyl bromide has provided an impetus to the revival of research for the use of organic amendments to control of soil-borne pathogens. However, techniques to evaluate the efficacy of organic soil amendments are less straightforward than chemical testing. Interactions are complex and a larger time frame for evaluation is necessary. A technique is currently being developed by Dr. Lazarovits in collaboration with the U.S. EPA.

Feather meal, meat and bone meal, hydrolyzed pig hair, blood meal, fish by-products, chitin, and various manures have been evaluated for inhibition of *Verticillium dahliae* and *Streptomyces* spp. A number of the organic amendments were found to reduce viability of *Verticillium microsclerotia*, diminish scab incidence, and restrict populations of *Sclerotinia scabies*, pathogenic nematodes and weeds (Lazarovits *et al.*, 1997). Effects were rate and soil specific, with sandy soils being most amenable to the treatment. Yields in the treated plots were as much as twice those found in the control plots, especially in the second growing season; high nitrogen levels were found occasionally to cause phytotoxicity in the first season.

Meat and bone meal (MBM) used as a control for *Verticillium dahliae* (Kleb.) can have benefits over fumigation (Tenuta *et al.*, 1997). Incorporation of MBM into the soil led to increased soil microbial populations and diversity, broad spectrum control of nematodes, weeds, other soil-borne fungi and bacteria, increased soil fertility and residual control over several years. Early dying syndrome, a condition caused by *Verticillium dahliae*, has been identified as the second most important disease of potatoes by the Potato Association of America.

The practicality and economic effectiveness of using soil amendments to control soilborne pathogens will depend on their availability. Costs will be considerably lower if a farm is close to a supplier of organic products.

Contact: George Lazarovits, Southern Crop Protection and Food Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ON, N5B 4T3 Tel: (519) 663-3099 Fax: (519) 663-3454 E-mail: lazarovitsg@em.agr.ca Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

4. Strawberry Transplant Production

4.1 Focus on Canada

There is a strong demand for disease free transplant stock both in Canada and the United States. Canadian conditions are particularly ideal for the production of transplants for the US strawberry industry. Strawberry nurseries exist in Nova Scotia, Quebec, and Ontario to provide for this lucrative market. Fumigation is essential for keeping the plants disease and nematode free and to meet certification standards. With the phaseout of methyl bromide, alternative fumigants or methodologies must be found for the control of diseases, nematodes, and weeds.

4.2 Production Trends

Canada's climate favours strawberry transplant production. Particular cultivars are reproduced in Ontario, Quebec, N.S. and P.E.I. specifically for US farms. These varieties are exported south in the autumn for immediate planting in various American states.

Some strawberry transplant producers have phased out methyl bromide use completely, while others are not yet reconciled to the Canadian year 2001 deadline. A collaborative project to study weed control in strawberry nurseries using alternative fumigants and herbicides was undertaken by Charles Keddy of Keddy Nursery and Klaus Jensen of Agriculture and Agri-Food Canada at Kentville, NS.

Foliar herbicides are not permitted for use on strawberry nursery plants in Nova Scotia because the effects on daughter plants are not known. Most herbicides used in strawberry fruit production cause damage to the leaves and fruits and can reduce runnering. Studies were conducted to determine the effects of incorporated Treflan, post-emergence Dacthal and post-emergence Fusilade on nursery

seedlings. Measurements were taken of the effects of the herbicide treatments on daughter plants of two cultivars. Minimal damage was recorded. Fusilade has since been registered for use in strawberry nurseries to control grassy weeds.

In other studies, Keddy and Jensen looked at various soil fumigants. They found 898 L/ha Busan 1020 (Metam sodium) injected into the soil in the fall at depths of 12, 25, and 37 cm, eradicated up to 94% of the weed population. When Vapam at 225 L/ha was incorporated into the top 3–4 cm of the soil, the soil was sealed with a power cultipacker and 427 L/ha Telone was injected into the top 8–10 cm, weed control was recorded at 96%. Additionally, applications methods for soil fumigants were evaluated. Jensen's work noted that, at this point, the Rumpstaedt applicator was superior for weed control over the conventional shank applicator. In 1998, research continued to evaluate new Telone formulations.

When evaluating the use of pesticides and herbicides, the potential effects on groundwater must be taken into account. The seriousness of this factor depends on local conditions and can be a major problem in some areas.

4.3 *Industry Resources*

1. Keddy Nurseries

Charles Keddy has been involved in field trials looking at alternatives to methyl bromide fumigation and has attended international meetings to report on results. He is currently concentrating on his own farm interests, and continues to grow without the use of methyl bromide for four consecutive years.

Contact: Charles Keddy, Keddy Nursery,
R.R.#3 Kentville, NS, B4N 1J5
Tel: (902) 678-4497

4.4 *Government Resources*

1. Atlantic Food and Horticultural Research Station (AFHRC)–Agriculture and Agri-Food Canada–Kentville, NS

As part of their mandate, the AFHRC develops new cultivars and technologies for producing, adapting, and protecting horticultural crops including innovations for their storage, handling and processing. Strawberries are one of several crops studied.

Contact: Klaus Jensen, Atlantic Food and Horticultural Research Station, Agriculture and Agri-Food Canada, 32 Main St.,
Kentville, NS, B4N 1J5
Tel: (902) 679-5761 Fax: (902) 679-2311
E-mail: jensenk@em.agr.ca
Internet: http://res.agr.ca/kentville/centre

2. Southern Crop Protection and Food Research Centre–Agriculture and Agri-Food Canada–London, Ontario

Scientists at the Southern Crop Protection and Food Research Centre are working to develop lesion nematode-tolerant or resistant strawberry cultivars, through selection and breeding from wild and cultivated varieties. They are endeavouring to reduce dependence of the grower on chemical fumigants by improving the predictability of nematode damage.

Contact: J.W. Potter, Southern Crop Protection and Food Research Centre, Agriculture and Agri-food Canada, 1391 Sandford Street,
London, ON, N5V 4T3
Tel: (519) 457-1470 Fax: (519) 457-3997
Internet: http://res.agr.ca/lond/pmrc/pmrchome.html

5. Tobacco Production

5.1 Focus on Canada

Canadian production of unmanufactured tobacco in 1998 was equivalent to 69 300 tonnes grown on 27 800 ha (USDA figures). Canada produced 68 500 tonnes of flue-cured tobacco in 1998 on 27 400 ha, and 800 and 700 tonnes on 400 ha each of dark air and sun cured tobacco and dark air and sun cured tobacco for cigars, respectively.

Methyl bromide is not used for tobacco production in Canada, as it is in some other countries, for control of root knot nematodes, grenville wilt, black shank, damping off and fumigation of greenhouse styrofoam plug trays. In Canada, Telone and Vorlex brand soil fumigants are the preferred chemical treatments.

5.2 Production Trends

For tobacco production in Canada, soil is steamed or fumigated to rid flue-cured tobacco seedbeds of weeds, soil-borne diseases and/or nematodes (OMAFRA, 1997/1998). Steaming, either in spring or fall, is generally effective when done at a temperature of 82°C for 30 minutes to a depth of 15 cm. A longer sterilization period is required when the soil is covered with plastic rather than metal pans. Steam pasteurization is used on 80–85% of tobacco seedbeds in Ontario (Van Hooren, 1998 – personal communication).

Due to Canada's climatic conditions, fumigation must be undertaken in the early fall with recommended chemicals that include Vapam (primary choice), Basamid, Mylone, and Vorlex Plus. Most weeds, fungi, and nematodes are controlled by fumigation with the exception of the fungal disease black root rot which can be a major problem in tobacco seedbeds. Steam treatment is more effective in this case.

Damping off disease, caused by *Rhizoctonia* and to a small degree by *Pythium*, affects seedlings both at emergence and in the early stages of growth. In Ontario, damping off is controlled by a combination of good greenhouse management practices such as humidity control and optimum seeding rates, and use of the fungicide Benlate.

Tobacco fields are row fumigated before transplanting to control plant parasitic nematodes and the black root rot disease (OMAFRA, 1998). Recent studies at Agriculture and Agri-Food Canada's Delhi Research Station have produced new cultivars such as AC Gayed that are resistant to black root rot. Non-chemical practices, such as rotating crops with marigolds, millet, or sorghum, have been shown to reduce nematode problems.

Scientists at the University of Guelph are using genetic engineering techniques in an effort to develop nematode-resistant varieties.

