UNEP

Phasing-out Methyl Bromide in Developing Countries

A success story and its challenges

United Nations Environment Programme

Disclaimer

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the United Nations Environment Programme, nor does citing of trade names or commercial processes constitute endorsement.

ISBN: 978-92-807-3382-2

ACKNOWLEDGEMENTS

This document was produced by UNEP Division of Technology, Industry and Economics (UNEP DTIE) OzonAction Programme as part of UNEP's work programme under the Multilateral Fund for the Implementation of the Montreal Protocol.

The project was managed by the following team in the OzonAction Branch:
Ms. Shamila Nair-Bedouelle, Head
Ms. Anne-Maria Fenner, Information Manager
Mr. Ezra Clark, Programme Officer

This publication was written by:
Ms. Marta Pizano, Consultant, Co-chair of Methyl Bromide Options Committee (MBTOC)

We are very grateful to the following for reviewing this document:
Mr. Jonathan Banks, Consultant, MBTOC member, former co-chair of MBTOC
Ms. Julia Anne Dearing, Multilateral Fund Secretariat
Ms. Melanie Miller, Touchdown Consulting, former MBTOC member
Mr. Alejandro Valeiro, INTA Argentina, MBTOC member
Mr. Ezra Clark, Programme Officer UNEP

Erjan Aisabay, OzonAction Branch
Florence Asher, OzonAction Branch
Artie Dubrie, OzonAction Branch
Khaled Klaly, OzonAction Branch
Mirian Vega, OzonAction Branch

Design and lay-out: Aurelie Ek

Photo credits: Marta Pizano
Page 6: Grafted tomatoes, Mexico
Page 10: Roses growing in substrates, Kenya
Page 14: Eggplant on solarized soil, Turkey
Page 24: Gerbera cut flower production, Brazil
Page 44: Solar collector developed in Brazil
Page 48: Lilium cut flowers in substrate, Brazil

Cover images
Background image: Hypericum cut flower beds treated with plant (organic) mulch
Main image: Harvesting gerberas in Turkey

EXECUTIVE SUMMARY

Since 1991, UNEP DTIE OzonAction Compliance Assistance Programme (CAP) through its information clearinghouse and nine regional networks has been providing assistance to developing countries to make informed decisions to fulfil their commitments under the Montreal Protocol on Substances that Deplete the Ozone Layer. This is achieved by providing quality reviewed, need-based information services as well as policy and technology support and capacity-building.

Methyl bromide (MB) is a potent ozone depleting substance that damages the stratospheric ozone layer, which is essential to all forms of life on the planet. The Montreal Protocol controls specific uses of MB; developed countries phased out such controlled uses of MB in 2005 while developing countries have to phase out controlled uses of MB by 1 January 2015. Remarkably, by 2013 over 85 per cent of controlled MB uses in developing countries have already been replaced with alternatives, ahead of the 2015 target.

MB is an efficient broad-spectrum fumigant, which became increasingly preferred for pest and disease control by farmers around the world after its introduction in the 1970s. It was mainly used as a soil fumigant for controlling soil-borne pests, diseases and weeds in the agro industrial production of some high value crops such as strawberries, tomatoes, peppers, cut flowers and tobacco seedlings. MB was also used widely in some countries for post harvest fumigation of durable commodities (grain, dried fruit and other foodstuffs) and structural fumigation (warehouses, mills). These uses were classified as controlled uses under the Montreal Protocol. A special provision was left for countries to apply for time-limited critical use exemptions (CUE) for specific circumstances where replacing MB was particularly difficult.

MB is also used for quarantine and pre-shipment treatment (QPS), to prevent the introduction and/or establishment of quarantine pests which could endanger the livelihood of different productive sectors in many countries. Since such applications are not controlled by the Protocol, QPS uses are referred to as exempted uses.

