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Alternatives to Methyl Bromide: Selected Case Studies

2001: Canadian Leadership in the Development of Methyl Bromide Alternatives

Canada

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Front cover photos
Top: Pre-planting treatment of field with washed sand using a big A spreader.
Bottom: Roll floor in flour mill.

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Foreword

The *Montreal Protocol on Substances that Deplete the Ozone Layer* is a global agreement aimed at protecting the ozone layer by reducing the production and consumption of ozone-depleting substances. Under the Montreal Protocol, participating nations have agreed to a complete phase-out of the non-quarantine use of methyl bromide. For developed nations (including Canada and the United States) the phase-out date is 2005 (this includes Canada and the United States) and for developing nations 2015.

Reduction in the use of methyl bromide has resulted in an urgent need to develop alternatives methods of pest and weed management.

This report provides an assessment of the current agricultural use of methyl bromide and alternatives in Canada, and outlines Agriculture and Agri-Food Canada's (AAFC) strategy regarding its phase-out. It also presents the results of the June 2000 survey and case studies of selected users who have successfully implemented methyl bromide alternatives.

To maximize research collaboration and the development of alternatives, two working groups were set up in the mid-1990s: a Canadian government/industry working group, and a Canada/U.S. working group, the latter comprised of Agriculture and Agri-Food Canada and the United States Department of Agriculture (USDA). Since 1996, these two groups have collaborated on laboratory experiments and other research projects, many of which have been documented in written reports. These reports are listed at the end of this paper.

Through government research programs and commercial development of alternative technologies and products we have made excellent progress. This work will continue to ensure good control of pests and plant diseases in agriculture and food processing.

On behalf of Agriculture and Agri-Food Canada, I would like to extend our appreciation to the companies and farmers presented in the case studies for generously giving their time and expertise. I would also like to thank the Canadian Joint Industry-Government Working Group on Methyl Bromide Alternatives for their contribution.

Yaprak Baltacioglu
Assistant Deputy Minister
Strategic Policy Branch
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Executive Summary

- The *Montreal Protocol on Substances that Deplete the Ozone Layer* is an international agreement that responds to the thinning of the stratospheric ozone layer. In 1992, parties to the Montreal Protocol recognized methyl bromide as an ozone depleting substance responsible for up to 10% of the depletion of the ozone layer. In 1997, developed nations that were parties to the Montreal Protocol agreed to a phase-out schedule requiring methyl bromide reductions of 25%, 50%, 70% and 100% by January 1, 1999, 2001, 2003, and 2005, respectively.

- In response to methyl bromide's classification as an ozone depleting substance, the Government of Canada conducted broad consultations with industry, research organizations and environmental experts in Canada and in the U.S. The objective of these consultations was to develop a solution that would protect the environment, while minimizing the economic impact that eliminating methyl bromide would have on the agriculture and agri-food sector.

- In 1995, the government established the Canadian Joint Industry–Government Working Group on Methyl Bromide Alternatives to identify obstacles, propose solutions and disseminate information.

- Marcotte Consulting Inc., on behalf of Agriculture and Agri-Food Canada carried out a survey to identify and interview allowance holders who had successfully implemented alternatives to methyl bromide.

- The survey showed that 72% of allowance holders were growers and 38% were space users.

- The survey also revealed that all the space users and 83% of the growers were aware of the impending phase-out of methyl bromide, although a few allowance holders still misunderstand the impact of methyl bromide on the environment and the mechanism by which it harms the ozone layer.

- A number of growers with large allowances indicated that they were transferring their quota to other users. As a result, much of the transferred quota left the farm and was used for space fumigation.

- Recent changes to the Canadian Environmental Protection Act (CEPA) have assisted in the transfer mechanism by establishing a Web site (http://www.ec.gc.ca/CEPARegistry/Permits/ozone.cfm) listing allowance holders and their quotas.

- In all, 73% of growers responded to the survey. According to the survey results, 23% of large allowance holders are still using their quota, compared to 40% and 37% for medium and small holders, respectively. Growers' motivating reasons for finding alternatives to methyl bromide were: an increased cost of methyl bromide, negative environmental impacts, regulatory prohibitions and lack of availability of applicators. Of those growers who still used methyl bromide, the majority stated that there were no adequate competitive alternatives.

- For greenhouses, alternatives used were soil-less mediums, commercially sterilized soil, bleaching/shade cloth/hand-weeding, hand-weeding and steam or heat.
- Since the 1990s, greenhouse users have been moving towards soil-less mixes or pre-purchased sterile soil using a variety of integrated pest management measures, biological control agents and sanitation measures.
- The field growers' alternatives to methyl bromide were: 11,3-dichloropropene, metam sodium, 1,3-dichloropropene, post-emergence herbicides, insecticide/plastic culture/hand-weeding.
- Many field growers have found adequate control using chemicals, primarily 11,3-dichloropropene or 11,3-dichloropropene-metam sodium mix.
- This report presents three case studies of growers who have adopted pest management systems that minimize or eliminate the use of methyl bromide.
- Potential drawbacks of using alternative chemical fumigants include the fact that they are restricted in their application and that they may only provide limited long-term disease control.
- 69% of space users were still using methyl bromide.
- The space users' suggested alternatives to methyl bromide were: Integrated Pest Management (IPM), phosphine, sanitation, heat, carbon dioxide, CO2/phosphine/heat combination, diatomaceous earth (DE), pyrethrins, IPM/pheromones/UV light/sanitation and ethylene oxide.
- Changes to traditional pest management practices in the flour-milling sector were necessary because of the imminent phase-out of methyl bromide and new regulations on pesticide use.
- This has resulted in the development of an Integrated Pest Management Strategy, which takes a holistic approach using biological, cultural, physical, mechanical and chemical methods to manage pest problems in a more environmentally sound and cost-effective manner.
- This report presents three case studies of space users. Two case studies present companies that have developed an integrated pest management strategy in-house. One study presents a pest management professional whose clients include a mix producer and a flourmill.
- Some growers and space users find that the alternatives to methyl bromide now available do not meet their needs and that they require more information about other existing alternatives. In response to their need, the Department of Agriculture and Agri-Food Canada (AAFC) prepared this report, and is creating an interactive Web site and information clearinghouse for methyl bromide users.

Introduction

Objective
The purpose of this document is to provide an assessment of the current status and use of methyl bromide, and its alternatives, in Canada. The document also outlines the Federal Government's strategy regarding its plan to phase-out the use of methyl bromide. It presents the results of a June 2000 survey of allowance holders, and case studies of various users who have successfully implemented methyl bromide alternatives. This document is a tribute to the successful collaboration and cooperation between the stakeholders and government, and illustrates the need for continued work together.

Background
Methyl bromide is a broad-spectrum gas used predominantly as an agricultural fumigant to control pests in soils, structures, and commodities. Methyl bromide can be injected into the soil, sterilizing it and providing effective control of a wide variety of insects, weeds and diseases. Structures and commodities have been routinely fumigated to control and eliminate pest infestations, and meet the phytosanitary requirements of importing countries. Although the quantities used in Canada are small, they represent significant economic activity.

The Montreal Protocol
Created in 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer is an international agreement that responds to the thinning of the stratospheric ozone layer. In 1992, parties to the Montreal Protocol recognized methyl bromide as an ozone depleting substance responsible for up to 10% of the depletion of the ozone layer. In 1997, developed nations that were parties to the Montreal Protocol agreed to a phase-out schedule requiring methyl bromide reductions of 25%, 50%, 70% and 100% by January 1; 1999, 2001, 2003, and 2005, respectively. Developing nations have agreed to cap consumption at 2002 levels, with a complete phase-out by 2015. The parties to the Montreal Protocol have agreed on some exemptions to these phase-out schedules. The exemptions include: quarantine and pre-shipment uses, and critical and emergency uses. Financial assistance for projects that test or adopt alternatives to methyl bromide is available to developing countries that are signatory to the Montreal Protocol through the Multi-Lateral Fund (MLF).

Management of Methyl Bromide in Canada
In response to methyl bromide's classification as an ozone depleting substance, the Government of Canada conducted broad consultations with industry, research organizations, and environmental experts in Canada and in the U.S. The objective of these consultations was to develop a solution that would protect the environment while minimizing the economic impact that eliminating methyl bromide would have on the agriculture and agri-food sector.

In 1995, the government established the Canadian Joint Industry-Government Working Group on Methyl Bromide Alternatives.

Category	Global Use	Canadian Use
Soil	75%	45%
Commodities	22%	5%
Structural Fumigation	3%	50%
Total Consumption	***71 400 tonnes***	***200 tonnes (<1%)***

Table 1: *Methyl Bromide Use and Consumption (1997)*

Co-chaired by Environment Canada and Agriculture and Agri-Food Canada, the working group meets three times a year. Members include industry stakeholders, environmental groups, and government representatives from Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, the Pest Management Regulatory Agency (Health Canada) and the Canadian Food Inspection Agency (CFIA). This collaborative approach to working with industry and the public has proven to be extremely effective in identifying obstacles, proposing solutions, and disseminating information. Members have been extremely pro-active in their approach; organizing conferences, workshops and demonstration projects. The Federal Government, and Agriculture and Agri-Food Canada in particular, has played a key facilitative role; identifying research needs and funding opportunities, organizing demonstration and pilot projects, developing effective regulations, and negotiating Canada's position at international meetings. Agriculture and Agri-Food Canada also co-chairs a Canada-U.S. Joint Industry Government Working Group that meets two times per year.

Regulation in Canada – Allowance Holders

Environment Canada has established a system of tradable allowances for methyl bromide use, based on 1993 consumption. Under the Ozone Depleting Substances Regulations (and their amendments) each allowance holder is given a percentage of Canada's total allowance. Allowance holders may choose to relinquish or trade their allowance if they no longer require methyl bromide. When the system was established in 1995, there were about 160 allowance holders. Changes in technology and the efforts of government and industry have reduced that number to 68, in 2001.

Quarantine and Pre-shipment (QPS) Exemption

When control measures were considered in 1992, parties agreed that the alternatives to methyl bromide available at the time could not meet the phytosanitary and sanitary requirements of exporting and importing countries. Therefore, under the Montreal Protocol, quarantine and pre-shipment applications of methyl bromide were exempted from all controls (for example, reduction in consumption, freeze or phase-out). However, many parties have begun to express concern over the amount of methyl bromide used for QPS purposes. In 1998, approximately 20% of the global consumption of methyl bromide (16000 tons) was under QPS, and this figure is believed to have increased substantially over the last three years. Furthermore, methyl bromide used for QPS purposes is vented directly into the atmosphere at the end of the treatment. Limited technologies have been developed for the recapture, recycling and destruction of methyl bromide used in a variety of QPS and structural applications. Canada is continuing a dialogue with industry to examine the viability of using methyl bromide alternatives for QPS purposes, and the long-term implications of the QPS exemption.