5.3 *Industry Resources*

1. DeCloet Ltd.

DeCloet Ltd., established in 1967, provides equipment to the tobacco-growing industry both in Canada and internationally. Its products focus primarily on tobacco harvesting and tobacco bulk curing systems. However, the company also produces greenhouses for tobacco seedlings, sterilization boilers, seeding and planting equipment for the domestic market. DeCloet produces a 13.3 HP oil-fired portable boiler used to generate steam that is distributed under plastic sheets through the use of a perforated drain tile down the centre of the plastic. This method of sterilization is proven to be very effective and has been in use for several decades.

Contact: Mr. Vance Veinot, Vice President of Sales,
DeCloet Ltd., P.O. Box 143,
Tillsonburg, ON, N4G 4H3
Tel: (519) 842-7361 Fax: (519) 688-0760

5.4 *University Resources*

1. University of Guelph

Scientists at the University of Guelph are involved in the development of transgenic tobacco plants resistant to nematodes. The laboratory of Barry Shelp currently uses the tobacco/root knot nematode interaction as a model system for testing new strategies. Tobacco is easily transformed, and appropriate constitutive, root-specific and nematode-responsive promoters are available. Currently, they are investigating nematode resistance in engineered plants with elevated levels of GABA, a naturally occurring amino acid that acts as inhibitory neurotransmitter. Ingested GABA has ready access to the nervous system of invertebrates. The investigation of GABA is a promising initiative for the control of root parasitic nematodes. Financial support for this research is provided by the Natural Sciences and Engineering Research Council of Canada, and the Ontario Ministry of Agriculture, Food and Rural Affairs.

Contact: Barry Shelp, Department of Plant Agriculture, Division of Biotechnology,
University of Guelph, Guelph, ON, N1G 2W1
Tel: (519) 824-4120 ext. 3089
Fax: (519) 767-0755
E-mail: bshelp@evbhort.uoguelph.ca

5.5 *Government Resources*

1. Ontario Ministry of Agriculture, Food and Rural Affairs

A publication entitled *1997-1998 Flue-cured Tobacco Recommendations* (Publication 298) is available from OMAFRA detailing all aspects of tobacco production in Canada, including disease and pest control. This publication is available by calling 1-888-466-2372 (in Ontario), (519) 826-3100 (outside Ontario) or through the OMAFRA website at http://www.gov.on.ca/omafra

2. Agriculture and Agri-Food Canada

Tobacco research at Agriculture and Agri-Food Canada is being gradually phased out. At present, the tobacco growers and manufacturers are establishing a research foundation to continue evaluation of fungicides for disease control in tobacco. The Canadian Tobacco Research Foundation is still in its early stages of development and a contact was not available at the time of publication of this report.

Information on tobacco production in Canada is available through: Dan Van Hooren, Tobacco Specialist, Southern Crop Protection and Food Research Centre, Agriculture and Agri-Food Canada, Schafer Rd., P.O. Box 186,
Delhi, ON, N4B 2W9
Tel: (519) 582-1950 Fax: (519) 582-4223

6. Grain Production

6.1 Focus on Canada

Canadian production of grains and oilseeds, has more than doubled since the 1950's when Canada was considered the world's breadbasket. Almost CDN$10 billion of grains, oilseeds, and related products are exported each year from Canada. Bulk grain exports are approximately CDN$6 billion, and account for more than 25% of total Canadian agri-food exports. In 1996, total Canadian wheat exports were over 16 million tonnes.

Canadian grain exports are known worldwide for their uniform, consistent quality, and desirable end-use characteristics. Canada has earned this reputation by creating an environment in which plant breeders, producers, and storage, transportation and marketing companies work together to provide the product required by international and domestic clients.

The major categories of wheat grown in Canada are spring wheat, winter wheat, feed wheat, and durum wheat grown. Canada is also recognized as the source of the world's highest quality buckwheat, producing almost one half of the world's total buckwheat supply.

Canada has developed a reputation for exporting wheat that is pest free and free of chemical residues. Methyl bromide is not used during growing, handling or storage of grains in Canada. From production to the retail store, an integrated approach is used to ensure pest control and high quality in grains, cereals and processed products. The economic importance of grains and cereals gives very strong incentive for innovations to sustain Canada's leadership in the production and handling of these crops.

6.2 Production Trends

Canada's cold climate may fuel the assumption that Canada does not have pests or pest problems. Canada does not have the same number of pest species to control as some other countries, and the pests may have fewer life cycles in a year, but Canada does have serious stored grain pests and most of these are the same pests Canada's our customers and suppliers also deal with. Canada's grains, cereals and milling sectors fight battles with *Tribolium* spp. (red flour beetle, confused flour beetle), *Sitophilus granarius*, *Dermestids* spp., *Attagenus* spp., *Plodia interpunctilla* (Indianmeal moth), *Gibbium psylloids* (spider beetle), *Tenebio molitor* (yellow meal worm) and *Cryptolestes* spp. Cockroaches can also be a problem in some parts of the sector and in some geographic regions.

An integrated system — The Canadian grains, cereals, and milling sector is characterized by an integrated pest management system from production to end use. All sector participants recognize that integrated pest management methods are needed to ensure productivity and pest control with a goal of minimal chemical intervention. There are several elements to Canada's IPM system. The Canadian Grain Commission (CGC) regulations set grain quality and export standards. CGC inspection programs encourage and ensure pest-free shipments. An extraordinary emphasis on sanitation pervades all parts of the sector. Canada's long-term government research commitment has resulted in advances in agricultural productivity, entomology, pest detection methods, and pest control with minimal chemical intervention. There is a significant resource and philosophical commitment by agri-food business to adapt research, to market, and to encourage adoption of new technologies and products that are more environmentally sensitive.

Sanitation — Stringent and constant sanitation is a very important component of any treatment program. It reduces the costs of fumigation and plant shut-down or compliments fumigation or other pest control treatments. The goal of sanitation is to reduce the need for chemicals by removing pests and the places where they live, reproduce, and hide and preventing their access to the facility, equipment, product, or commodity. Sanitation, looked at simply, involves cleaning, removing food sources and harborages from all parts of the building and equipment, as well as good warehouse practices such as keeping product away from walls and rotating stock. Packaging that is as pest proof as possible is another sanitation measure.

The relative simplicity of advice on sanitation makes it look deceptively easy. In fact, an effective sanitation program is neither simple nor easy. Each of the companies, researchers and technology transfer specialists included in this section could provide advice on designing and improving sanitation in grain and cereal production and processing.

Cold to control pests — In the summer, Canadian grain growing regions are very sunny and hot, but in the winter, cold temperature sets in. Often our weather makes agricultural production difficult, and presents both challenges and advantages in grain storage. Canadians make use of cold to control pests in two ways: freezeouts and bin aeration.

As temperatures decrease, pests stop reproducing, become dormant, and eventually die. Both temperature and time affect the outcome of cold on pest populations. Grain is an effective insulator. Therefore grain temperature is the important measurement, not air temperature.

The mode of action of cold on pest is starvation and dehydration. At temperatures below 10°C, pests are less able to move, are unable to reproduce and feed. At temperatures below -15°C, most pests require only a few days exposure for death. Various pests have different cold tolerances and the life stages of pests also vary in their cold tolerance. For these reasons (and because cold energy is free in winter in Canada) cold treatments, or freezeouts, have been well researched. For example, we know most pests found in Canadian grain will die in properly cooled storage facilities, the third instar Indianmeal moth is highly resistant, requiring over 14 days at -10°C or one day at -15°C. The rusty grain beetle is also highly cold tolerant and requires two weeks at grain temperature of -15°C, or six weeks at grain temperature of -10°C, or eight weeks at grain temperature of - 5°C.

Grain cooling in storage is accomplished by: forced air (fans), transferring grain from one bin to another, or transferring the grain to a truck and leaving it outside to cool for a few days before returning it to storage. When transfers are done, the grain is checked for infestation. At this time, surface infestations of moths, mites, and spider beetles, as well as infested patches are removed. Bulk surfaces are raked to break up the crust and assist grain drying.

CO_2 to control pests in grain elevators — Health and safety concerns about the use of phosphine, and marketing concerns about the use of other chemical treatments, has resulted in tests of CO_2 to control pests in grain elevators. Phosphine is still sometimes used on farm but its effectiveness under Canadian cold weather conditions is often poor. Grain elevator operators have concerns about the activation of phostoxin in the elevator with the arrival of warmer spring temperatures. Family farm operators also have health concerns about its use. Concern about phostoxin safety also becomes an economic problem when grain handlers at some major ports refuse to handle shipment treated with phosphine in transit.