The Multilateral Fund for the Implementation of the Montreal Protocol (MLF) has continuously assisted developing countries to meet their MB phase-out obligations by providing technical and financial support for projects that identify and implement effective and appropriate alternatives to MB. By end of 2013, the MLF had approved over US $120 million for 239 such projects (excluding 15 global projects) to be implemented by its bilateral and implementing agencies. The MLF has further supported the phase-out process through monitoring and evaluation studies to assess barriers to the adoption of alternatives and identify feasible solutions.

There are two broad categories of alternatives to MB: in-kind alternatives or systems, consisting in replacing MB by another fumigant that produces comparable effects (e.g. dichloropropene, chloropicrin, phosphine), and not-in-kind systems including soilless systems, steaming, grafting, hermetic storage and heating systems, used within an integrated pest management approach.

Substituting MB often requires a different approach to pest and disease control. Various systems can produce the same effect as MB, but they need to be implemented at an acceptable economic cost and in a sustainable way. A combination of measures and evaluation of alternatives under the particular circumstances involved in each case was most often the best approach, particularly in the agricultural sector. Training and capacity-building also played an important role.
The MB phase-out process has been instrumental in raising awareness about the fragility of the ozone layer and the need to protect it. It has also generated a wealth of information, expanded knowledge and expertise among key stakeholders in various sectors and often provided them with better and more modern pest management practices and production techniques. Many growers around the world have been able to improve yields and quality of their products, business efficiency and sustainability of production, making market headway in the international trade scenario.

A major barrier when introducing alternatives was that this process often had to be carried out against the background of an established system, with infrastructure, equipment, and supply chains already in place. In the agricultural sector, there are large numbers of farmers and different crops scattered across countries. The process followed for selecting the most suitable alternatives, where these were first trialed and demonstrated, and where key stakeholders were involved, contributed to creating a good level of acceptance towards the alternatives proposed. A wide approach is necessary, including registration and commercial availability of successful alternatives, at a feasible cost. Training was an essential component of the phase-out process, and should be continued.

Methyl bromide phase-out has come a long way in developing countries and it is expected that developing countries will be able to make the transition for the remaining uses smoothly and in time for the 2015 deadline. However, it is always theoretically possible to return to using MB after implementing alternatives. As long as QPS uses are exempt and MB is available and economically attractive, there is a risk that MB could be diverted from QPS to non-QPS uses. Initiatives taken by some Parties in recent years to evaluate the feasibility of adopting alternatives for QPS have shown that it is possible to replace MB at least for some such uses.

Many developing countries have expressed concern over illegal trade and/or use of MB, and in particular, the diversion of MB imported for QPS uses into controlled applications. Countries should explore options to ensure the continuity of programmes established through projects - particularly technical assistance and awareness raising. These should further include health related risks associated to both MB phase-out and chemical alternatives and particular effects on men and women. Linkages with other initiatives – regional or local and incorporating training and technical assistance on MB alternatives within programmes already in place, could be considered.

This publication is intended to be a useful tool for National Ozone Units (NOUs) and other stakeholders. You are encouraged to disseminate, reproduce, extract or otherwise make use of this publication for non-profit purposes (please acknowledge UNEP OzonAction Branch as the source).

CONTENTS

FOREWORD

Threatened by the depletion of the ozone layer, the global community developed and signed the Montreal Protocol to protect the ozone layer and set-up the Multilateral Fund to support developing countries to meet their commitments under the Montreal Protocol.

UNEP's OzonAction Compliance Assistance Programme (CAP), along with the other Implementing Agencies (UNDP, UNIDO and the World Bank) assists developing countries to meet their Montreal Protocol targets. UNEP CAP currently facilitates the operation of 10 Regional Ozone Networks involving 148 developing countries and countries with economies in transition. These Regional Ozone Networks are coordinated by the CAP Regional Network Coordinators and offer a unique forum for exchange of experience and knowledge between National Ozone Officers and other national stakeholders from developing countries and their counterparts in developed countries. The Networks can be credited with ensuring more rapid ratification of the Protocol and its amendments, expediting more effective and timely adoption of national legislation on ozone depleting substances, enhancing the countries' compliance with the ozone regime and assisting in providing updated information on technology choices.