Critical and Emergency Use Exemption

After 2005, parties to the Montreal Protocol will be able to request methyl bromide for emergency or critical uses. Stringent criteria have been developed for critical uses, including demonstrating that all technically and economically feasible alternatives have been tried and found to be inadequate. Emergency uses will be limited to 20 tons, and evaluated by the same criteria. The use of methyl bromide under these exemptions will be evaluated by the Secretariat of the Montreal Protocol, and non-compliant nations will be penalized. In Canada, the Methyl Bromide Industry–Government working group has developed a critical and emergency use criteria document entitled Process and Criteria for the Evaluation of Exemptions for Critical and Emergency Uses of Methyl Bromide. The document describes the criteria, process and schedule that the Canadian regulatory body (Environment Canada) could use to determine whether or not to grant an exemption for critical or emergency use of methyl bromide, after the

2005 phase-out date. This document will act as a guide for Environment Canada's decisions and is available on the Environment Canada Web site at *http://www.ec.gc.ca/ozone/e/subsec/mbr/workgroup.*

Government's Roles and Objectives

The Federal Government is committed to eliminating methyl bromide use while ensuring the protection of the environment and minimizing the economic impact of the phase-out on the agriculture and agri-food sector. Continuous consultation and collaboration with stakeholders, largely through working groups, is a key component of this strategy. The government also recognizes that the industry may need assistance in the research, development, and application of alternatives to methyl bromide. In addition, the government understands that it needs to contribute to international efforts to eliminate the use of methyl bromide, particularly in developing nations.

The Federal Government's Responsibility with regard to these issues is shared among several of its departments and agencies:

Environment Canada: Environment Canada's primary role is to develop control measures for, and track the usage of methyl bromide and other Ozone Depleting Substances (ODS). Environment Canada consults stakeholders in the development of control instruments (including regulations). Environment Canada is also the lead in developing Canada's negotiating position for all ODS-related international meetings.

Agriculture and Agri-Food Canada: Agriculture and Agri-Food Canada plays largely a facilitative and supportive role, helping industry and other government departments in identifying research needs and funding opportunities; partnering with industry to develop technologies; organizing demonstration and pilot projects; examining regulations and collaborating in the development of Canada's negotiating position on methyl bromide, for international meetings.

Canadian Food Inspection Agency: The Canadian Food Inspection Agency (CFIA) oversees quarantine and pre-shipment activities. Among the Agency's responsibilities is being the official sanitary and phytosanitary certification body for Canada. The Agency protects Canada and its trading partners from the distribution of alien or destructive pests and diseases in products that we import or export. As part of this role, the Agency manages quarantine programs in collaboration with other government departments, industry sectors and other national governments. The Agency is continuing to work with many sectors to update and introduce systematic approaches to production and pest management and to adapt existing alternatives so that they meet the phytosanitary requirements of both domestic and importing countries. This is especially important in helping the industry maintain desired market access.

Industry Canada: One of Industry Canada's mandates is to promote, develop and expand the environmental technologies industry. Consequently, Industry Canada has an interest in assisting Canadian companies that have developed methyl bromide alternatives and expertise in exporting their products internationally.

Pest Management Regulatory Agency (Health Canada): The Pest Management Regulatory Agency is responsible for the federal regulation of pest control products, including pre-market assessment of the products' health and environmental safety, and establishing the merit and value of products submitted for registration. Submission of applications to register alternatives to methyl bromide is encouraged throughout the Joint Review Program (a collaboration with the U.S. Environmental Protection Agency), and through minor use registration.

AAFC Case Studies – Background

Agriculture and Agri-Food Canada has prepared case studies in response to the allowance holders' need for more information on viable alternatives to methyl bromide. The objective of these case studies is to provide concrete, Canadian examples of the successful implementation of methyl bromide alternatives. These case studies used the survey responses to identify and interview those allowance holders who had successfully implemented alternatives to methyl bromide. Agriculture and Agri-Food Canada also invited members of the Joint Industry– Government Working Group on Methyl Bromide Alternatives to participate at the January 30 meeting. AAFC asked Working Group members to circulate the invitation to their various professional organizations. Agriculture and Agri-Food Canada contacted individuals and companies from January to March 2001. Those who agreed to participate in the case studies were interviewed over the phone for 30 to 90 minutes, and later participated in editing and reviewing of the written study.

Results of Methyl Bromide Allowance Holders Survey

In May to June 2000, on behalf of Agriculture and Agri-Food Canada, Marcotte Consulting Inc. carried out a telephone survey of methyl bromide allowance holders in Canada. The objective of the survey was to determine whether allowance holders were informed of the phase-out schedule; find out if they were still using methyl bromide and for what purpose; and, establish the participants' readiness to adopt methyl bromide alternatives. The survey also examined the methyl bromide users' need for more alternatives.

Marcotte Consulting divided allowance holders into two main categories: growers and space users; and divided these two categories into three sub-groups: small (<1 kg–100 kg), medium (101 kg–500 kg) and large (501 kg–40000 kg). The grower category encompassed all soil users, greenhouse and field producers, and pest management companies that dealt with soil applications. The space category encompassed both structural and commodity users, and included both pest management and quarantine and pre-shipment applications. The actual allowances of each allowance holder remained confidential; the contractor was given a list of growers and space users with small, medium and large allowances. The contractor attempted to contact all 106 holders of methyl bromide allowance. In all, 84 quota holders responded to the survey for a success rate of 79%. The results of the survey are presented in this section and analyzed in the next section.

Awareness of Phase-out

The survey revealed that all of the space users and 83% of the growers were aware of the impending phase-out of methyl bromide use. The growers who were not aware of the phase-out all came from the same region in Quebec, and many of them had not been using methyl bromide for several years.

Over the years, Environment Canada has distributed various information packages on the environmental impacts of methyl bromide and the rationale for the phase-out. Despite this, a few allowance holders still misunderstand the impact of methyl bromide on the environment, and the mechanism by which it harms the ozone layer. Two individuals felt that using methyl bromide in contained spaces minimized pollution problems and that bromide release from the oceans outweighed the amounts resulting from industrial use. Several individuals believed that methyl bromide would not be phased out in the U.S. or in Canada. Their opinion was based primarily on their contact with the U.S. industry and lobby groups.

Awareness of the existence of The Working Group

Awareness of the existence of The Working Group was much greater for the structural users (72%) as compared to the growers (31%). In both groups, large allowance holders (rather than small or medium allowance holders) were more likely to be aware of The Working Group. This is understandable because the phase-out will have a greater influence on the large allowance holders' businesses.

Transfer of Allowance Quotas

A number of growers with large allowances indicated that they were transferring their quota to other users of methyl bromide. This was mentioned by the structural users only twice. The survey indicates that much of the transferred quota is leaving the farm to be used for space fumigation.

Respondents commented that the costs of methyl bromide and allowance transfers are rising rapidly. Some respondents were concerned that people selling their quota are making unfair profits. One respondent indicated that they have insufficient methyl bromide to meet their current demands, but cannot find anyone selling their quota because the list of quota holders is not a public document. They felt that the current quota system should be revamped so that those who really need methyl bromide can get it.

Growers

Of the 106 methyl bromide quota holders in Canada, 66 (62%) are classified as growers. This group's response rate to the survey was 73%. Of the 48 respondents, 16 (33%) were still using their quota and 32 (66%) had stopped using their quota for various reasons. Only 3 (23%) of the large allowance holders indicated that they are still using their quota, as compared to 40% and 37% for medium and small holders, respectively. Many growers were having fairly good success with several currently registered soil fumigants (other than methyl bromide), but identified some problems. Those still using methyl bromide include greenhouse and field producers of berries, bedding plants, strawberry plants, fruits, vegetables, flowers, cuttings and nursery stock (trees), and one pest management contractor who services growers. Those that have found alternatives include the producers of sod, strawberry seedlings, cranberries, raspberries, vegetables and flowers. This list is not complete because growers who no longer use methyl bromide did not always indicate their type of farming operation.

Individuals who have stopped using methyl bromide gave various reasons for having done so:

1. The increasing cost of methyl bromide;
2. The negative environmental impact of using methyl bromide and the dangers inherent in applying it;
3. They had sold their farm or had changed the crops they were growing or the way they were growing them;
4. They were unable to obtain methyl bromide (despite having an allowance) because it was being "blocked at the border", or because the regulations were prohibitively complicated. Some respondents were unable to find an applicator willing to travel to their farm to apply it.

Growers still using methyl bromide

Of the sixteen growers who reported still using methyl bromide in their operation, less than half had tried using alternatives. All stated that available alternatives were too expensive (heat, steam, soil-less mix, commercially sterilized soil, metam sodium), less effective (metam sodium, 11,3-dichloropropene, 1,3-dichloropropene), or required a prohibitively long treatment period (metam sodium, 11,3-dichloropropene). Two growers were unable to find a company that would deliver commercially sterilized soil because their production was too small. The majority stated that there were no adequate alternatives and that it will be impossible to remain competitive without using methyl bromide.

<u>Growers using alternatives to methyl bromide</u>

Respondents identified and critiqued the following alternatives:

Note: These critiques represent the opinions expressed in the survey, and are not necessarily a definitive, scientific evaluation of any of the alternatives.

1. Greenhouse – soil-less mediums: Growers found hydroponic systems or alternate substrates (such as rockwool and peat) to be significantly more expensive but highly effective. The majority of greenhouse growers reported having adopted this alternative.
2. Greenhouse – commercially sterilized soil: Growers found commercially sterilized soil to be more expensive but very convenient.
3. Greenhouse – bleaching/shade cloth/hand-weeding: Growers found this method effective but probably more expensive because it is time consuming.
4. Greenhouse – hand-weeding: Growers found this method effective but labour-intensive and time-consuming.
5. Greenhouse – steam and/or heat: Two growers identified this alternative as effective but prohibitively expensive.
6. Field – 11,3-dichloropropene: Growers reported varying levels of success with

11,3-dichloropropene. 11,3-dichloropropene, a mixture of 78% 1,3-dichloropropene plus 17% chloropicrin, was more expensive than methyl bromide but provided "reasonable" (95% to 98%) control. Growers reported having to do some hand-weeding in addition to using it. 11,3-dichloropropene was sometimes used in combination with other chemicals (for example, 1,3-dichloropropene or metam sodium). One grower compared 11,3-dichloropropene, metam sodium and 1,3-dichloropropene, and found that 11,3-dichloropropene was as effective as methyl bromide and the least expensive of the three. Several growers expressed a desire to try a product with higher chloropicrin content for additional disease control.

7. Field – Metam sodium: Growers who tried it, did not consider metam sodium alone to be a viable alternative to methyl bromide. It was less expensive but not nearly as effective. Growers reported some disease control but no weed kill.
8. Field – 1,3-dichloropropene: Growers found that 1,3-dichloropropene did not provide adequate control.
9. Field – Post-emergence insecticides/plastic culture/hand-weeding: The grower who was using this technique found it less effective and more time consuming, but less expensive than methyl bromide.
10. Field – Hand-weeding: Growers with medium and small quotas were more likely to mention manual weed control. This method is labour-intensive, time consuming and costly. Growers agreed that it was not a very effective alternative to methyl bromide, but some growers were using it on a regular basis.

Many growers indicated a desire for more information, particularly about effective and economically feasible methods of sterilizing the soil, including non-chemical means.

Many growers expressed an interest in products with a higher level of chloropicrin or a 1,3-dichloropropene/chloropicrin mix. Specific products that were mentioned included: 35% chloropicrin, Ethofumesate, 3,5-dimethyl-1,3,5-thiadiazinane-2-thione (a granular product mixed with the soil in the fall), a new 11,3-dichloropropene formulation (with better soil binding capability so that less of it leaches through to the ground water) and methyl iodide. Several small growers were interested in steam and electrical sterilization, but indicated that the equipment was too costly for them to purchase on their own.