To resolve this issue, researchers at the Cereal Research Centre, Winnipeg Manitoba, investigated CO_2 effectiveness and stability under Canadian grain handling, storage, and weather conditions. Modelling studies to characterize CO_2 movement and mechanism of action in various commonly used grain holding bins were completed by Winnipeg Research Centre and University of Manitoba researchers and tested on a commercial scale in Manitoba.

Pests exposed to high levels of CO_2 asphixiate. The key to effective treatment of grain is to find and maintain sufficient CO_2 concentration throughout the grain for the required time. Grain temperature must also be known and controlled since it affects the effectiveness of the treatment. Several effective combinations of CO_2 concentration, time and temperature have been found. Generally, under the relatively cool storage conditions found in Canada, a 60% concentration kills common stored grain pests in about one week. Carbon dioxide is not very effective below 10°C; however, control is seen at grain temperatures between 20–25°C. At higher temperatures, CO_2 is even more effective.

Diatomaceous earth (DE) — is a natural chalk-like substance composed of microscopic plant skeletons called diatoms. Diatomaceous earth provides continuing protection from grain pests. Diatomaceous earth is a safe registered food additive, and is removed from the grain during processing.

Past practices and less effective products required the use of excessive amounts of DE, resulting in equipment problems, test weight downgrading of grain, and other grain quality issues. After extensive research to characterize the diatomaceous earth types to find the best shape of diatoms, and adding a natural source synergist, Hedley Technologies Inc. a Canadian company, has registered a significantly improved diatomaceous earth (Protect-It™). Collaborative research between Hedley Technologies and Agriculture and Agri-Food Canada (Winnipeg Research Centre) led to the development and registration of the product. The amount of Protect-It™ required is significantly less than for previous products, thus avoiding previous problems.

6.3 Industry Resources

1. Hedley Technologies Inc.

Hedley Technologies Inc. is a life science company that develops, acquires and commercializes new agricultural technologies that safely meet the increasing demands of consumers and the environment. This company develops and supplies innovative natural products for protecting against insect contamination in the grain, food storage, handling, transportation, and processing industries. Hedley's stored grain protectant, Protect-It™ is a diatomaceous earth product that, when used in conjunction with IPM practices, offers an alternative to the use of fumigants such as methyl bromide. The powdered diatomaceous earth absorbs the waxy outer layer that protects insects causing them to dehydrate. Hedley works closely with government organizations and is currently involved in joint ventures in China and Pakistan.

Contact: Peter Ormesher, Chairman and CEO,
Hedley Technologies Inc. Mississauga, ON,
L4W 5B2 Tel: (905) 206-0013
Fax: (905) 206-1413 E-mail hedceo@ibm.net
Internet: http://www.hedleytech.com

2. Praxair (formerly Liquid Carbonic)

Praxair is the world's largest supplier of carbon dioxide. Carbon dioxide can be used as a fumigant to protect stored grains, nuts, and processed products against insect infection and fungal attack. Injected into storage facilities, CO_2 creates an atmosphere sufficiently low in oxygen to cause death by asphxiation of all stages and types of insects. It is a method that is both safe and cost-competitive compared to other chemical fumigants. Carbon dioxide has other advantages in that it is residue-free, retards bacterial growth, insects cannot develop resistance to it and it can be used in conjunction with chemical fumigants to enhance their effectiveness.

Contact: Robert Douglas, Praxair Canada Inc., 1 City Centre Dr., Suite 1200, Mississauga, ON, L5B 1M2, Tel: (905) 803-1748 Fax: (905) 803-1696 Internet: www.praxair.com

3. Adalia Preventive Services Ltd.

Adalia Preventive Services Ltd. is a company dedicated to protecting grain from the ravages of insects and pests. Research and development undertaken by Adalia resulted in the creation of proprietary and revolutionary new in-transit fumigation techniques. Adalia has developed a deep-probing fumigation technique designed to treat grain which has already been loaded into silos or ships. The fumigation is placed from the base of the cargo and rises gradually to the surface.

Contact: Denis Bureau, Adalia Preventive Services Ltd., 8685 Lafrenaie, St. Leonard, QC, H1P 2B6 Tel: (514) 852-9800 Fax: (514) 852-9809

Photo: Adalia Preventive Services Ltd.

6.4 Government Resources

1. Canadian Grain Commission

The CGC, a Special Operating Agency of the Government of Canada, is responsible for grain quality and grain handling. It is a self-sustaining agency, operating from the revenues generated by selling its services to the agricultural industry.

As a technology transfer partner, the CGC brings years of market support experience in the international grain industry, with proven expertise in cereal grains, coarse grains, oilseeds, and pulse crops; demonstrated experience in designing systems and implementing programs to suit individual market or grain handling environments using its system-wide resources, including grain inspectors and weighers, scientists and laboratory technicians, statisticians and documentation specialists.

The CGC has extensive experience with the national organizations responsible for grain quality and quantity control in many countries, including, Algeria, Brazil, Central America, Chile, Colombia, Cuba, Hungary, India, Indonesia, Italy, Iran, Japan, Malaysia, Mexico, People's Republic of China, Philippines, Russia, Saudi Arabia, South Korea, Syria, United Kingdom, United States, and Vietnam.

CGC offers training and expertise in the following areas:

- design and implementation of quality standards to meet end-use requirements,
- post-harvest quality management,
- grain policies, regulations, and related legislation,
- buyer contract specification and design,
- representative sampling,
- laboratory testing and analysis,
- infestation detection and control strategies,
- cleanliness and purity verification,
- quantity control and scale inspection,
- information and documentation services,
- grain quality certification, and
- integrated electronic data capture management.

International experience includes projects in Vietnam, focusing on mycotoxins in corn, including storage and handling, and testing methods; China in grain transportation logistics; Eritrea consulting in insect control and grain storage; Uruguay, for a grain grading, standards, and transportation project; China for training in modern grain storage methods and techniques; Romania for a grain quality workshop; Hungary, to improve the system of grain standards; Mongolia where the CGC consultant examined current agricultural practices; Central America to recommend grain standards; Kazakhstan to assess the viability of establishing a company which would

market Kazakh grain into hard currency markets, as well as supply inputs and expertise to farmers interested in this concept; and Romania to provide training in grain grading and standards.

Contact: G.F. (Rick) Morgan, Canadian Grain Commission, Business Group 600-303 Main Street, Winnipeg, MB, R3C 3G8
Tel: (204) 983-7905 Fax: (204) 983-2751
E-mail: rmorgan@cgc.ca Internet: www.cgc.ca

2. Cereal Research Centre, Agriculture and Agri-Food Canada, Winnipeg Manitoba

Research scientists at this research centre are responsible for pest detection and control and grain quality aspects. They improve prediction, prevention, detection, and control of storage problems of grain and grain products on farms, in grain eleveators, feed mills, flour mills, warehouses, and homes based on miltidisciplinary research. The relationships among insects, mites, microorganisms and mycotoxins in stored grain are emphasized and non-chemical prevention and control tactics are developed. Safe storage guidelines to prevent food contamination by pests and toxins are defined and the phsyical and handling properties of new crops and cultivars are determined to improve safety and efficacy of grain storage and movement after harvest.

Computer software to provide expert information for grain farmers and grain storage managers has been designed by the Cereal Reseach and the Department of BioSystems Engineering of the University of Manitoba. The program is designed to help farmers and grain handlers make wise management decisions by explaining grain management principles and techniques rather than simply dictating instructions.

The program works with information on initial grain conditions provided by the grain handler. Expected grain storage life is calculated and compared with the planned grain storage life. Recommendations for altering the grain moisture content or temperature are given to assist the grain handler to meet storage objectives. In the instance of pest infestations, information on pest identification, and control is provided. Pest risk analysis are presented based on information provided by the grain handler. Designed for cold weather climates, the developers of this expert system are capable of assisting other researchers to alter the program design to more closely fit the requirements of grain handlers in other climates.

The program is available at reasonable cost from the Cereal Research Centre, Agriculture and Agri-Food Canada. It requires Microsoft Windows Version 3.1 and at least a 486 cpu with 7MB of disk space and 4MB of RAM. A math co-processor is required to run the simulation models.