Methyl bromide (MB) was the fumigant of choice globally owing to its extreme efficacy for pest control of both durable and perishable commodities and for quarantine and pre-shipment (QPS) uses. This broad-spectrum fumigant not only eradicated weeds, but also crop pests such as nematodes, rodents, insects, and soil-borne diseases. In 1992, the international community recognized this fumigant as an important Ozone Depleting Substance (ODS) with an ozone depleting potential (ODP) of 0.6 to be listed under the Montreal Protocol. Under the Protocol, developing countries will need to phase-out controlled uses of MB by 1 January 2015. Great strides have been made, and over 85% of such controlled uses in developing countries have been already replaced with efficient alternatives ahead of this deadline.

Efforts undertaken in finding and implementing the best alternatives for a wide variety of particular instances where MB was used in the past have presented important lessons and provided very valuable experiences. Thousands of growers around the world have received training and successfully trialled and adopted alternatives to control pests and diseases. Crop production and management strategies have been improved and updated, leading to better quality and yields and reducing dependence on chemical controls. As a result, sustainability standards are being improved. Environmental benefits associated to replacing MB are thus going beyond the very important goal of stopping ozone depletion and protecting the ozone layer. In addition, the MB phase-out has a positive impact on human health. MB not only carries a direct health hazard due to its very high toxicity. Although there is currently inadequate evidence in humans for the carcinogenicity of methyl bromide. For many years, various studies have linked MB to an increased risk of developing prostate cancer. Avoiding MB applications thus carries large benefits for men, as they are generally in charge of performing the fumigations. Adoption of alternatives has also brought specific benefits to women: grafting for example, requires intensive hand labour, which is often performed by skilled feminine hands. In many developing countries, vegetable grafting units are providing large numbers of jobs to women, and much needed income to many families.

In addressing the phase-out of MB there is no single or ideal replacement. In accessing sustainability of alternative technologies and in reducing the risk of reversal to use of MB, cross cutting factors such as cost-effectiveness, technical, economical, and commercially availability have to be considered. Moreover, non-chemical alternatives are capital and knowledge-intensive. This coupled with emerging issues such as changes in eco-systems due to invasive species and climate change, are introducing new diseases whose management requires additional practical MB-alternative training.

This booklet addresses the efforts undertaken to phase-out MB in developing countries, the lessons learned and what is pending to reach final phase-out. It further analyses factors that may impact or put at risk the continuity of the phase-out and possible ways to mitigate them.

It aims to promote the south-south and north-south-south cooperation, facilitate information exchange on advanced technologies for materials, varieties, rootstocks, etc. and raise awareness on risk of reversibility to MB uses and encourage policy to avoid it happening.

UNEP CAP will continue to assist countries in developing programmes that are relevant to their realities and concerns. It is our wish that this publication will promote active involvement of NOUs, local MB experts and key national stakeholders to prioritize the MB phase-out. We are grateful to Ms Marta Pizano for her expert work and in assisting us to 'put a face to the ozone layer' protection through this study on uses of MB and how it permeates our daily lives.

Shamila Nair-Bedouelle
Head of OzonAction Branch

1 INTRODUCTION: METHYL BROMIDE AND THE MONTREAL PROTOCOL

Fumigating grain stacks with phosphine, Egypt

The Copenhagen Amendment, adopted by the Parties to the Montreal Protocol in 1992, brought methyl bromide under the jurisdiction of the Protocol as an ozone depleting substance (ODS). Distinct phase-out schedules were agreed for developed countries -non Article-5 (non-A-5) Parties to the Protocol – in 1992, and for developing countries - Article 5 (A-5) Parties - in 1997. Aside from its ozone depleting potential, MB is highly toxic to humans, and is a possible carcinogen.