Space Users

Of the 106 methyl bromide quota holders in Canada, 40 (38%) fell into the category of structural or commodity users (Table 2). All but four holders were successfully surveyed, a success rate of 90%. Of the 36 respondents to this survey, 25 (69%) were still using methyl bromide, including all of the large quota holders. All but one of the medium quota holders and 54% of the small quota holders were using methyl bromide. The 11 small allowance holders who were no longer using their quota did not necessarily find alternatives because they were no longer doing fumigation work. They also pointed out that the quota was too small to be useful. Government, universities and colleges were the majority of small allowance holders that were still using their quota, and this was for research and teaching purposes. One researcher was investigating the possible damage to the ozone caused by the release of methyl bromide into the atmosphere.

Space users still using methyl bromide

Of the small allowance holders that were still using their quota of methyl bromide, most used it for structural and commodity fumigation. They could be divided into four categories:

- pest management professionals (22)
- food processors (8)
- government (2)
- universities or colleges (4)

With one exception, large holders of methyl bromide were all pest control operators.

Category	Size of allowance	Number of allowance holders	Number of responses (% response)	Using methyl bromide		Aware of phase out?			Aware of working group?		
				Yes	No	Yes	No	n.a.	Yes	No	n.a.
Grower	Large	16	13 (81%)	3	10	12	0	1	9	2	2
	Medium	8	5 (63%)	2	3	4	0	1	1	2	2
	Small	42	30 (71%)	11	19	21	8	1	5	23	2
	Total	**66**	**48 (72%)**	**16**	**32**	**37**	**8**	**3**	**15**	**27**	**6**
Space	Large	7	6 (86%)	6	0	6	0	0	6	0	0
	Medium	6	6 (100%)	5	1	6	0	0	6	0	0
	Small	27	24 (89%)	13	11	24	0	0	14	7	3
	Total	**40**	**36 (90%)**	**24**	**12**	**36**	**0**	**0**	**26**	**7**	**3**
Combined		**106**	**84 (79%)**	**40**	**44**	**73**	**8**	**3**	**43**	**34**	**9**

Table 2: *Number of Survey Respondents Using Allowance, Awareness of Phase out and Working Group (n.a. = not answered)*

Space users using alternatives to methyl bromide

There was a strong dichotomy in the respondents' outlook on the future use of methyl bromide. Some allowance holders saw the need for the phase-out and were confident that the industry could adapt. Others felt that the future of their business was at stake.

Most of the space users knew of or had tried alternatives. Respondents identified and critiqued the following alternatives:

Note: These critiques represent the opinions expressed in the survey, and are not necessarily a definitive, scientific evaluation of any of the alternatives.

1. Integrated Pest Management (IPM) – IPM is a holistic approach to pest control that uses biological, cultural, physical, mechanical and chemical methods to manage, control and eliminate pest populations. Respondents found that applying IPM principles enabled them to effectively manage pest populations using the available alternatives to methyl bromide (at a comparable cost), and identified IPM as a long term, low-cost alternative.
2. Phosphine – Phosphine is the most widely used chemical alternative. Those currently registered in Canada are Degesch magnesium and aluminum phosphides. Respondents identified four major drawbacks of phosphine: effectiveness, cost, treatment time and corrosiveness to metals. The corrosiveness was particularly problematic for some commodities (i.e. brass door handles). While the purchase price of phosphine is generally lower than methyl bromide, the longer treatment time required (three to four days as opposed to 24 hours) resulted in greater costs due to longer plant shut downs. Effectively, this made phosphine more expensive to use at its current prices. Some respondents also complained that phosphine was temperature sensitive (and therefore could not be used in the winter), and that it was highly flammable when exposed to moisture. Respondents identified Aluminum phosphide as an effective alternative for commodity fumigation.
3. Sanitation – Several respondents indicated that they were able to significantly reduce the frequency of pesticide and fumigant applications because of improvements in cleaning, maintenance and general sanitation.

but said that sanitation alone did not provide sufficient pest control.

4. Heat – This method was generally considered to be costly and time consuming in terms of preparation and treatment. Users stated that its effectiveness depended on buildings having good seals and that it was inadequate for use in bins. One user had found it effective and inexpensive for use in small-scale applications, but inappropriate at larger scales.
5. Carbon dioxide – Users found that it was difficult, if not impossible, to obtain the target carbon dioxide concentrations required because structures were simply not air tight enough. Carbon dioxide also required a longer treatment time than other alternatives.
6. Carbon dioxide /phosphine/heat combination – One respondent indicated that this combination was less effective than methyl bromide and more time consuming. Phosphine and heat mix was found to be effective, although more expensive in terms of time and equipment requirements.
7. Diatomaceous earth (DE) – Several respondents found DE an effective and inexpensive residual insecticide. One respondent indicated that using heat and DE was only 50% as effective as methyl bromide, and required monthly applications as opposed to annual.
8. Pyrethrins – Good for spot fumigations between annual treatments.
9. IPM/pheromones/UV light/sanitation – One respondent identified this as an alternative that was more labour-intensive (and therefore more costly) than methyl bromide.
10. Ethylene oxide – One user found this method effective for vault fumigation.

Virtually all pest control companies surveyed indicated some level of dissatisfaction with the alternatives available, or noted that no suitable alternative was available for some or most circumstances. Many of the allowance holders indicated that they were using their quota for quarantine or pre-shipment use; indicating some misinformation with regards to quarantine and pre-shipment exemptions.

Several respondents identified carbon dioxide mixed with phosphine and sulfuryl fluoride as products that should be investigated and fast tracked for registration in Canada. Other products that the respondents identified were the phosphine products, magnesium phosphide, and the Horn generator. Since the time of the survey, magnesium phosphide (for use in the phosphine generator) has been registered. Several individuals requested more data on the efficacy of non-chemical alternatives such as heat and cold treatments.

Other Comments

One respondent indicated that he would shift to using aluminum phosphide, but that the importing countries would have to be willing to accept goods fumigated with this product, rather than with methyl bromide, as currently stipulated. Consumers will need to be educated about the phase-out and be willing to accept higher levels of insect infestation as a trade-off for environmental sustainability. Other respondents questioned the need for the phase-out, particularly in Canada where the use of methyl bromide constitutes a small percentage of its worldwide use. These respondents felt that there were other chemicals released into the environment that were just as detrimental as methyl bromide. One respondent mentioned that the monthly inspections by the Canadian Food Inspection Agency (CFIA) were a strong incentive to keep up with sanitation procedures in their facility.

Large quota holders expressed general dissatisfaction with the phase-out. They did not see any viable alternatives to methyl bromide.

Several respondents indicated that product registration takes too long and chemicals available in the U.S. are not registered for use in Canada. They suggested that Canada re-evaluate some of the older fumigants to be brought back into usage. Respondents said that all countries—Canada, the U.S. and Mexico in particular—need to be on an equal basis in terms of methyl bromide use.

Analysis of Results of Methyl Bromide Allowance Holders Survey

This section takes the conclusions and observations of the survey and places them in the context of other information. It outlines actions already taken to address problems identified by the survey, and identifies the next steps industry and government must take to ensure a smooth transition from using methyl bromide to using its alternatives.

Several features of the survey (and the allowance system itself) make an in-depth analysis of the survey results difficult. Not all end-users of methyl bromide are allowance holders (for instance, the food processing industry contracts pest management professionals to apply methyl bromide). As a result, an analysis of the use patterns of allowance holders may not accurately reflect the use patterns of all end-users. In addition, the specific quantities of each allowance was classified information under the Canadian Environmental Protection Act (CEPA), making it difficult for Marcotte Consulting Inc. to conduct any quantitative analyses of the amount of allowances being transferred, used or lapsed. Subsequent to this study, CEPA has been modified and that information has become unclassified.

Communications Issues

The survey identified communications issues that needed to be resolved for both growers and space users. In the case of growers, many users stated that they were no longer using methyl bromide and that they would like to have their quota removed so that they would not have to deal with the paperwork. Officers of Environment Canada contacted all of these individuals in person, and some have chosen to give up their allowance.

The survey also identified some confusion concerning the way allowances are calculated and re-distributed, and what constitutes quarantine and pre-shipment use. Environment Canada responded with a presentation to the Joint Industry Government Work Group on Methyl Bromide Alternatives. General information about this presentation and other topics about methyl bromide are available on the Internet at http://www.ec.gc.ca/ozone/. Additional information is available through Environment Canada, Chemicals Control Division, telephone (819) 953-1665, fax (819) 994-0007.

Research Needs

The survey identified that there is a small number of researchers who are using methyl bromide to study its impact on the ozone layer, and for other research-related purposes. Some researchers surveyed suggested that research needs should be exempted from the allowance system. Unfortunately, there are no provisions in the Montreal Protocol to make such an exception until 2005, at which time the researchers could apply for an exemption under the Critical Uses criteria. Until that time, researchers can purchase or request the transfer of any additional quota from other allowance holders. This should not be difficult or prohibitive given the small quantities involved.

Allowance System and Transfers

Several allowance holders mentioned that the price of methyl bromide and methyl bromide transfers was rapidly increasing, and that there were no adequate alternatives in place. This concern came predominantly from the space users, who felt that growers were profiting unfairly from the system.

There are several responses to this criticism:

1. Environment Canada's analysis of methyl bromide use indicates that in 1999 allowance holders imported only 83% of the allowance they were authorized to import. Growers failed to import 22% of their allowance, while the space users failed to import 13%. Evidently, both sectors do not use all of the methyl bromide available.

2. Environment Canada data show that transfers are occurring from growers to space users, between space users, and from allowance holders to non-allowance holders, but not from space users to growers. After those transfers are taken into account, it is evident that the space users sector actually increased the amount of methyl bromide it used from 1997 to 1998, despite their knowledge of the impending phase-out. This suggests that by failing to control and reduce its consumption, the space users sector might have contributed to the price increase by increasing demand under conditions of limited supply.

Several allowance holders mentioned that they were unable to identify other allowance holders in order to purchase additional allowance under the transfer system. Given recent changes to CEPA, Environment Canada has been able to respond to this critique by establishing a Web site (http://www.ec.gc.ca/CEPARegistry/Permits/ozone.cfm) that lists allowance holders and their quota.

Alternatives

Both growers and structural users of methyl bromide were concerned that the phase-out would occur before alternatives were in place. They emphasized the need for a level playing field among all countries so that Canada would remain competitive in the global economy. Some growers and space users are finding that the alternatives now available do not meet their needs. They require more information about the existing alternatives that they have not yet heard about. Other allowance holders have been very successful in finding and refining alternatives for their particular uses.

In response to this need, the Department of Agriculture and Agri-Food Canada have prepared this report, including the case studies. In addition, AAFC is creating a Web site and information clearinghouse for methyl bromide users, and continuing an ongoing collaborative work with the industry and the Working Group.

Canada continues to communicate and collaborate with the international community through the Canada–U.S. Working Group on Methyl Bromide Alternatives, the Methyl Bromide Technical Options Committee (MBTOC), and the Meetings of the Parties of the Montreal Protocol.

Several allowance holders mentioned concerns that the U.S. was not going to eliminate methyl bromide, or was going to provide an exemption for space fumigation. Canada maintains regular communication with the United States Department of Agriculture and the United States Environmental Protection Agency. These organizations have reiterated their commitment to phasing-out methyl bromide use by 2005.

Next Steps – Growers

INTRODUCTION

Both field and greenhouse producers have found alternatives to methyl bromide. They may have been motivated by cost, availability, safety or a change in their farming situation. In general, for every crop currently or historically grown using methyl bromide, it is possible to find growers growing the same crops using alternatives to methyl bromide.