Contact: Dr. Paul Fields and Dr. Noel White, Agriculture and Agri-Food Canada, Research Branch, Cereal Research Centre, 195 Dafoe Rd. Winnipeg, MB, R3T 2M9
Tel: (204) 983-1468 (Fields) or
(204) 983-1452 (White) Fax: (204) 983-4604
Internet: http://www.cgc.ca

6.5 University Resources

1. University of Manitoba, Department of BioSystems Engineering and Faculty of Agricultural and Food Sciences

Researchers in this faculty study the diffusion, stability and sorption of CO_2 in stored wheat and heat transfer in stored grain as well as pressurization. They have validated mathematical models to explain the action of CO_2. Computer models and expert systems that support decisions for the design and management of grain storage ecosystems are being developed as are management guidelines for the aeration of stored grains in tropical and subtropical climates to optimize control strategies for near-ambient drying of wheat in prairie climate. Researchers also work on mathmatical models for fungal deterioration of stored grain, heat production, heat transfer and stored grain expert systems.

Contact: Dr. D.S. Jayas (Department of BioSystems Engineering) and Dr. W.E. Muir, University of Manitoba, Faculty of Agricultural and Food Sciences, Winnipeg, MB, R3T 2N2
Tel: (204) 474-6033 (Jayas) or
(204) 474-9660 (Muir) Fax: (204) 474-7512
E-mail: Digvir_jayas@umanitoba.ca

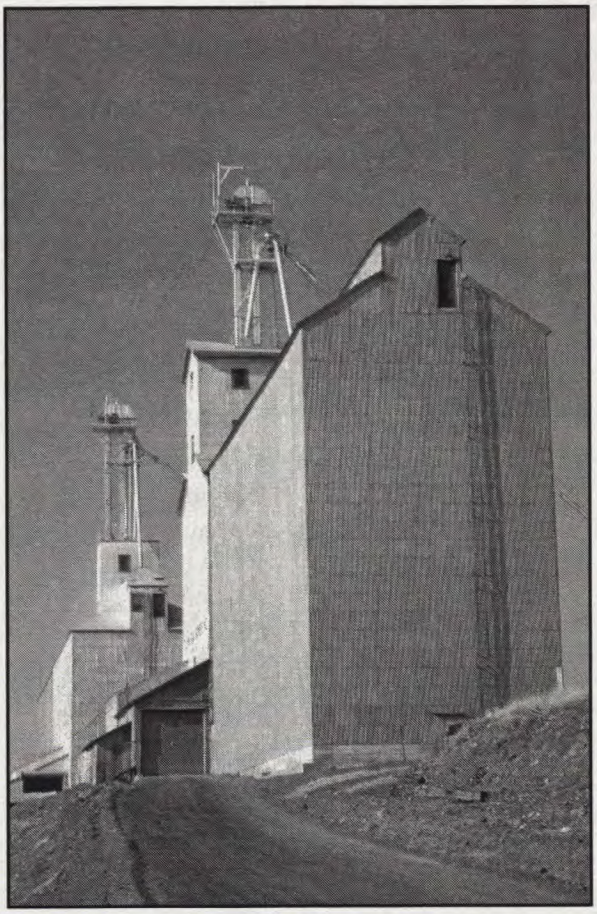
7. Food Processing Facilities

7.1 Focus on Canada

In late 1996, representatives of the Canadian food processing sector indicated a need for further development of methyl bromide alternatives for pest control in their industry. The Methyl Bromide Industry Government Working Group responded by setting up a subcommittee to identify and facilitate the adoption of alternatives focusing on integrated pest management (IPM) techniques. Integrated pest management IPM is a process that combines suitable prevention and treatment strategies to develop a sustainable and effective pest control regimen. There are many biological, physical, and chemical pest management products and techniques available for the food processing sector. However, there is unlikely to be one product or method to replace methyl bromide for all types of facilities.

Adopting IPM practices helps food processing facilities to control their pest problems using minimal chemicals. The steps involved in creating an IPM strategy prepared by the Methyl Bromide Industry Government Working Group are outlined in a Government of Canada publication entitled "Integrated pest management in food processing: Working without methyl bromide" (October, 1998).

To undertake an IPM strategy, the management of a food processing facility must go through a series of steps. These include assessment, development of a pest management plan, plan implementation, plan evaluation, and adjustments. A good plan considers building and materials design and retrofitting, exclusion practices, sanitation practices, building maintenance, inspections and monitoring, pest identification, and physical and chemical controls.



7.2 Methods of Pest Control in Food Processing Industries

In an IPM program, several types of pest control can be used depending on the type and extent of pest infestation and characteristics of the food processing facility itself. Pest control methods fall under the general categories of physical, mechanical, controlled atmosphere, and pesticide treatments. Methods include baiting and trapping for insects and rodents (including pheromone traps), use of natural and synthetic pyrethrins and organophosphates, exterior insecticide applications using synthetic pyrethroids, chlorpyrifos or diazinon, targeted

interior insecticide applications, phosphine gas, heat treatment, cold treatment, CO_2, diatomaceous earth, or a combination of methods.

Heat treatment — Most pests found in food processing facilities will die if exposed to a minimum of 50°C for an hour. Quaker Oats Canada has been using heat treatment as an effective pest control method for several years. Steam pipes deliver heat to heat exchangers that strip the heat off and distribute it by electric fan. Since there are tremendous variables affecting the delivery of the minimum temperature to all parts of the plant, and particularly to the floor level, a minimum temperature must be held for 24 hours (Marcotte, 1995). Quaker conducts heat treatments four to six times a year. Outfitting an existing plant for heat treatment can be very costly, although in some cases it may be possible to modify existing heating equipment. Building in heat treatment capability in a new facility is more cost-effective.

A number of Canadian milling and food processing sectors have expressed concern about the replacement of methyl bromide and other chemical fumigants with heat treatment. Heat treatment requires considerable capital investment and potentially higher operating costs. Two studies were done, in conjunction with Agriculture and Agri-Food Canada, on the effectiveness of heat treatment combined with other pest control techniques in food processing facilities.

Heat, phosphine and CO_2 — In 1996, a heat, phosphine, and CO_2 experimental structural fumigation was done through the Environment Bureau of Agriculture and Agri-Food Canada in conjunction with Environment Canada, the Methyl Bromide Industry Government Working Group, and representatives of the space fumigation and food processing sectors (Marcotte *et al.*, 1996). The testing took place at the Quaker Oats site in Peterborough, Ontario; a nine-story milling and processing facility. The building was sealed and the temperature was raised to 37°C, liquid carbon dioxide was gasified and piped in to provide a concentration of 4.3% and magnesium phosphide Fumi-Strips were distributed on several floors to provide an average 29.3 ppm phosphine. The kill rate for confused flour beetle adults and eggs exceeded 95%, a highly successful level. It was concluded that this new technique could be used as an adequate replacement for methyl bromide structural fumigation.

The issue of corrosive effects of phosphine, carbon dioxide, heat, and humidity on electronic equipment was addressed in another study (Brigham, 1998). In that study, four metals — silver, copper, brass and solder, were exposed to simulated fumigation parameters under carefully controlled steady-state laboratory conditions. Three temperatures, three concentrations of phosphine, four levels of relative humidity, two levels of CO_2, and three exposure times were tested. Weight gain and corrosion effects were studied and possible failure mechanisms for electronic equipment were identified to help the industry anticipate possible problems and avoid them. Further investigations are planned.

Enhanced diatomaceous earth and heat — A study was conducted in 1997 combining an enhanced diatomaceous earth (EDE) product with heat treatment for the control of insect pests in food processing facilities. This study was done by Fields, Dowdy and Marcotte for the Environment Bureau of Agriculture and Agri-Food Canada and the United States Department of Agriculture, as part of the Canada–United States Working Group on Methyl Bromide Alternatives.