MB is a highly efficacious broad-spectrum fumigant, which became an increasingly preferred method for pest and disease control among farmers around the world, after its introduction in the 1970s. In agriculture, MB was mainly used as a soil fumigant for controlling soil-borne pests, diseases and weeds in the agro-industrial production of some high value crops. Nevertheless, there are various examples of A-5 countries, which never used MB and still have very successful crop productive sectors, for example strawberry production in Brazil and cut flowers in Colombia.

MB was also used widely in some countries for post-harvest fumigation of durable commodities (grain, dried fruit and other foodstuffs) and structural fumigation (warehouses, mills). However, some large A-5 grain producers, for example India, China, some South-East Asian countries and Brazil, never adopted MB for treating grain as routine protection. Efficient results have been achieved since the early 1990s principally with phosphine fumigation and contact insecticides. Consumption of MB for these uses of MB were classified as controlled uses under the Montreal Protocol. This MB consumption has to be phased out as per the agreed schedule detailed in Table 1.

Non Article 5 Countries	Article 5 Countries
• Freeze at the baseline (1991 level) on 1 January 1995 • 25% reduction by 1 January 1999 • 50% reduction by 1 January 2001 • 70% reduction by 1 January 2003 • Complete phase-out by 1 January 2005 with provision for possible critical use exemptions	• Freeze at the baseline (average 1995-1998 level) on 1 January 2002 • 20% reduction by 1 January 2005 • Complete phase-out by 1 January 2015 with provision for possible critical use exemptions Freezes and reductions refer to baseline levels

Table 1. Montreal Protocol control schedule for methyl bromide

A special provision was incorporated for countries to apply for Critical Use Exemptions (CUE) for specific sectors or circumstances where replacing MB was particularly difficult. Exemptions may be obtained to allow for further use of MB for one year, and require countries to submit a very detailed justification for consideration of the Methyl Bromide Technical Options Committee (MBTOC), an advisory panel to the Parties to the Protocol.

As the 2015 deadline for final phase-out of methyl bromide in A-5 countries approaches, an important achievement of the Montreal Protocol has become evident: over 85% of the controlled uses of this once widely-used fumigant have already been replaced with alternatives in A-5 countries.

This booklet addresses the efforts undertaken to achieve this important milestone, the processes involved, the lessons learned and what is pending to reach final phase-out. It further analyses factors that may impact or put at risk the continuity of the phase-out and possible ways to mitigate them. The phase-out process has further provided an invaluable opportunity to promote and adopt integrated pest management and non-chemical options. In short, it has helped developing countries make headway in achieving improved sustainable production standards.

MB is also used as a quarantine and pre-shipment treatment (QPS), to prevent the introduction and/or establishment of quarantine pests, which could endanger the livelihood of different production sectors in many countries. Article 2H of the Protocol (Copenhagen, 1992) specifically excluded QPS from control measures, since at that time no alternatives to MB for a diverse range of QPS treatments were available. Although in the early 1990s QPS was about 10% of global MB consumption, this was still significant in allowing inter- and intra-country trade in commodities,

which were treated with MB in the absence of specific alternatives. Parties were nevertheless urged (and continue to be urged) to use alternatives to MB for QPS and to reduce emissions and use of MB whenever possible.

As an example, many countries use heat instead of MB to comply with ISPM-15, an international standard aimed at disinfesting wood packaging materials. QPS uses are referred to as *exempted uses*. A detailed description of historic MB uses can be found in Section 3.

Quarantine and Pre-shipment

Decisions VI/11, VII/5 and XI/12 of the Montreal Protocol explain the terms "quarantine" and "pre-shipment" as follows:

(a) 'Quarantine applications', with respect to methyl bromide, are treatments to prevent the introduction, establishment and/or spread of quarantine pests (including diseases), or to ensure their official control, where:

(i) Official control is that performed by, or authorized by, a national plant, animal or environmental protection or health authority;
(ii) Quarantine pests are pests of potential importance to the areas endangered thereby and not yet present there, or present but not widely distributed and being officially controlled;

(b) 'Pre-shipment applications' are those non-quarantine applications applied within 21 days prior to export to meet the official requirements of the importing country or existing official requirements of the exporting country. Official requirements are those which are performed by, or authorized by, a national plant, animal, environmental, health or stored product authority.