Since the 1990s, greenhouse users have been moving toward soil-less mixes or pre-purchased sterile soil, which eliminate the need for on-site soil fumigation. This supports the results of a 1997 survey of growers, which found that other market factors might be driving the change to soil-less systems (see box). Successful soil-less systems employ a variety of integrated pest management measures, biological control agents, and sanitation measures to control pests and manage diseases. Some smaller operations, however, have indicated that such systems are too expensive or not available to them.

Many field growers have found adequate control using chemicals, primarily 11,3-dichloropropene or 11,3-dichloropropene metam sodium mixes. An extensive case study of strawberry production in Nova Scotia is provided. Growers who have successfully used these products indicate that proper preparation is essential to obtain adequate control levels.

There are two potential long-term drawbacks to using the existing methyl bromide alternatives in fields:

1. These alternative chemical fumigants are restricted in their application due to their toxicity to humans and the environment.
2. While most growers have found acceptable alternatives for pest and weed control, there is a concern among the research community that available chemical fumigant alternatives provide only limited long-term disease control.

Methyl Bromide Use in Southwestern Ontario

In 1997, AAFC conducted a survey of 39 southwestern Ontario growers who used methyl bromide but were not allowance holders. These growers—29 greenhouse operations, seven combination of greenhouse and field operations and three field-only operations—were clients of a pest management professional who had been providing fumigation service for a number of years. At that time, all of the field growers and almost one-half (14) of the greenhouse growers had switched to alternatives; 12 were using hydroponic/rockwool systems; one was using steam sterilization; and the remaining grower was using individual pots in combination with a chemical root drench treatment. Though many growers were concerned with the higher operating costs, the authors of the survey noted that many had stopped using methyl bromide without knowing about the impending phase-out and ban. This implies that other reasons (such as labour costs, safety, environmental considerations or market demands) may have motivated the switch.

The survey concluded that "Changeover to an alternative technology is not simply a technological problem for many growers — there are issues of information availability, personal situations and the need for vision, resources and ability to manage change and the risks posed by change."

In fact, methyl bromide has been so effective as a disease management tool in numerous crop systems, that very little research examining diseases of the soil agroecosystem has been undertaken. Greenhouse growers would also benefit from a more detailed understanding of the ecology of disease.

New chemicals that could replace methyl bromide (such as methyl iodide) are being developed, but they may not be registered in Canada due to relatively minor demand. The Pest Management Regulatory Agency has developed a User Requested Minor Use Registration program that allows users to work with a registrant to submit registration requests for products, for minor uses.

Other alternatives to methyl bromide which are being investigated are organic amendments. Research has shown that certain soils and organic amendments (such as swine manure and pulp and paper wastes) support microbial communities that actively suppress disease. Many of these are already in use in organic agriculture, but their mechanisms of action are not well understood. Plant diseases in nature are relatively rare. The vast majority of crops are produced without fumigants. The reason why some soils become conducive to disease while others are disease suppressive, is not understood. It is possible that a commercial-scale soil management system incorporating organic amendments could be developed to provide disease control, without the use of chemical fumigants. Such a system could be both economical and environmentally beneficial. More research is needed in this area.

Sod Farming or Soil Farming?
Contrary to what one might expect, sod farming actually contributes to topsoil production. When sod is harvested, only the top quarter of an inch of soil is removed, leaving behind 10 to 12 inches of root mass, produced during the growing period.

CASE STUDY 1: ALTERNATIVES FOR SOD PRODUCTION

Background

Canada supports a large sod industry that supplies rolls of mature grass to a variety of clients for use in landscaping parks, houses, sports facilities, etc. The value of sod varies between $0.80 and $4.50 per yard, and is dependent on the hardiness of the sod, the species of grass and the absence of unwanted weeds. Kentucky bluegrass *(Poa pratensis)* is the predominant species for most uses, while other grasses, such as bentgrass *(Agrostis spp.)*, are used for specialty markets, such as golf course putting greens. Many of these specialty markets require 100% weed-free sod for aesthetic or practical purposes. Annual bluegrass *(Poa annua)* is the primary weed species, particularly on the West Coast, due to its rapid growth and frequent seed production. The hardiness of the sod depends on its age and health; sod growers typically guarantee the survival of their transplants, and their reputation and sales depend on the reliability of their product.

Methyl bromide has been used extensively by the industry as a pre-plant fumigant to sterilize soil in order to control disease, pests and weed species. However, due to the high cost, its use has been primarily limited to high-value specialty crops and markets. There is considerable regional variability in growing conditions as well as market preferences and prices. Southern British Columbia's mild winters and favorable growing climate have fostered a highly competitive industry with a pervasive *Poa annua* problem. In general, consumers on the West Coast (as far down as California), have a stronger preference for *Poa annua*-free product than those in the rest of Canada. In contrast, while the harsh winters in the rest of the country create additional challenges for crop production, they also serve to provide some control over *Poa annua* and other weeds.

A. ALTERNATIVES FOR BENTGRASS PRODUCTION

(The company wishes to remain anonymous.)

Background

The company produces Kentucky bluegrass and, more recently, bentgrass for golf course putting greens.

Methyl Bromide Use

The company has never used methyl bromide, but many of their competitors in Canada and the U.S. do.

Current Pest Management Program

There are basic procedures that apply to both crop species that the company produces. Prior to planting, fields are treated with glyphosate and tilled to a depth of five inches using a Rotavator. Crops are seeded from late April or early May until late August, depending on when the last crop is harvested. Crops are typically left to grow for more than one season (to ensure their sod strength) and are harvested from April to late November. Winter snow mould protection is required (for bentgrass) to ensure that crops survive the winter. Late harvested fields are left fallow over winter. The company selects fields with sandy loam soil that is well drained, for maximum productivity.

In terms of Kentucky bluegrass, the company caters to a market that does not require the product to be 100% free of *Poa annua*, and sells the bluegrass for 10 to 16 cents per square foot. *Poa annua* does not survive the cold winter climate. Consequently, the company has found that they are able to control pests without the extensive use of pesticides. They have found that the occasional use of 2,4-D, mecoprop and 3,6-dichloro-2-methoxybenzoic acid through the growing season is sufficient for pest control.

Bentgrass sod for golf courses must be 100% *Poa annua* free for both aesthetic and practical reasons. The stringent requirements of this market support prices of up to 50 cents per square foot. During the growing season, the fields are frequently irrigated, and mowed daily, to maintain an ideal length of five sixteenth of an inch; practices that promote *Poa annua* growth and reproduction. Due to harsh winters, golf greens that become contaminated with *Poa annua* must be repaired or replaced each spring. The grass weed species does not survive the cold, resulting in an unattractive and uneven green. Because this company has never had an allowance for methyl bromide, they have been forced to develop cultural and chemical practices to control *Poa annua*. Chemically, they apply metam sodium (at label rates, using a custom injection applicator) three weeks prior to planting, which provides about 80% control of *Poa annua*. They remove the remaining *Poa annua* by hand, picking it or burning it out with a propane torch. This is extremely labour-intensive because identifying *Poa annua* is a difficult and tedious task. If a field becomes too polluted, the company turns the crop under, burns it down with glyphosate and leaves it to winter fallow until the following year. To avoid contamination of a field, the company employees constantly wash or blow off equipment between fields, and use glyphosate to maintain a five-foot buffer of bare ground on the edges of each field.

B. ALTERNATIVES FOR SPECIALTY MARKETS – ANDERSON SOD

Background

Founded 26 years ago by its owners Michael, Jerry, and Steve Anderson, the Anderson Sod Farm cultivates 650 acres located near Dendrey, in the Lower Mainland of British Columbia. The Anderson Sod Farm has 20 employees and produces approximately one million yards of turf every year; a value of almost two million dollars. The company clients include contractors, homeowners, golf courses, school boards, municipalities and parks. The company produces a variety of species: bluegrass, rye grass, and fescues; and specializes in high-quality *Poa annua*-free sod for specialty markets and consumers who prefer that product.

Methyl Bromide Use

Anderson Sod began using methyl bromide to kill dormant seeds in the early 1990s. They contract a custom applicator who uses a track machine to inject the fumigant to a depth of 16 to 18 inches, seals the soil with a roller and covers the field with a plastic tarp. Fumigation occurs in the spring, prior to planting, and provides

100% control of *Poa annua*. Once a field is fumigated, it will remain free of weeds unless it is accidentally contaminated by: buying and seeding contaminated seed; weed seed transported from equipment or employees; or, wind transported seed from the edge of the field.

Anderson Sod still uses methyl bromide to periodically sterilize the majority of their fields, but they have adopted and developed a number of cultural practices that reduce the frequency of fumigations and that in the long run will replace methyl bromide. Using the cultural methods described below, Anderson Sod has managed to maintain their soils free of *Poa annua* for up to 10 years between fumigations.

Current Pest Management Program

Anderson Sod farms 500 acres of coarse, loamy sand and sandy soils, which can be harvested year-round; and 150 acres of heavy clay soils, which are typically too wet to access from November until the end of February. The loamy soils are the preferred soils for sod production, and are periodically fumigated with methyl bromide as a response to *Poa annua* infestation; the clay soils are not fumigated. Soil pH is maintained at 6.5 using composted grass clippings and lime. Depending on the soil type, harvesting can occur year round. Seeding, using certified *Poa annua*-free seeds, occurs from April first until the end of September. When possible, fields are seeded immediately after harvest. Fields harvested in the fall are seeded with fall rye as a winter cover crop; those harvested in the winter are left bare. Prior to seeding, fields are treated with glyphosate, and fumigated soils are reworked to the depth of fumigation (14 to 15 inches), using a Ripper.

Fields are mowed on a weekly basis, and watered using wheel lines and solid set irrigation. Glyphosate is used to maintain a buffer zone around the edges of the fields. To reverse the effects of soil compaction, fields are periodically worked to a depth of 18 inches using a Ripper. Anderson Sod began developing alternatives to methyl bromide in the 1990s, in an effort to increase productivity on marginal land, and in response to the imminent phase-out of methyl bromide. They experimented briefly with metam sodium, but unable to obtain better than 80% control, chose to explore other options. They currently use four common methods of cultural control: crop rotation, winter fallow, germination cycles and sanitation, and a novel technique involving washed sand. Combined, these practices provide 90% to 100% control.

Crop rotation: Fields are planted with fall rye, over winter, every three years from September to October.

Fallow: Fields are left fallow for one to four months, over winter, every three years from December to February.

Germination Cycles: Workers harrow the soil to a depth of 1-inch every 7 to 10 days to germinate as many seeds as possible. This cycle is repeated up to five times prior to planting the seed crop, depending on the degree of weed infestation in the field.

Sanitation: Workers and equipment are carefully washed before entering the field to avoid cross contamination. The workers use custom built mowers that vacuum and collect unwanted weed seed. Collected material is then composted (the composting process generates enough heat to kill any seeds). Finished compost is used to fertilize and pH-balance fields.

Washed sand: This technique involves spreading a 1 ¼-inch layer of washed sand on top of the soil and then planting the seed crop in that layer. The sand works as an alternative to fumigation because any seed below the layer will not receive enough light to germinate. Big A spreaders are used to spread the sand.

This technique has been developed over the years. Anderson Sod has experimented with different sources of sand and tried spreading it at different depths. Washed sand purchased from gravel pits is ideally suited to this treatment as it contains no organic material or seed, and is more or less sterilized. As quarter of an inch of sand is removed with the sod during harvest, new sand must be added each year resulting in a gradual increase in topsoil. Anderson Sod experimented with spreading 6 inches of sand and reusing it each year, but found there was too much compaction after two years.