Protect-It™, produced by Hedley Technologies Inc., was used in laboratory and commercial scale tests in conjunction with heat treatments. The heat treatment and EDE product had a synergistic effect; the insects died faster and at lower temperatures. Confused flour beetles (*Tribolium confusum)* were completely controlled in the Quaker Oats plant in Peterborough, Ontario by dry application of Protect-It™ after 13–22 hours or when temperatures reached 41°C. Insects that were exposed only to heat died after 32–38 hours or when temperatures reached 46–47°C. Quaker Oats has been successfully using heat treatment for pest control for over 15 years, despite the age of its

building and Canada's cold winters. A full copy of this report can be found on the internet at http://res.agr.ca/winnrecpub.htm

7.3 *Industry Resources*

1. Abell Pest Control

Abell Pest Control has always played a role in trying to utilize alternatives to methyl bromide. Through the Abell Plus program, designed around the food processing and distribution network, Abell Pest Control combines regulatory standards, their expertise and company personnel to implement IPM methods to eliminate pest problems. Abell has earned ISO 9002 certification in all aspects of their services and can offer the expertise, of staff entomologists, registered sanitarians, certified public health inspectors, and consulting microbiologists. Current clients include some of the Canadian food industries largest, most demanding processors and manufacturers. In addition to their Abell Plus program, Abell Pest Control has been instrumental in introducing both aluminium and magnesium phosphide to the Canadian marketplace. Abell is offering the Horn Generator, a new portable automatic tool for the production of hydrogen phosphide, on an experimental basis pending registration that is anticipated by the end of 1998. Hydrogen phosphide is an ideal product for pest control in food processing and storage facilities.

Contact: Brian Menard, VP Eastern Region,
246 Attwell Dr., Etobicoke, ON, M9W 5B4
Tel: (416) 675-1635 Fax: (416) 675-6727

2. The Canadian Pest Control Association (CPCA)

The CPCA is comprised of members from all of the Provincial Structural Pest Control Associations. The CPCA's mandate is to ensure that members are represented at the Federal government level and that lines of communication remain open. The CPCA is very concerned about environmental issues and takes an active role in education and the development of new technologies. In addition to chemical alternatives, CPCA is open to preventative and non-chemical methods of pest control. The CPCA has accepted the Montreal Protocol position on methyl bromide and recognizes that the association needs to be involved in the search for alternatives. Good Manufacturing Practices, environmental modifications, and alternative pesticides can all play a role in the methyl bromide phaseout.

Contact: Dean Stanbridge, Director of Government Affairs, Canadian Pest Control Association,
208 Glen Castle Rd., Kingston, ON, K7M 4N6
Tel: (613) 384-0898 Fax: (613) 389-3849
E-mail: elite1@kingston.net

3. Cooper Mill Ltd.

Cooper Mill Ltd. is one of the most experienced Canadian companies in the commercial supply of biological and chemical pest control products. During the past 15 years, the company has developed a well-established network of sales and distribution across Canada, and conducts on-going field testing of new products, before marketing them. In 1986, Cooper Mill Ltd. became the first company in Canada to set up commercial-scale trials involving pheromone mating disruption. This work was carried out in grapes against the Grape Berry Moth, and by 1992, it resulted in the first government registration approval for the use of a pheromone mating disruption system. Commercial use of this method is now well established in many Niagara vineyards. Concurrently with the mating disruption research, the company also began introducing pheromone monitoring systems into the professional structural Pest Control industry, since it was already well established in this sector as a supplier of insecticides. The company has now accumulated nine years of commercial experience with many different pheromone-related products, which, when added to many years of commercial pesticide experience, makes Cooper Mill Ltd. one of the leaders of Integrated Pest Management in the industry. Cooper Mill Ltd., which is also involved in limited international sales, has an enviable reputation for fast and reliable supply of products across Canada.

Contact: John Hastings, Cooper Mill Ltd.,
R.R. 3, Madoc, ON, K0K 2K0
Tel: (613) 473-4847 Fax: (613) 473-5080
E-mail: ipm@coopermill.com
Internet: www.coopermill.com

4. Demysh Group Inc.

Demysh Group Inc. produces explosion-proof thermal reactors that are useful for pest control in food processing facilities. They have been in operation for over 35 years.

Contact: Anthony Demysh, Demysh Group Inc., 2568 Royal Windsor Dr., Mississauga, ON, L5J 1K7, Tel: (905) 822-2966
Fax: (905) 823-6924

5. Food Safety Management Inc.

Mr. Livingston Clarke has spent over thirty years in the Canadian food processing industry occupying various positions in both the public and private sectors. He has acquired extensive experience and practical knowledge of food pest management and control, and was instrumental in establishing Canada's first two-year college program in Environmental Pest Management (at Sir Sanford Fleming College). Mr. Clarke has been a strong advocate of methyl bromide alternative technologies and in co-operation with both Environment and Agriculture and Agri-Food Canada and the Canadian pest control industry, he has played a leading role in the research and development of viable alternatives to methyl bromide that have world-wide applications.

Contact: Mr. Livingston Clarke, 1310 Hazeldean Ave., Peterborough, ON, K9J 5Z4
Tel: (705) 748-4619 Fax: (705) 748-0826

6. Gardex Chemicals Ltd.

Gardex Chemicals Ltd. is one of the leading suppliers of structural pest control products and equipment to the Canadian market. They are awaiting final registration of a magnesium phosphide product that will be marketed under the label "Magtoxin." Magnesium phosphide is an alternative to methyl bromide and will be available in Magtoxin, Fumi-cel, Fum Strip, Prepac Spot Fumigant and Granules. The Magtoxin Granules will be used in conjunction with the Horn Phosphine Generator (see Abell Pest Control). Magnesium phosphide is effective for control of pests in stored grain, processed foods, feeds, and non-food commodities such as tobacco.

Contact: Karen Furgiuele, Vice President, Gardex Chemicals Ltd., 7 Meridian Rd., Etobicoke, ON, M9W 4Z6
Tel: (416) 675-1638 Fax: (416) 798-1647
E-mail: kfurgiuele@gardexinc.com
Internet: www.gardexinc.com

7. Hedley Technologies Inc.

Hedley Technologies Inc. is a life science company that develops or acquires and commercializes new agricultural technologies that safely meet the increasing demands of consumers and the environment. Hedley Technologies Inc. develops and supplies innovative natural products that protect against insect contamination in the grain and food storage, handling, transportation, and processing industries. Hedley's stored grain protectant, Protect-It™, is a diatomaceous earth product that when used in conjunction with IPM practices, offers an alternative to use of fumigants such as methyl bromide. The powdered diatomaceous earth absorbs the waxy outer protective layer of insects causing them to dehydrate. Hedley works closely with government organizations and is currently involved in joint ventures in China and Pakistan.

Contact: Peter Ormesher, Chairman and CEO, Hedley Technologies Inc., Mississauga, ON, L4W 5B2, Tel: (905) 206-0013
Fax: (905) 206-1413 E-mail: hedceo@ibm.net
Internet: http://www.hedleytech.com

8. PCO Services

PCO Services is one of Canada's largest providers of pest control programs and systems. Through their network of technicians and offices, PCO Services provides full service integrated pest management programs across Canada. PCO Services has been involved in the Industry-Government Working Group on Methyl Bromide Alternatives for several years and were key members of the research team investigating new structural pest control technologies with the Working Group (see Marcotte *et al.*, 1996). Combined with PCO Services' sister company, Prism, in the United States (owned and operated by SC Johnson Professional), is provided throughout North America.

Contact: Bernie McCarthy, PCO Services,
5840 Salbourne St. Mississauga, ON,
L5R 3L8, Tel: (905) 502-9700
Toll-free: 1-800 PCO PEST (726-7378) in Canada
Fax: (905) 502-9510 Internet: www.pco.ca

9. Phero Tech Inc.

Phero Tech Inc. manufactures and distributes a wide variety of products for environmentally sound management of insects and mammals. Phero Tech Inc. has a product line that includes insect control strategies for the forestry, agricultural, greenhouse, and structural pest control sectors. Products such as insect pheromone trapping systems allow for more informed pest management decisions. Product quality and valuable technical support are among Phero Tech's strengths.

Contact: Julie McCarthy, PheroTech Inc.,
7572 Progress Way, Delta, BC, V4G 1E9
Tel: (604) 940-9944 Toll-free: 1-800-665-0076
Fax: (604) 940-9433 E-mail: sales@pherotech.com
Internet: http://www.pherotech.com/

10. Praxair Canada Inc. (formerly Liquid Carbonic)

Praxair is the world's largest supplier of CO_2. Carbon dioxide can be used as a fumigant to protect stored grains, nuts, and processed products against insect infection and fungal attack. Injected into storage facilities, CO_2 creates an atmosphere sufficiently low in oxygen to cause death by asphyxiation of all stages and types of insects. It is a method that is both safe and cost-competitive compared to other chemical fumigants. Carbon dioxide has other advantages in that it is residue-free, retards bacterial growth, insects cannot develop resistance to it, and it can be used in conjunction with chemical fumigants to enhance their effectiveness.

Contact: Robert Douglas, Praxair Canada Inc.,
1 City Centre Dr., Suite 1200,
Mississauga, ON, L5B 1M2
Tel: (905) 803-1748 Fax: (905) 803-1696
Internet: www.praxair.com

11. Professional Pest Consultants Inc. (Pro-Pest)

Pro-Pest focuses on proactive pest control techniques such as good manufacturing practices (GMP), environmental modifications, pheromone monitoring, spatial analysis, and DNA fingerprinting and bar coding for data collection. Combined, these tools and techniques allow Pro-Pest to assist food processing facilities to successfully eliminate their methyl bromide use. Pro-Pest is interested in supplying their technology and expertise in methyl bromide alternatives on an international level. Dean Stanbridge is Vice President of Pro-Pest as well as the Director of Government Affairs for the Canadian Pest Control Association.

Contact: Dean Stanbridge, Box 246,
348 Bronte St. South, Units 9 & 10,
Milton, ON, L9T 4N9
Tel: (905) 878-8468 Fax: (905) 878-9223

Photo: Professional Pest Consultants Inc.

12. RUFFNECK Heaters (Division of Starozik Industries Ltd.)

RUFFNECK Heaters, an ISO 9002 registered quality system company, was incorporated in 1975 and has become recognized as a high quality manufacturer leading the way in the industrial heating market. RUFFNECK's industrial grade unit heaters were originally developed to satisfy the demanding requirements of the oil and gas well drilling industry. The harsh operating conditions of this application required the utmost in heater reliability.

The unique design features and rugged, quality construction details that made RUFFNECK heaters the choice of the oil and gas industry, are also appreciated by other heavy-duty industries throughout the world. These include: pulp and paper, mining, food processing, wastewater treatment, steel, and chemical and hazardous material storage facilities.

With the approaching deadline of the Montreal Protocol and the elimination of methyl bromide in the food processing industry, RUFFNECK Heaters is developing both explosion-proof and nonexplosion-proof steam unit heaters that will be able to withstand the rigorous duties required to operate in a heat treatment process for food processing facilities. The heater will feature an anti-fouling core and a high heat resistant motor.

RUFFNECK's business philosophy is to concentrate on what they know best, provide the best possible service, and supply good quality products at competitive prices.

Contact: Alan LeBrun, RUFFNECK Heaters,
2827 Sunridge Blvd. NE,
Calgary, AB, T1Y 6G1
Tel: (403) 291-5488 Fax: (403) 291-7042
Toll-Free: 1-800-661-8561 (US and Canada)
E-mail: alanl@ruffneckheaters.com
Internet: www.ruffneckheaters.com

7.4 Government Resources

1. Health Canada — Pest Management Regulatory Agency (PMRA)

The PMRA is a Canadian regulatory agency widely respected in Canada and abroad for the quality of its decisions and its commitment to sustainable practices. Its mission is to protect human health and the environment by minimizing the risks associated with pest control products, while enabling access to pest management tools.

The PMRA has just published a working tool for the food processing industry entitled "Integrated pest management in food processing: Working without methyl bromide" (Sustainable Pest Management Series S98-01). This document outlines complete integrated pest management strategies for the industry and is available by contacting the Publications Co-ordinator at the Pest Management Regulatory Agency.

Contact: Pest Management Regulatory Agency,
Health Canada, 2250 Riverside Dr., A.L. 6606D1,
Ottawa, ON, K1A 0K9 Tel: (613) 736-3799
Toll-free: 1-800-267-6315 Fax: (613) 736-3666
E-mail: pminfoserv@pmra-arla.hc-sc.gc.ca
Internet: http://www.hc-sc.gc.ca/pmra-arla

2. British Columbia — Ministry of Environment, Lands and Parks

Integrated Pest Management Manual for Structural Pests in British Columbia:

A manual was prepared to help structural pest control operators in British Columbia adopt an Integrated Pest Management approach. It describes the basic principles of IPM as they apply to structural pests and gives examples of IPM programs for pests such as ants, cockroaches, fleas, stored products pests, silverfish and firebrats, rodents, termites, powderpost beetles, and birds.

There is a chapter on preferred pesticides, such as borates, sorptive dusts, botanicals and insect growth regulators. Chapters also describe other commonly used pesticides in the structural industry and precautions for using them. Published in 1996, this 108 page publication was co-authored by L.A. Gilkeson and R.W. Adams.

Available from: Office Products Centre, 4248 Glanford Ave., Victoria, BC, V8Z 4B8 Tel: 1-800-282-7955 Fax: (250) 952-4442 Cost CDN $15.00. Cheques, money orders, Visa, Mastercard orders accepted. Orders are mailed via Canada Post, with normal delivery in BC in 5 days; urgent orders can be couriered.

Integrated Pest Management Information System (IPMIS) is an electronic library of information on integrated pest management in agriculture, landscapes, buildings, homes, gardens, right-of-ways, and other locations. Topics include identification, monitoring and prevention of pests, using least-toxic controls, biological controls, pesticide safety and other pest management related subjects. Co-funding for this BC Environment project has been contributed by the Canada-British Columbia Green Plan for Agriculture, Environment Canada, and Agriculture and Agri-Foods Canada. IPMIS is found at: http://pupux1.env.gov.bc.ca/~ipmis/ipmis.html

8. Methyl Bromide Recovery and Recycling

8.1 Focus on Canada

Methyl bromide has been applied both as a regular treatment for pest control in agriculture and as an emergency measure. Half of Canada's total consumption of methyl bromide is for the control of pests in structures and product transport vehicles (Fields *et al.*, 1997). Other countries have used methyl bromide to a much smaller degree than Canada for these purposes.

Canada has made a commitment to phase out methyl bromide use by the year 2001, except for pre-shipment and quarantine fumigations. These exemptions will not necessarily be in place indefinitely and indeed although these exemptions are in place, venting into the atmosphere does not fall into the spirit of the Protocol. A proposal has already been put forward by several countries that the Montreal Protocol review these exemptions.

Methyl bromide emissions fall under two categories. There are inadvertent emissions due to leakage and permeation, and intentional emissions that result from venting at the end from of a fumigation treatment. Total emissions will depend on a number of factors including local environmental conditions, characteristics of the fumigated material and the facility, and chemical reactions that occur during use. Emissions from agricultural and related uses range from approximately 40–85%.

Containment methods for methyl bromide emissions are in limited use world-wide. Collection of methyl bromide depends on how gastight the fumigation containers are. In facilities where fumigation is done on perishables for quarantine purposes, the level of gas tightness is high, making them more amenable to methyl bromide recapture.

8.2 Industry Resources

1. Knowzone Solutions Inc. and Cryo-Line Supplies, Inc.

Cryo-Line Supplies, in conjunction with Knowzone Solutions, has developed a recovery system for methyl bromide. The system is based on a molecular sieve that selectively recaptures methyl bromide molecules from the exhaust stream, after fumigation. Ozone-damaging emissions can be reduced by more than 75%.

Tests of the Knowzone/Cryo-Line methyl bromide recapture and recovery system were undertaken in 1998 at Quality Hardwoods in Powassan and Abell Pest Control in Mississauga, Ontario. The purpose was to examine the potential for methyl bromide recovery from a kiln, after pre-shipment fumigation treatment of hard wood before exportation. For the purposes of the kilns were empty during testing. The portable collecting cylinders were transported to the Abell site and connected to the recycling unit. Heated air was circulated through the cylinders releasing the methyl bromide. Methyl bromide was collected in the recaptured unit, passed through dryers and recondensed into a liquid form for rebottling. The absorption capacity of zeolite and carbon were compared in the tests. After 90 minutes, carbon absorbed 40% of the methyl bromide gas that had been released into the kiln, while zeolite had absorbed 75%.

The current design of the Knowzone/Cryo-Line methyl bromide recycling system consists of a series of stainless steel cylinders that contain enough zeolite to adsorb 25 pounds of methyl bromide. The number of cylinders used in a fumigation operation is

therefore flexible, depending on the amount of gas used. The cylinders are transported to a reclamation site where the methyl bromide is desorbed, purified, and tested before rebottling in a format that the fumigators find familiar to work with.