Another complication that required some experimentation to resolve, was the length of time required to grow a hardy crop. It takes longer for grass to grow a root system in sand substrate; and a stronger root system than normal is required to support grass when it is harvested and rolled up. Dirt products are stronger and hardier. While at first 20 months was required to produce a crop, subtle refinements and experience have reduced that time to as short as eight to 10 months.

Market Price Comparison for Top Grade Products (price per yard)

$2.25	Fumigated, washed sand
$1.62	Fumigated soil
$1.10	Non-fumigated, washed sand
$0.50–0.70	Non-fumigated soil

Comparison of Methyl Bromide with Alternatives

While products produced on methyl bromide-fumigated fields still fetch the highest market price (see box), the washed sand products and cultural methods continue to improve each year and present a viable alternative to methyl bromide. The main additional cost associated with the cultural methods was the capital cost of the custom built mower with vacuum unit. However, this is used on both fumigated and non-fumigated fields. The disadvantages of the washed sand method are the extra cost of equipment and materials (dump trucks, spreaders, loaders, sand), the labour to apply the sand each year and the fact that there is less flexibility in terms of the time it takes to grow the crop.

CASE STUDY 2: ALTERNATIVES FOR STRAWBERRY NURSERIES

Strawberry production in Nova Scotia consists of both berry and nursery stock transplant crops. In 1999, strawberry nurseries produced 39 million transplants, valued at approximately $3.7 million; berry nurseries produced 3.9 million quarts, valued at approximately $5.8 million. Due to the strict phytosanitary requirements of the export market and the Nova Scotia certification program, strawberry nursery fields are routinely fumigated to sterilize the soil prior to planting. Methyl bromide has been the fumigant of choice to control a broad spectrum of weeds, nematodes and diseases.

Background

C.O. Keddy Nursery Ltd. is located in Lakeville, in the Annapolis Valley west of Kentville, NS, Canada. Charles and Doris Keddy purchased the farm in 1979, and have been cultivating strawberry plants for the transplant market ever since. The farm has 500 acres (250 cleared, 250 wooded), and an additional 175 acres are rented (100 of which are intensely cropped). Keddy Nursery employs an average of 10 to 15 people for eight to 10 months of the year, as few as seven in the winter and as many as 90 during the two to three-month fall harvest. They produce exclusively nursery stock: strawberries, raspberries, rhubarb, asparagus crowns, high and low bush blueberries; for export all across North America. They sell direct, retail and wholesale, and do not use brokers. Keddy Nursery produces 10 to 12 million strawberry plants per year, 200000 raspberry canes and lower numbers of the other crops.

Physical location and climate

The nursery has coarse, loamy sand and sandy soils. These soils have developed from glacial till, have low organic matter (less than three percent), and tend to be droughty. All fields have solid, set irrigation; water is collected in artificial ponds on the property. The nearby Bay of Fundy has a moderated climate. It averages

1177 mm of precipitation per year (897 mm of which is rain), and has late cold springs and short winters. It has an average of 138 frost-free days and more than 2400 Corn Heat Units (CHU) per year. The growing season averages 203 days in length. Planting begins as early as April 10, and harvest may run as late as December 20. The year-round average temperature is 6.8°C, with lows of –31°C in winter and highs of 37°C in summer.

Nova Scotia Strawberry Certification
Agriculture and Agri-Food Canada and the Nova Scotia Department of Agriculture and Marketing have developed a policy, in an effort to increase the productivity of Nova Scotia's strawberry fields and meet phytosanitary requirements for the export of nursery plants.

The plan has been carefully developed to reduce viral diseases, mycoplasmic diseases, fungal diseases, bacterial diseases, and insect and mite infestations.

Strawberry production
Keddy Nursery caters to two distinct markets:

Southern markets – Florida, Alabama, Georgia
Keddy Nursery grows five varieties of strawberry plant for this market, accounting for approximately two thirds of their production. They purchase the mother plants from California in late April, and plant in early May. They aim to produce at least 25 daughter plants from each mother. Daughter plants are typically harvested from mid-September until the end of October, and shipped as a green top (living) plant to their southern clients, where they are immediately put into berry production.

Northern markets – Canada, Northern states
Keddy Nursery grows 17 varieties of strawberries for this market, accounting for approximately one third of their production. Many of these varieties were developed at the AAFC Kentville research station. These are planted in early May, harvested when dormant (late November to mid-December), put into storage over the winter, and then shipped out in spring. Some plants may be left to winter in the fields and are dug up in April. These plants will not produce fruit until the following season.

Methyl Bromide Use
Keddy Nursery used both 11,3-dichloropropene and 1,3-dichloropropene until the mid-1980s. Keddy started using methyl bromide because they had heard that it was a superior product and very forgiving (for example, the timing of application not as crucial as with 11,3-dichloropropene). In addition to being competitively priced, it was what their customers in Florida were using.

Application
Soils are only fumigated once every three years due to the Keddy's crop rotation program (described below). Keddy contracted a Pest Control Operator (PCO) (Hendrix and Dail) from North Carolina, U.S. Soils were fumigated from late August to September. The contractors applied 400 pounds of a 67% methyl bromide/33% chloropicrin mixture per acre, which was injected eight to 10 inches into the soil using PCO's custom applicator. A 0.5 mm plastic tarp was used to cover the soil and increase methyl bromide retention. The fields were then left undisturbed for a minimum of five to seven days, before planting a winter cereal crop (rye or wheat).

Preparatory work prior to fumigation
The preparatory work prior to fumigation was the same as for 11,3-dichloropropene, described below.

Efficacy
Methyl bromide provided excellent, consistent control (90% to 95%) of nematodes, weeds and soil-borne diseases.

Rationale for phasing-out methyl bromide

Keddy stopped using methyl bromide in early 1994–95 because: Canada had decided to implement a quota system to gradually phase-out the use of methyl bromide; with the reduction of Keddy Nursery's quota, they were limited as to how much acreage they could fumigate with methyl bromide, and needed alternatives for the remainder; the cost of methyl bromide was increasing due to the poor Canadian–U.S. dollar exchange rate; they were concerned about increasing landfill costs to dispose of the plastic tarp; and they had always continued to use 11,3-dichloropropene on parts of their fields and felt confident that it would be an effective replacement.

Current Pest Management System

There were not many alternatives to methyl bromide available at the time Keddy Nursery started its operation. They resumed the use of 11,3-dichloropropene at 38 gallons per acre. The Keddys also tried using a combination of 25 gallons per acre 11,3-dichloropropene and 25 gallons per acre metam sodium. This combination was comparable in cost to using 11,3-dichloropropene alone, and provided slightly (5% to 10%) better control. However, they were more labour-intensive to co-apply, and required renting a more expensive Rumptstad-brand applicator to inject the metam sodium into the top four inches of soil. As a result, they decided to purchase a conventional s-tine broadcast applicator (from Agrispray) and returned to using 11,3-dichloropropene alone.

In Keddy Nursery's current system, crops are rotated on a three-year cycle (nursery crop, rotation crop, green manure crop) to control disease, improve soil-health, and reduce the accumulation of weed seed stock in the soil. Consequently, only 85 acres (24%) are used for the nursery each year, of which 70 acres (20%) are used for strawberry transplant production.

Nursery stock is planted in the spring of year one; strawberry nursery stock arrives in late April and daughter plants are started as soon as possible, typically May 1. Mechanical cultivation is undertaken every seven to 10 days throughout the growing season. Herbicides are not used; any remaining weeds are removed by hand when picking flowers or setting runners. Plants are harvested from mid-September until mid-December. Plants exported to the southern market are harvested by mid-October, and then the fields are planted with a winter cereal crop (rye or wheat). This serves both to protect the soil during the winter months and to reduce the workload in the spring. Plants destined for the Northern market are either harvested November to December and placed in storage, or covered with straw and left in the ground until early April. These fields are then planted with a spring grain crop (barley or oats).

Pests of issue

Weeds include shepherd's purse *(Capsella bursa-pastoris)*, common chickweed *(Stellaria media)*, St. John's wort *(Hypericum perforatum)*, mouse-eared chickweed *(Cerastium fontanum)*, sand spurry *(Spergularia rubra)*, lamb's quarters *(Chenopodium alba)*, redroot pigweed *(Amaranthus retroflexus)*, white clover *(Trifolium repens)*, low cudweed *(Gnaphalium uliginosum)*, fireweed/willow herb *(Epilobium spp.)*, pineapple weed/scentless chamomile *(Matricaria spp.)*, common purslane *(Portulaca orleracea)*, sheep sorrel *(Rumex acetosella)*, plantains *(Plantago spp.)*, annual grasses *(Digitaria spp., Echinochloa crus-gali)*, Bluegrasses and bentgrass *(Poa and Agrostis spp.)*, sedges *(Carex spp.)* and rushes *(Juncus spp.)*.

Other pests include Root Lesion and Root Knot nematodes *(Pratylenchus penetrans, Meloidogyne hapla)*, Verticillium wilt *(Verticillium albo-atrum, Verticilium dahliae)*, Black Root Rot (caused by *Fusarium, Cylindrocarpon, Rhizoctonia)* and Rhizoctonia Root Rot *(Rhizoctonia solani)*.

Strawberry Tyme Farms, of Simcoe, Ontario uses a similar system of pest management with their strawberry and nursery stock. John Cooper follows a crop rotation program jointly administered by the University of Guelph, the Ontario Berry Growers Association and Agriculture and Agri-Food Canada. He uses a pre-plant herbicide (trifluralin) in the top two inches of the soil, hand-weeds as necessary, and fumigates fields with 11,3-dichloropropene or metam sodium, depending on the disease history of the field. In his experience, metam sodium is less expensive than 11,3-dichloropropene, but provides inferior disease control. Both fumigants' efficiency is increased with good soil moisture, but significantly decreased if it rains within three days of application.

The winter cereal and spring grain crops are left to grow throughout the spring and summer of year two. Herbicides are rarely used on these crops. They combine the fields in late August; sell the grain; and keep the straw for mulching. The fields are then harrowed and planted with a winter cereal crop (rye or wheat).

Keddy Nursery workers leave the winter crop to grow until mid-June of year three and then plow it into the fields as green manure. They then summer fallow the fields to get them into seed bed condition. The workers try to harrow the fields every seven to 10 days to germinate as many weed seeds as possible and break down any clumps of organic matter. They fumigate the fields in late August or September, depending on the soil moisture (Also see example in box on the right).

Keddy applies 11,3-dichloropropene at a sterilant rate of 38 gallons per acre, as indicated on the label. The applicator's tines are eight inches apart, and inject the fumigant eight to 10 inches into the soil. A power roller seals the furrow and packs the surface to increase fumigant retention. Soil moisture is crucial to ensure adequate fumigant retention. Charles Keddy assesses soil moisture by grabbing a handful of soil from a depth of six to seven inches, and then balling the soil in his hand. If it stays clumped together, there is sufficient moisture to proceed with fumigation.

Non-chemical alternatives to methyl bromide used at C.O. Keddy Nursery Ltd.

- *Crop rotation* – Cultivation of successive crops that are non-hosts, less suitable hosts, or antagonistic crops for the target pests.
- *Fallow* – Temporarily taking land out of production to reduce soil pest populations by denying them hosts or substrate for their development and exposing them to adverse environmental conditions.
- *Soil amendments and compost* – Adding green manure and other organic amendments to control certain soil-borne pests in various crops, and to add nutrients to the soil.
- *Mulching and cover crops* – Mulches (soil covers), cover crops and green manures can be used to control a wide range of soil pathogens and insects.
- *Sanitation* – Sanitation is the avoidance or elimination of pathogen inoculum or pest sources (such as infected plant residues) before planting. Seedbed sanitation in commercial production permits better management of disease problems in horticultural and other crops.
- *Germination cycles* – Germination cycles are used for additional weed control. During summer fallow the soil is harrowed every seven to 10 days with the objective of germinating any seeds that are present in the soil, so that the planted crop does not compete with other crop species.