The reclamation unit is the centrepiece of Knowzone/Cryo-Line's technology. In the 1998 test, the unit was found to successfully desorb all of the methyl bromide captured from the kiln. Knowzone/ Cryo-Line's system is attractive because it is flexible, efficient, cost-effective, and easy to handle. Further testing is required to determine purity of the recovered methyl bromide, potential for use on perishable commodities and effectiveness in other climates, particularly where high humidity is a factor.

Contacts: Errick (Skip) Willis, Knowzone Solutions Inc., 288 Mill Rd., Unit C32, Etobicoke, ON, M9C 4X7
Tel: (416) 622-7920 Fax: (416) 622-6723 and
Murray Weightman, Cryo-Line Supplies Inc. 3100 Ridgeway Dr. Unit 28, Mississauga, ON, L5L 5M5
Tel: (905) 608-2919 Fax: (905) 608-2926
Internet: www.ceia.on.ca/memberprofiles/cryo.htm

9. *Methyl Bromide Alternatives—Expertise in Canada*

There are a number of individuals, companies, and organizations in Canada that are knowledgeable in the area of methyl bromide alternatives. Some of these companies are listed in the preceding chapters. The people and organizations that follow either work in more than one agri-food sector, or have expertise that does not fit under previous chapter headings. They are interested in working with organizations and companies nationally and internationally to facilitate of methyl bromide phaseout.

Besides the government resources listed in the preceding chapters, other bureaus and directorates within the government are listed that are key resources for agriculture, agri-food business, research, and other issues related to methyl bromide alternatives.

9.1 Industry Resources

1. ConsultAsia Inc.

Arlyle Waring is an international development and trade specialist working with Canadian industry, Canadian government departments, the World Bank, and the Asian Development Bank in China and other Asian countries. Ms. Waring has studied and worked in China since 1979. Her major specialty is technology transfer and joint ventures in the environmental sector. Ms. Waring undertook the first Department of Foreign Affairs and International Trade (DFAIT) survey, *Opportunities for Canadian Companies in the Environmental Sector in China* in 1985, and continues to work with private companies, government departments and IFI's in the environmental sector in China. In 1984 and 1995 she prepared Guide toTechnology Transfer in the People's Republic of China for DFAIT. Ms. Waring's experience related to methyl bromide includes the preparation of *Summary Report: Potential Projects for Non-Chemical Alternatives to Methyl Bromide in Selected Asian Countries* for FOE/UNEP, a study, *Desk Study: Methyl Bromide Use in China* for Friends of the Earth Canada/IDRC, participation in discussions on the sector strategy for methyl bromide in China with Environment Canada, UNEP and the National Environmental Protection Agency of China, and coordination of a research publication *Case Studies: Methyl Bromide Use in Costa Rica, Chile, and Mexico* for Friends of the Earth Canada.

Contact: Arlyle Waring, Suite 208,
5764 Monkland Avenue,
Montreal, QC, H4A 1E9
Tel: (514) 488-2588 Fax: (514) 488-3588
E-mail: arlyle.waring@eudoramail.com

2. Forsyth Consulting Essentials

Sheila Forsyth of Forsyth Consulting Essentials has been active in policy analysis, research, and input for environmental and agricultural groups in Canada on methyl bromide and other toxic chemical issues. This includes the preparation of a practical guide to Canadian research, alternative product suppliers, and other sources of information on methyl bromide for Friends of the Earth Canada. Sheila has been involved in the development of funding proposals under the Multilateral Fund on behalf of the United Nations and in co-operation with developing countries, for demonstration projects to reduce the use of methyl bromide.

Contact: Sheila Forsyth, Forsyth Consulting Essentials, Box 558, Metcalfe, ON, K0A 2P0
Tel/Fax: (613) 821-3163
Alternate telephone: (613) 821-4442
E-mail: naecfors@magi.com

3. Friends of the Earth Canada

Friends of the Earth Canada is an nongovernment environmental organization involved in public policy and education on the phaseout of methyl bromide. This organization is part of an international network of organizations in 58 countries.

Contact: Bea Olivastri, Friend's of the Earth, 47 Clarence St., Suite 306, Ottawa, ON, K1N 9K1 Tel: (613) 241-0085

4. ICF Kaiser Consulting Group

ICF Kaiser has been offering methyl bromide consulting services in the areas of evaluation of alternatives to methyl bromide, assessment of cost effectiveness, determination of treatment efficacy and preparation of descriptions of alternative technologies for more than five years. This group maintains a data base of stakeholders, has prepared more than 40 case studies on alternatives to methyl bromide, and facilitates Article 5 (1) country participation in workshops and conferences. In terms of technical assistance projects, ICF Kaiser has been involved in the preparation of project proposals for submission to Multilateral Fund and the identification and evaluation of investment projects.

Contact: Abyd Karmali, Project Manager, ICF Kaiser Consulting Group, 90 Richmond St. East, Suite 201, Toronto, ON, M5C 1P1
Tel: (416) 363-1250 Fax: (416) 363-1895
E-mail: akarmali@icfkaiser.com

5. The LRS Group

The LRS Group (Loss Reduction Strategies) was founded in response to the need for preserving global food resources. The primarily aim of the LRS Group is to facilitate consultation and education in the field of stored product protection and food processing, including the commercialization of technologies when and where appropriate. The group acts as an umbrella organization, employing the services of professional consultants from government, industry, and universities for specific projects. LRS projects are aimed at identifying and resolving problems at a regional or national level and seek to find lasting solutions. Most projects involve local experts, follow-up recommendations and progress reviews.

Contact: The LRS Group can be contacted through Chris Van Natto, Hedley Technologies Inc. 2600 Skymark Ave., Suite 101, Building 4, Mississauga, ON, L4W 5B2
Tel: (905) 206-0013 Fax: (905) 206-1413

6. Manitoba Ozone Protection Industry Association (MOPIA Inc.)

MOPIA is a "not-for-profit" association that was appointed to assist the Minister of the Environment (Manitoba). Part of MOPIA's mandate, is to provide information and infrastructure for industry and the public to comply with Manitoba's regulation and innovative stratospheric ozone protection program that allows for the phaseout of ozone-depleting substances. MOPIA was created in 1993 by a group of individuals from various associations, companies, groups, and government institutions and operates successfully through the efforts of volunteers from across the province. While they are most active on the provincial front, they are involved in some issues on national and international levels. MOPIA is presently looking at establishing a working group for methyl bromide phaseout.

Contact: Mark Miller, MOPIA Inc., 2141-B Henderson, Hwy., Winnipeg, MB, R2G 1P8
Tel: (204) 338-0804 Fax: (204) 338-0810
Toll-free: 1-888-mopia-03
E-mail: mopia@mb.sympatico.ca
Internet: www.mts.net\~mopia\mopia.htm

7. Marcotte Consulting Inc.

Marcotte Consulting provides services to assist industry, governments and other organizations to improve competitiveness and prosperity. They aid market development for new technologies and new products through technology assessment, regulatory development, research co-ordination, market strategies, and consumer, media, and industry communications. Michelle Marcotte has over twenty

years experience guiding companies through market development issues. She is a member of the United Nations Environment Program Methyl Bromide Technical Options Committee and provides leadership within Canada in the development and assessment of pest control technologies that provide alternatives to methyl bromide. Michelle's governmental and regulatory affairs experience with clients in Canada, the United States, Australia, the United Kingdom, and Japan enables her to provide representation to government and strategic corporate development advice to clients in the international business community.

Contact: Michelle Marcotte, Marcotte Consulting Inc., 443 Kintyre Private, Ottawa, ON, K2C 3M9
Tel: (613) 727-1469 Fax: (613)727-8541
E-mail: marcotte@magi.com

9.2 Government Resources

1. Canadian Food Inspection Agency (CFIA)

Canada has one of the world's best food inspection systems. All federally mandated food inspection and quarantine services were consolidated into the Canadian Food Inspection Agency in the spring of 1997. The purpose of the consolidation into a single agency was to enhance food safety systems by integrating the delivery of inspection and quarantine services previously provided by Agriculture and Agri-Food Canada, Health Canada, Industry Canada, and the Department of Fisheries and Oceans Canada. Canada has a strong national and international reputation for safe, high-quality food products on which the prosperity of the food sector depends. The goal of the CFIA is to help build a thriving and competitive agri-food and seafood industry by monitoring the health, safety, and quality of Canadian products and by overseeing the arrival of food products from around the world into the Canadian domestic marketplace.

Contact: Canadian Food Inspection Agency,
59 Camelot Dr., Nepean, ON, K1A 0Y9
Tel: (613) 225-2342 Fax: (613) 228-6634
Internet: www.cfia-acia.agr.ca

2. Environment Bureau — Agriculture and Agri-Food Canada

The Environment Bureau of Agriculture and Agri-Food Canada is involved in policy, research, partnership development, and international protocol negotiations in the area of methyl bromide phaseout. It is the focal point for environmental analysis and activities within Agriculture and Agri-Food Canada for and information and advice in the area of environmental sustainability for the agriculture and agri-food sector. The Department, through its Environment Bureau, ensures the views of the agriculture and agri-food sector are represented during the development of domestic or international environmental legislation or protocols.

The Environment Bureau co-chairs the Canadian Industry-Government Working Group on Methyl Bromide Alternatives. It also co-chairs the Canada/United States Industry–Government Working Group on Methyl Bromide Alternatives.

Contact: Sheila Jones, Policy Branch, Environment Bureau, Sir John Carling Bldg., 930 Carling Ave., Room 367, Ottawa, ON, K1A 0C5
Tel: (613) 759-7300 Fax: (613) 759-7238
E-mail: jonessh@em.agr.ca

3. Environment Canada

Within Canada, Environment Canada is the lead department for environmental issues, including development of domestic regulations, negotiations under the Montreal Protocol, funding under the Multilateral Fund, bilateral projects, and technology transfer projects. Responsibility for these programs is covered by several directorates within the Department. Inquiries addressed to the following contact person will be directed to the best directorate for response.

Contact: Bernard Madé, Commercial Chemicals and Evaluation Branch, Environment Canada,
351 St. Joseph Blvd. Hull, QC, K1A 0H3
Tel: (819) 994-3249 Fax: (819) 953-4936

4. Expert Committee on Integrated Pest Management (ECIPM) — The Pest Management Research Report (PMRR)

One of the objectives of the ECIPM is to facilitate the exchange of information on integrated pest management (IPM) among persons involved in research and advisory services on IPM of insect pests and plant diseases of importance to the agri-food industry in Canada. The Pest Management Research Report (PMRR) is an annual compilation of recent field research results on materials, strategies and methods for the management of plant diseases and insects and related pests of crops and farm animals. The 1- to 2-page research reports are peer-reviewed and are available to support the registration of pest control products and devices as well as to develop recommendations for insect and disease management programs. Authors include federal and provincial government, university and industry research and advisory personnel. Reports for 1995, 1996, and 1997 can be downloaded from the internet.

Contact: Stephanie Hilton, Pest Management Research Report, Agriculture and Agri-Food Canada, Southern Crop Protection and Food Research Centre, 1391 Sandford St., London, ON, N5V 4T3
Tel: (519) 457-1470 ext. 218 Fax: (519) 457-3997
E-mail: hilton@em.agr.ca
Internet: http://res.agr.ca/long/pmrc/report/

5. Industry Canada

Through its Environmental Affairs Branch, Industry Canada promotes the development and expansion of environmental technologies including alternatives to methyl bromide. Industry Canada facilitates the identification and growth of companies and individuals that have techniques, products, and services to offer. This allows Canadian companies to expand their operations domestically and internationally. Linda Dunn of the Environmental Affairs Branch is a member of MBTOC.

Contact: Linda Dunn, Environmental Affairs Branch, Industry Sector, 235 Queen St., 7th Floor East, Ottawa, ON, K1A 0H5
Tel: (613) 952-4081 Fax: (613) 954-3419
E-mail: dunn.linda@ic.gc.ca

Industry Canada's Canadian Environmental Solutions (CES) is an award-winning multimedia tool available on CD-ROM, diskettes and the Internet. Containing over 1500 environmental problems, 2000 solutions, and 700 company descriptors, CES addresses problems related to water, air, soil, energy, and research and development in several industry sectors including food and agriculture. Canadian Environmental Solutions is available for free on the internet or can be purchased on CD-ROM ($74.89) or diskettes ($42.79).

Contact: Wai Fai Lee, Industry Canada, Environmental Affairs Branch, CES, Room 725A, 235 Queen St., Ottawa, ON, K1A 0H5
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E-mail: lee.waifai@ic.gc.ca
Internet: http://strategis.ic.gc.ca/ces

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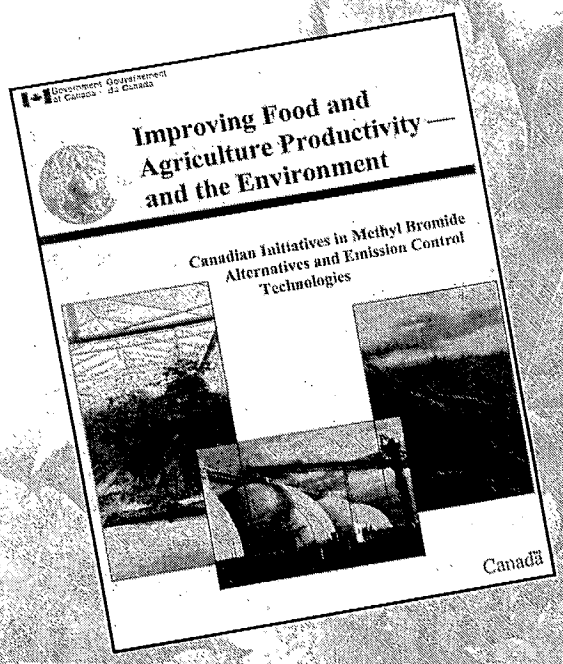

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Canadian Initiatives in Methyl Bromide Alternatives and Emission Control Technologies

Methyl bromide is an ozone-depleting substance regulated under the Montreal Protocol. The elimination of the use of methyl bromide in agricultural production has been a challenge to the Canadian agri-business. However, in recognition of the fact that prevention of further environmental damage to the ozone layer is paramount — Canada's approach has been to embrace this challenge and work towards ensuring that our agricultural sector develops in an environmentally sustainable manner.

The aim of this document is to provide a comprehensive overview of the alternative solutions that Canadian policy makers, researchers and industry representatives have formulated and tested to date as replacements for the use of methyl bromide.

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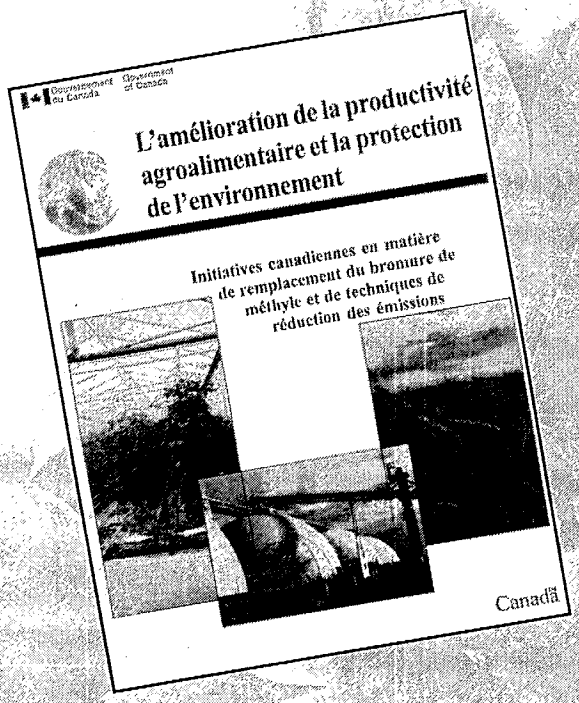

L'amélioration de la productivité agroalimentaire et la protection de l'environnement

Initiatives canadiennes en matière de remplacement du bromure de méthyle et de techniques de réduction des émissions

Le bromure de méthyle est une substance appauvrissant la couche d'ozone réglementée dans le cadre du Protocole de Montréal, et son élimination de la production agricole a été un défi pour les entreprises de l'agri-négoce. Toutefois, reconnaissant qu'il est essentiel d'empêcher que l'environnement ne se détériore davantage, les Canadiens se sont employés à relever le défi et à travailler ensemble pour que le secteur agricole se développe sans nuire à l'environnement.

L'objet de ce document est de donner un aperçu des solutions que les décideurs, les chercheurs et les représentants de l'industrie du Canada ont formulées et mises à l'essai jusqu'à présent pour remplacer le bromure de méthyle.

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