Two to three weeks after treatment, Keddy Nursery direct-drills a winter cover crop (rye or wheat). In the springtime they apply glyphosate to kill the cover crop, then harrow the fields and plant nursery stock again.

Comparison of Methyl Bromide with Alternatives

Keddy finds that they have excellent (90% to 95%), consistent control of nematodes, weeds and soil-borne diseases with 11,3-dichloropropene. According to Keddy, the key factors are properly preparing your soil so that it is in seed bed shape at the time of fumigation; ensuring that there is adequate soil moisture before fumigating; and allowing adequate time (two to three weeks) for the treatment to take effect.

When Keddy made the switch to 11,3-dichloropropene in 1995, he found the cost to be the same as using methyl bromide. Today, given the limited supply of methyl bromide under the quota system, and the strength of the U.S. dollar, 11,3-dichloropropene is much less expensive. Methyl bromide's advantages are that it is more forgiving if you have not adequately prepared your soil, and that it acts faster–five days, as compared to up to 21 days for 11,3-dichloropropene. The disadvantage of methyl bromide was the additional work to tarp the fields.

Keddy would like to use products with higher chloropicrin content for improved disease control. The Keddys recently participated in field trials of 35% chloropicrin, which has a higher chloropicrin content and is not currently registered for use in Canada. They found that it, at 25 gallons per acre, provided excellent control, but the trials were not comprehensive enough to draw other conclusions.

Farmers Teaching Farmers

Keddy and Cooper believe the key to success is in knowing what you want to accomplish, and applying common sense to achieve your goals. They developed their techniques through careful trial and error. They are open to sharing their experiences with other growers interested in reducing their dependence on methyl bromide. They can be reached at:

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Next Steps – Space Users

INTRODUCTION

The food-processing sector is a major contributor to the Canadian economy. It contributes to economic growth by acting as a supplier of food and providing a market for agricultural production. In terms of its relative size, Canada's food-processing sector, trade and processing intensity is similar to those in other large industrial countries. In 1999, the sector produced shipments valued at $49 billion and provided over 200000 jobs. Most processing activity in the sector occurs in central Canada, but the sector is relatively more important to the economies of the Prairie and Atlantic provinces.

Food processing facilities in Canada, particularly flourmills, usually run 24 hours a day, seven days a week. Tremendous costs are associated with shutdowns. While this high and constant product flow maintains a relatively pest-free product stream, the real challenges lie in managing the buildings themselves. As food is processed, there are numerous opportunities for insects and pests to access the system: bulk ingredient delivery and storage, product spills and dust that settles in inaccessible areas of buildings and equipment, and blockages in the flow of product between processing steps. The presence of food, warm temperatures and the structure of the building make flour mills the perfect environment for insect growth. Regular equipment cleaning and maintenance are therefore crucial to maintaining product flow and managing pest populations.

Pest Management in the Food Processing Industry

The food-processing sector has been using methyl bromide extensively to control pests in flourmills, warehouses, storage bins and production areas. The primary pests are rats, mice, red flour beetles and confused flour beetles. Less common pests are pigeons, rusty grain beetles, Indian meal moth, dermestid beetles, sawtoothed grain beetles, and merchant grain beetles.

> **The Milling Sector**
>
> There are 40 mills in Canada, which produced $1.2 billion worth of product and employed 2000 people in 1996. The basic process of milling involves several distinct steps: grain receiving, grain blending, cleaning, tempering with the addition of water, a resting period of approximately 20 hours, milling into flour, then flour packaging or bulk flour delivery. At the end of the milling process and prior to packaging, all the white flour is passed through an impact mill or Entoleter, a machine that consists of rotating disks with pins that pulverize any remaining insects.

Several regulations control pest management in the food processing industry. First, there is a specified limit on the percentage content of insect parts in products. Because flour mills' product is food, there are strict Health Canada regulations regarding what pest control products can be used in a food processing facility, and under what conditions. Some exporters are required to obtain a phytosanitary certificate from CFIA inspectors, to assure the exporting party that their products are (quarantine) pest-free.

There are renewed discussions on whether the facility-qualifying process should focus on pest management in the product stream or on the building itself. At this time, the focus is on both. Some representatives of the milling industry are arguing that because of Entoleters (a machine that consists of rotating disks with pins that pulverize any remaining insects – see box), their product is insect-free, regardless of what insect populations might exist in the rest of the building. They complain that in the past they have been penalized by "one insect" rules. The CFIA, in consultation with the millers, is in the process of examining and revising its inspection protocols and procedures.

Pest management in mills and in the food processing industry has historically been, and in many instances still is, reactive instead of proactive. Factories have generally contracted a pest management contractor only in the event of a noticeable infestation or emergency. In the past, pest managers did not have to have in-depth knowledge of the biology of the pests because of the chemicals at their disposal and the industry's desire for inexpensive treatment. At best, the role of pest managers has been to set traps, use trap counts to identify whether pests are reaching hazardous levels, and then eliminate the pests through the application of various chemicals (such as methyl bromide). Methyl bromide has long been the structural fumigant of choice due to its cost, availability, rapid action, lack of residue, and broad-spectrum activity. A factory's idea of proactive control has been to schedule regular fumigations (i.e. once or twice a year), regardless of pest levels. The main shortcoming of this old approach is that it fails to address the source of the problem, which is the fact that the facility and the process itself help the growth of pest populations.

The major pest management companies in Canada believe that the old approach is inefficient and does not effectively deal with the source of most infestations. New regulations concerning pesticides have also influenced attitudes. Many pest management experts argue that improved sanitation and maintenance programs–combined with physical modifications to the structure and equipment itself–can reduce the habitat available to pests populations, so that plant shutdowns for full-scale fumigation are not necessary. The costs of fumigating with methyl bromide or an alternative, are significant. The entire facility must be sealed to make it relatively airtight, the fumigant must be purchased and applied, and the facility must be shut down for the duration of the treatment, resulting in lost productivity. There are also complications related to human health and safety, particularly if the facility is located in an urban setting.

Specialists in the area of insect infestation support the application of Integrated Pest Management (IPM) strategies that take a more holistic approach, dealing with the root cause of the problem and not just the symptoms. IPM is often most effective when applied in conjunction with food safety and integrity systems, such as Hazard Analysis of Critical Control Points (HACCP). IPM is a holistic approach to pest control that uses biological, cultural, physical, mechanical, and chemical methods to monitor pest levels; identify and eliminate habitat; and develop systems of maintenance, sanitation and inspection that prevent or manage pest problems, in an environmentally sound and cost-effective manner. An important element of this program is to shift the perception of sanitation as a low-skill, low-value job, relegated to a few specific employees, to the understanding that sanitation is every employee's responsibility and is vital to the smooth operation of the facility.

The case studies in the next section highlight success stories of companies using a broad spectrum of IPM strategies; from fumigations with alternatives (such as phospine) to sanitation systems that have completely eliminated the need for full-scale fumigation. These studies show that many facilities have been able to implement effective, economical alternatives to methyl bromide, while remaining competitive. Many of these alternatives have resulted in better pest control than methyl bromide could offer. However, there remains an information gap.

Many mills and food processing facilities have been reticent in accepting the imminent phase-out of methyl bromide. Others see the alternative fumigants and "deep cleaning" techniques as prohibitively expensive and ineffective, without ever having experimented with them in their facilities. Pest management professionals must continue to educate themselves and their clients on the advantages and limitations of using methyl bromide alternatives, and must continue to refine these techniques. Clients must take a more pro-active and involved approach to pest management in their facilities.

ELEMENTS OF AN EFFECTIVE INTEGRATED PEST MANAGEMENT (IPM) STRATEGY

IPM is a holistic approach to pest control that uses biological, cultural, physical, mechanical and chemical methods to monitor pest levels. The approach also identifies and eliminates pest habitat, and develops systems of maintenance, sanitation and inspection that prevent or manage pest problems; all in an environmentally sound and cost-effective manner.

Gather information

Enlist the management – To facilitate and expedite the process, it is necessary to consult with the managers, who know the facility and can authorize any changes or expenditures. A team should be assembled that includes managers of maintenance, sanitation, quality assurance, pest control and production, as well as the plant manager. The suppliers and the clients of the facility should be contacted and asked about their needs and pest management protocols.

Understand the facility – It is critical to examine every square inch of the building to identify potential pest habitat. This includes examining the structural layout of the building to locate dead spaces in the walls or under the floors that could be potential pest entry points. It is necessary to learn how each piece of equipment works, how it is cleaned, how it comes apart, and what pest control methods have been tried and are currently in use. The maintenance and sanitation schedules and routines should also be reviewed.

Understand the pests – Traps should be set out and pests correctly identified. It is necessary to research their lifecycle, nutrition, and habits to identify potential habitat, points of entry, feeding and reproductive areas, in the facility.

Elements of a pest management plan

- Good sanitation practices
- Building maintenance
- Exclusion practices
- Inspections and monitoring
- Pest identification
- Physical and chemical controls
- Building and materials design and retrofitting

Develop a pest management plan

Knowledge of the biology of the pests and the structure of the facility should be applied to locate and eliminate infestations. A pest management plan should then be developed to prevent re-infestation by eliminating food supplies and habitat, disrupting reproduction, and blocking entry points. Working with both employees and a team of experts allows the development of innovative, cost-effective solutions. The system can later be optimized through continual monitoring and evaluation.

A short-term pest management plan does not necessarily involve fumigation or fogging; these methods often deal with the symptoms, and not the cause. For instance, Indian meal moth eggs require 25 days to develop to the adult stage. In some cases, simply ensuring that every part of a facility is cleaned and inspected every 25 days can prevent the moth from reproducing; eliminating the source of the infestation.

The long-term pest management plan may involve major structural changes to the facility and significant capital investment. By working with the management team, one can identify solutions that combine pest-related changes with other benefits, such as reduced maintenance or cleaning time, improved air circulation, and other beneficial structural, maintenance or quality control changes.

For further reading on this subject please refer to: ***Integrated Pest Management in Food Processing: Working Without Methyl Bromide****, and the accompanying brochure* ***Integrated Pest Management in Food Processing: Adapting to the Phase Out of Methyl Bromide****. Both are available on the PMRA's Web site at: http://www.hc-sc.gc.ca/pmra-arla/english/pubs/spm-e.html.*

CASE STUDY 1: PILLSBURY CANADA LTD. (IPM)

Background

Pillsbury Canada Ltd., located in Midland, Ontario, produces a line of flour-based refrigerated dough products and frozen pizza snacks. The plant employs approximately 29 salaried and 190 hourly employees. The Quality Assurance Manager, Jim Bales, has been with Pillsbury since 1972.

Pillsbury Canada Ltd. has been in their current location since 1974. The plant consists of three connected structures: an office building, a three level concrete block building that houses two 36000 kg (80000 lbs) flour bins, and the main plant area. The main building is a Butler-style building that is metal clad on the outside; structural steel supports roof and cement block walls from the inside. The peak of the building is approximately 30 feet high, 25 feet on the sides. The total area occupied by the plant and offices is approximately 80000 square feet.

A mixing area occupies one end of the building. The mezzanine above it, houses the dry batching systems. The rest of the building is divided into the main production floor, a refrigerated/frozen food storage area and a dry goods warehouse. Half of the production area is devoted to cookies and refrigerated dough products, and half to pizza products.

Methyl Bromide Use

Pillsbury Canada Ltd. is an example of a well-designed IPM system eliminating the need for facility fumigation with methyl bromide, or an alternative. Pillsbury has never used methyl bromide, although many of their competitors have, and still do. Pillsbury has used phosphine occasionally, but not in the recent past. Their original pest management system required regular chemical use and involved regular cleaning. It also included monthly inspections by an external pest control operator, fumigations of the bulk flour bins with aluminum phosphide, and spot fumigations in response to localized infestations. They used ethylene dibromide as their spot fumigant, until its deregulation in the 1980s.

Current Pest Management Program

Pillsbury Canada Ltd. decided to implement IPM practices in their plant in 1997. They contracted Steritech Group Inc., a food safety and environmental hygiene company based in Milton, ON, which has four affiliate companies throughout Canada. On the food safety side, Steritech performs food safety audits and develops management systems using Hazard Analysis of Critical Control Points (HACCP). On the environmental hygiene side, Steritech provides pest management services to their clients in the food industry, as well as other large commercial structures such as office towers and shopping malls. Steritech specializes in developing Integrated Pest Management (IPM) systems.

Key Pest Control Issues and the IPM Solutions

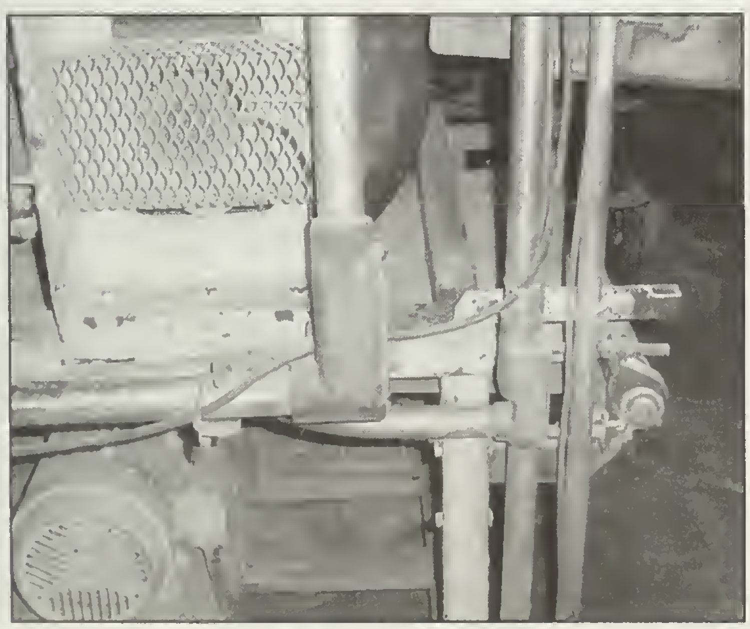
Background

Given Pillsbury's large volume of production, flour dust in the air has always been an issue. At full production, as much as 36000 kg (80000 lbs) of flour is sifted, weighed and mixed every 24 hours. This can create a substantial volume of dust that will settle out on every surface of the building, including difficult to access areas. Using IPM, Pillsbury re-evaluated its cleaning strategy and made a series of changes.

Replacing fumigation with cleaning
Traditionally, Pillsbury's employees cleaned and fumigated the flour bins with aluminum phosphide, as required. They monitored tailings from the flour sifters for insects and scheduled additional fumigations in response to infestations.

Pillsbury has managed to eliminate the need for fumigations by contracting out the annual cleanings to professionals, who do a more thorough job. They have expanded the cleaning of the bins to include a complete disassembly of the filter sock units and exhaust ducts, on top of the bins. The staff monitors tailings on a daily basis and keeps detailed records. This allows them to troubleshoot potential problems.

When insects are found in the tailings, they examine the filters on top of the bins, and then contact their supplier. Inspections of incoming flour trucks are also a part of the overall program. In the unlikely event of a major infestation, the staff is prepared to use heat treatment in place of fumigation.



Conduit junctions were opened up, inspected and DE blown in.

Step 1: Adopting a new approach to cleaning
Pillsbury staff was trained to be more aggressive in their approach to cleaning. They started using brushes and taking equipment apart, as opposed to just cleaning surfaces. Staff was trained to be proactive and to identify and report the potential "hot spots" before infestation occurs. At the outset, they conducted a thorough cleaning of the entire factory, opening and cleaning every piece of equipment, including items such as square conduit runs and electrical junction boxes; places they had never examined closely before. Empty spaces were then injected with diatomaceous earth (DE) to prevent infestation between cleanings.

For the Pillsbury staff, cleaning has become a tool used for both the prevention and the treatment of infestations. General cleaning occurs on a daily basis, and intensive "deep cleaning" is a regular part of their master sanitation schedule (weekly, monthly or quarterly). While in the past infestations were treated by superficial cleaning, spot fumigation and the use of residual chemical pesticides, they are now able to control infestations by conducting a thorough cleaning of the area; identifying the root cause of the problem and then adjusting their sanitation program to prevent re-infestation. The staff also has the option of using DE, a non-chemical residual pesticide.

Step 2: Upgrading equipment to reduce dust
Pillsbury installed a central vacuum system for cleaning the building and equipment. This helped to minimize the use of compressed air blowers (40 psi safety nozzles), which had contributed to the dust accumulation in the plant. Pillsbury also installed upgraded dust collectors. The disadvantage of vacuuming is that it can take longer to clean an area.

Production methods were examined to identify sources of flour dust. For example, in the cookie dough-making process staff weighed out the dry ingredients for the product and poured them into a hopper over the dry blender, creating a lot of dust. They solved the problem by installing a vacuum-conveying unit that delivered the ingredients to a closed hopper, eliminating the dust.

Step3: Being proactive – Inspections and Monitoring

The tailings from the flour sifters have always been inspected on a daily basis for the presence of insects. Pillsbury keeps detailed records that help to troubleshoot a problem and better evaluate whether the source of the infestation is internal or one of the suppliers.

Problem

The mezzanine wall was a frequent site of infestation of confused flour beetles. In the past, each infestation was treated with spot fumigations and surface cleaning, which only solved the problem for a short period of time. Steritech determined that the root cause of the problem was inside the blocks themselves. Over the years, various configurations of equipment had been mounted to the wall and then moved around. Poor practices had resulted in a number of unsealed holes, through which flour had accumulated inside the cement blocks. Replacing the blocks would have been prohibitively expensive due to the structure of the wall.

Solution

Diatomaceous earth (DE) was blown inside the blocks through one-centimeter (3/8 inch) diameter holes, drilled into the side of the wall. The wall was then completely sealed, including the areas where pipes and other equipment penetrated the block. There have been virtually no sightings in that area in the two years since the treatment.

With IPM, Pillsbury changed from monthly to weekly pest prevention inspections, and set up a logbook and a voicemail phone line (dial "bug") for employees to record any insect sightings or potential problem areas. Steritech has also improved the quality of the monitoring by conducting more thorough examinations; correctly identifying pest species; and reporting any relevant structural and cleaning problems they encounter. Steritech established a routine of checking sticky-, mechanical-, and pheromone-traps located in various areas inside and outside the Pillsbury plant. Whereas the original pest prevention operator relied heavily on the company's inspections for information, Steritech is more proactive, conducting their own inspections and constantly pushing the company to follow up on any problems they find.

In general, adopting an IPM system has led to a more holistic approach to pest prevention. Ease of cleaning, maintenance and sanitation are key considerations when purchasing new equipment, renovating and retrofitting. All capital projects have approval sign-offs by the Quality Assurance and the product safety people, who look at how the projects will impact the ease of cleaning. Contractors are given strict instructions on how to carry out the repairs so that there are no safety or infestation risks created.

Comparison of Methyl Bromide with Alternatives

Pillsbury Canada Ltd. has not conducted a detailed analysis of the costs and benefits of implementing IPM as compared to their traditional pest prevention. However, Jim Bales feels confident that the benefits do indeed outweigh the costs, and Pillsbury had no difficulty remaining competitive.

In terms of cost, Steritech's pest prevention services are significantly (2 times) more expensive than Pillsbury's previous contractor, partly due to added services. There have been additional costs over the years for equipment (central vacuum system, vacuum conveying system, dust collectors, etc.), and some initial increased labour costs for sanitation. However, it is Jim Bales' experience that these costs can be greatly reduced by working "smarter" and more efficiently. This includes scheduling the detailed cleaning of known "hot spots", and cleaning at intervals that break the life cycle of the pest they are trying to control.

Savings result from having no fumigation and associated plant shut-down costs ($7000 to $10000 per day), and knowing that with the controls Pillsbury has implemented, it is highly unlikely that an infestation could develop to a level that would seriously impede production or require plant shut down. There are also the environmental, human health and marketing benefits of not using pesticides in the workplace.

CASE STUDY 2: ROGERS FOODS LTD.

Background

The Rogers Foods Ltd. flourmill is located in Armstrong, B.C., just north of Kelowna. It employs 95 people and processes approximately 220 tons of wheat, producing whole wheat and white flour products, as well as granola for groceries and bakeries. Rogers caters primarily to the Canadian market, with limited export to Pacific Rim countries. Rudy Bergen, Vice President in charge of Quality Assurance, has been overseeing Rogers' pest management system since 1981.

The mill (about 2000 m^3 in size) is housed in a five-storey cement building, and there are three adjacent warehouses constructed of cinder blocks. There are five floors of grain cleaning equipment and five floors of milling equipment, arranged to allow the product to be gravity-fed between floors. The mill was built in 1979 around an older, wooden building, constructed in 1950. This central wooden structure is slowly being replaced, but while it remains it presents unique pest control issues.

Rogers mill is located in the Okanagan Valley, and is surrounded by farm fields of barley and wheat, which are ideal rodent habitat. The climate supports a vibrant insect population. There is a long summer season with extreme heat (up to 40°C), and mild winters, with average temperatures of zero to –2°C, thus ruling out cold treatments. The fall is extremely wet and the summer extremely dry.

Methyl Bromide Use

Rogers conducts a major fumigation once every summer. In the 1980s, they experimented with methyl bromide and phosphine, alternating treatments each year. They found that phosphine provided better pest control for their mill. They also found that they were unable to maintain target concentrations inside the building with methyl bromide, but could with phosphine.

Current Pest Management Program

Bergen describes four key elements of their system: sanitation, monitoring, residual insecticides and fumigation.

Sanitation

In terms of cleaning, each department has been made responsible for their own basic sanitation. In the past, a separate sanitation department, consisting of three employees, was responsible for the entire plant. This, however, was ineffective as department workers tended to be careless and rely on others to clean up for them. Now, every employee is trained to identify problem areas and report any and all insect finds.

Monitoring

While Rogers' staff are responsible for many elements of the pest management system, they also contract a pest management expert who conducts weekly inspections of the facility; operates and maintains rodent traps outside the building; and works with Bergen to identify manufacturing issues which need to be addressed.

Residual Insecticides

The facility is fogged with pyrethrins every month in the summer, and every second month in the winter. Diatomaceous earth (DE) is blown into spaces in equipment and cracks in the floor, to provide residual control of insects.

Fumigation

Rogers conducts a major fumigation with phosphine once every summer; in-house staff conducts the fumigation during the August long weekend.

A successful fumigation requires extensive preparation. Maintenance crews begin work three days before the fumigation and extra staff is hired for the day before. The entire building is sealed using plastic sheeting and duct tape, cracks are filled with silicone, and vents and chimneys are blocked. The phosphine itself is applied using Aluminum phosphide (aluminum phosphide) pellets. Three-by-four- foot sheets of paper are spread out in various locations on every floor of the building.

On the day of the fumigation, five teams of two enter the building and spend 15 minutes spreading the aluminum phosphide pellets on various sheets of paper. Once exposed to air, the pellets react to produce phosphine gas. Phosphine levels are monitored in parts per million (ppm) using Dräeger hand pumps. The objective is to maintain the target application dose for at least 48 hours. This typically requires the building to be left sealed for three days, and then opened up by staff wearing protective clothing and SCBA equipment. Once open, the phosphine dissipates from the building in approximately 18 hours. The time required for treatment is influenced by humidity and temperature. Consequently, pails of water are placed throughout the facility to increase humidity, and the fumigation is conducted during the hottest weekend of the summer to maximize the rate of phosphine production and to increase the sensitivity of insects.

Comparison of Methyl Bromide with Alternatives

The major criticisms of phosphine are that it is corrosive to metals and requires a longer treatment time than methyl bromide. In Bergen's twenty year experience and sixteen treatments with phosphine, he has had only minor corrosion problems. His opinion is that its detractors have greatly exaggerated this issue and attributed routine electrical failure after shutdown to phosphine corrosion. In terms of time, the experience and expertise have allowed the entire procedure to be conducted with only a four-day shutdown. Bergen's long-term goal is to eliminate the need for fumigation through better sanitation and other chemical and non-chemical controls. The company is also experimenting with full-building spot heat treatment. They conducted a trial of enhanced diatomaceous earth (EDE) and superheated air in May 1997, and obtained 100% control of the test insects in just over 24 hours. While this option was considerably more expensive than phosphine, due to the cost of renting heaters, Bergen is investigating the option of purchasing equipment to implement this method as a long-term solution.

CASE STUDY 3: PEST MANAGEMENT PROFESSIONALS

Background

Tepeco Consultants Inc. was founded in 1973 with the sole purpose of minimizing or eliminating pesticide use in food processing plants. Tepeco is highly selective in its choice of clientele, developing pest prevention and product integrity (HACCP) programs for a small number of medium and large facilities with management that is committed to Tepeco's principles. Tepeco believes in going beyond pest management to pest avoidance and prevention, by applying three major principles: exclusion, harbourage removal, and structural and equipment modification. In their experience, the additional labour and capital costs are offset, in the long term, by increased efficiency and the elimination of plant shutdowns, for fumigation.

Tepeco acknowledges the cooperation of individuals like Mr. Bruce Scott, and the management teams of such forward thinking companies as ADM Milling Company and Lipton (a division of UL Canada), whose commitment to food safety and product integrity is an essential component of Tepeco's programs.

A MIX PRODUCER

In 1982, Tepeco began working with a three-storey 50 000 sq. ft. facility that produced and packaged food mixes (cake mix, doughnut mix, etc.) for their clients. The facility subsequently added a single storey (20000 sq. ft.) warehouse for storage and loading. In this facility ingredients enter the system from the top floor, are mixed on the second floor, and are dispensed from packaging hoppers on the bottom floor. An open area on the bottom floor is used for packaging the product into two to 50 kg bags. Flour and sugar are stored in bulk storage bins. Other ingredients (spices, oils, flavourings, leavenings, etc.) are stored in bags. The facility is run in two shifts and employs fewer than 65 people. The facility uses some 350 raw materials to produce over 300 different bakery mixes.

Problem

Pest management prior to Tepeco's involvement included weekly spraying with residual insecticides, weekly thermal fogging with pyrethrins throughout the summer; and one or more methyl bromide fumigations per year. Despite these efforts, the company complained of continual pest problems, commenting that the "bugs flew back in, the minute the door opened after a fumigation".

Solutions

With the support and co-operation of plant management, Tepeco:

Eliminated harbourage by applying the principle that structures and equipment must be 100% open or 100% closed. Tepeco went through the entire building and repaired cracks and crevices in the walls and floors. They removed drop ceilings that were collecting dust and food residue; "insect proofed" doors and entry points; replaced solid shelving with open mesh shelving; replaced, encapsulated or removed insulation; and ensured that all equipment was installed flush to the floor. In collaboration with plant management, Tepeco also made extensive changes to the electrical systems (over time), eliminating harbourage areas (such as replacement of splitter boxes, disconnect switches, etc.) by replacing them with dust-proof units. The workers relocated electrical boxes away from the production and high-dust areas. They also installed open grate mezzanines to provide access to the sides and ledges around flour storage bins for cleaning.

Modified equipment to ensure the smooth movement of product without rough spots, ledges or pockets that accumulate product; installed proper sifters and a tailing monitoring system to ensure accessibility for maintenance and cleaning; and installed dust-collection vacuum systems over mixers. Implementation of a HACCP program and documentation, ensured that inspections of equipment were performed and that critical items in the system (sifter screens, unloading screens, etc.) were in proper operating condition.

Developed regular cleaning and maintenance schedules for the equipment and physical facility, and proper procedures for shut down. Tepeco helped establish and perform weekly pest management inspections to ensure that facility cleaning was performed properly. The company helped with maintenance schedules, putting a particular emphasis on items such as blower filters and dust-collection systems, because these present a great risk as harbourage areas.

Results

Tepeco has eliminated weekly residual applications and summer weekly thermal foggings of the facility. As a result, the facility has not required a general fumigation since 1982. Chemical treatment is largely limited to occasional bin fumigation with phosphine (in the event of the arrival of contaminated product) and occasional use of small quantities of methyl bromide, if limited time is available.

A flour mill

In 1976, Tepeco began working with a typical medium-sized Ontario flour mill. The facility consists of a 100-year-old, five-storey stone wall building, a shipping and receiving warehouse, a loading building, a load-out building, and wheat storage silos.

Cost Comparison of Methyl Bromide with its Alternatives

Treatment	Cost		Down Time	Damage
Aluminum	$ 8,600	Labour (in-house)	96 hours	Minor, electrical
Phosphide	$ 800	Fan rental		
	$ 600	Draeger tubes, lock change, back hoe, filling air tanks		
	$ 6,000	Aluminum phosphide		
	$16,000	**TOTAL**		
Methyl Bromide	$ 8,600	Labour (in-house)	40 hours	None
	$15,500	Contractor		
	$ 900	Fan rental, lock change, air tanks		
	$ 5,000	Methyl bromide		
	$30,000	**TOTAL**		
Heat	$ 3,800	Labour (in house)	45 hours	Melted some plastic parts and fuses
	$29,800	Heater rental and technology		
	$ 5,800	Power consumption		
	$ 600	Fan rental		
	$40,000	**TOTAL**		
Heat + DE	$ 8,250	Labour (in-house)	48 hours	None
	$ 2,200	Heater rental		
	$ 1,200	Oil for heaters		
	$ 400	Fan rental		
	$ 150	Protect-it (DE)		
	$11,200	**TOTAL**		

Problem

Pest management prior to Tepeco involvement

Prior to Tepeco's involvement, the mill was operating five days a week. Pest management consisted of annual facility-wide fumigation with methyl bromide in the summer, a monthly residual spraying, with malathion, of the entire plant (during a closed-down weekend) along with spot fumigation, with methyl bromide, and spot treatment of equipment with ethylene dibromide.

Solutions

With the involvement of the mill superintendent, using maintenance, regular cleaning and inspection, and equipment modification, Tepeco has reduced choking events by over 95% and eliminated the need for spot and general fumigation, and residual spraying. Chemical treatment, typically triggered by infested wheat, is now limited to ULV fogging with pyrethrins, as needed, during long weekends (up to four times per year). Since 1978, the mill has conducted a single methyl bromide fumigation, which was necessary because of a long period without shut down which disrupted regular maintenance and cleaning procedures.

Appendix A: Product and Chemical Names

Recommendations for pesticide use in this publication are intended as guidelines only. Any application of a pesticide must follow directions printed on the product label of that pesticide, as prescribed under the Pest Control Products Act. Reading and following directions should also be recommended by provincial authorities. Because recommendations for use may vary from province to province, agricultural representatives should be consulted for specific advice.

Labels for these pesticides are available from the registrant or can be obtained from the Web site of Health Canada's Regulatory Agency: http://207.96.209.37/PMRA/Index-ang.asp.

Soil Pesticides

Product Name	Pest Control Products Act Registration No.	Registrant	Active Ingredients
Dicamba	19290	BASF Canada	3,6-dichloro-2-methoxybenzoic acid
Nortran°	Not registered in Canada	Not registered in Canada	ethofumesate
Roundup	•	•	glyphosate
Telone® C17	16323 & 16324	Dow AgroSciences Canada Inc.	78% 11,3-dichloropropene 17% chloropicrin
Telone® C35	Not registered in Canada	Not registered in Canada	65% 1,3-dichloropropene 35% chloropicrin trifluralin
Treflan	•	•	
Vapam®	6453	Amvac Chemical Corp.	42% metam sodium
Vorlex Plus CP®	18354	AgrEvo Canada Inc.	34% 1,3-dichloropropene 17% methyl 15% chloropicrin

Space Pesticides

Product Name	Pest Control Products Act Registration No.	Registrant	Active Ingredients
Basamid	15032	BASF Canada	3,5-dimethyl-1,3,5-thiadiazinane-2-thione
ECO2FUME®	Not registered in Canada	Not registered in Canada	2% phosphine 98% carbon dioxide
Fumi-Cel®, Fumi-Strip®	26188	Degesch America Inc.	56% magnesium
Gastoxin®	17187 (tablets) and 17188 (pellets)	Casa Bernardo Ltd.	57% aluminum
Magtoxin®	26523 (granules) and 26524 (prepac spot fumigant)	Degesch America Inc.	66% magnesium
Phostoxin®	15736	Degesch America Inc.	55% aluminum
Pyrethrins	18348	Gardex Chemicals Ltd.	Piperonyl
Vikane® / Profume®	Not registered in Canada	Dow AgroSciences LLC	sulfuryl fluoride

• Roundup and Treflan have several formulations, due to space limitations, please refer to the Pest Management Regulatory Agency website for more information: http://www.hc-sc.gc.ca/pmra-arla/

° Nortran (Benzofuran family) site of action is unknown: http://www.weeds.iastate.edu/reference/siteofaction.htm

Appendix B: Resources

Publications

Methyl Bromide Alternatives, Substitutes and Recovery Systems. Final Report. Prepared for Agriculture and Agri-Food Canada. December 1993.

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Alternatives to Methyl Bromide Fumigation of Empty Ship Holds. Canadian Leadership in the Development of Methyl Bromide Alternatives. Prepared for the Environment Bureau, Agriculture and Agri-Food Canada. November 1999.

Web sites

AAFC Environmnet Bureau
http://www.agr.ca/policy/environment/eb/public_html/ebe/ozone.html

AAFC Stored Products Group
http://res2.agr.ca/winnipeg/stored.htm

Environment Canada ozone Web site
http://www.ec.gc.ca/ozone/e/subsec/mbr/workgroup

U.S. EPA Web site for methyl bromide
http://www.epa.gov/docs/ozone/mbr/mbrqa.html

U.S.D.A. Web site for methyl bromide
http://www.ars.usda.gov/is/mb/mebrweb.htm

The Ozone Secretariat (United Nations Environment Programme)
http://www.unep.ch/ozone/montreal.shtml