Tobacco seedling production in floating trays, Peru

2 PHASING-OUT METHYL BROMIDE

Global consumption

Spading machine for applying metham sodium, Mexico

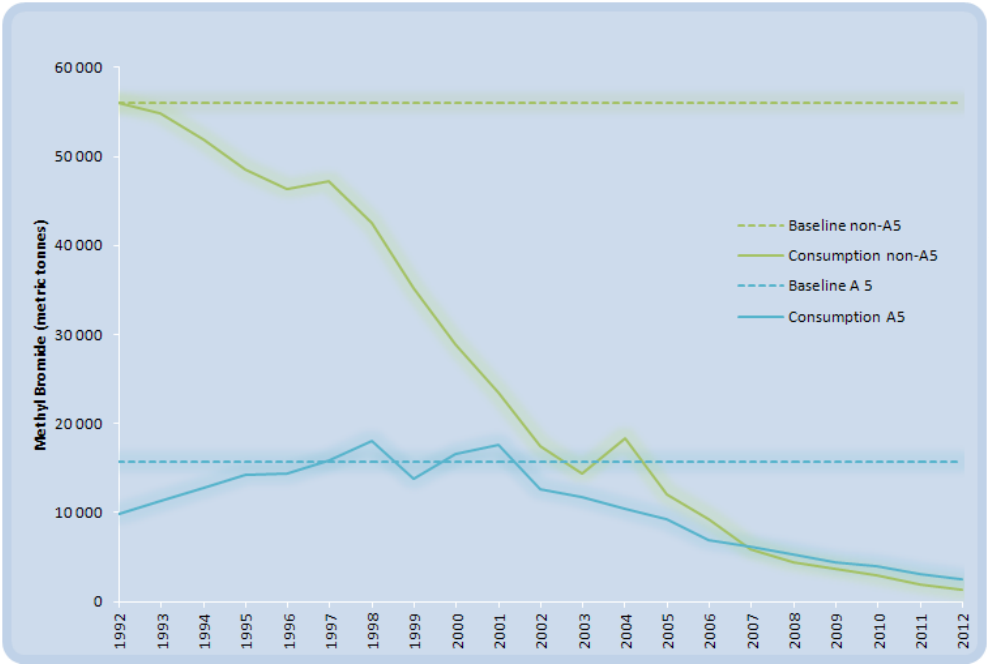
Methyl bromide phase-out for controlled uses has been achieved through a consistent and successful global effort, leading to 95% of the global baseline of 71,950 metric tonnes was eliminated by the end of 2012 (Table 2).

Region	Baseline (metric tonnes)	2012 consumption (metric tonnes)	% phase-out (as per baseline)
World	71,950	3,785	94.7%
Non-A5	56,084	1,303	97.7%
A5	15,867	2,482	84.4%

Table 2. Reported MB consumption for controlled uses in A-5 and non A-5 countries at the end of 2012 and phase-out achieved with respect to the regional baselines (Source: Ozone Secretariat Database, 2013)

By the end of 2012, non A-5 countries had phased-out more than 98% of MB consumption for controlled uses. The remaining percentage comprises four Critical Use Exemptions - strawberry runners in Canada and Australia and some applications for strawberry fruit and stored cured pork in the USA. The countries involved have already provided a date when final phase-out will occur for most of these uses.

In turn, A-5 countries had phased out about 85% of their consumption at the end of 2012, ahead of the 2015 deadline (Fig 1). In 2014, three A-5 Parties have submitted Critical Use Nominations for 2015 (Mexico for strawberry and raspberry runners, China for ginger and Argentina for strawberries, tomatoes and peppers.



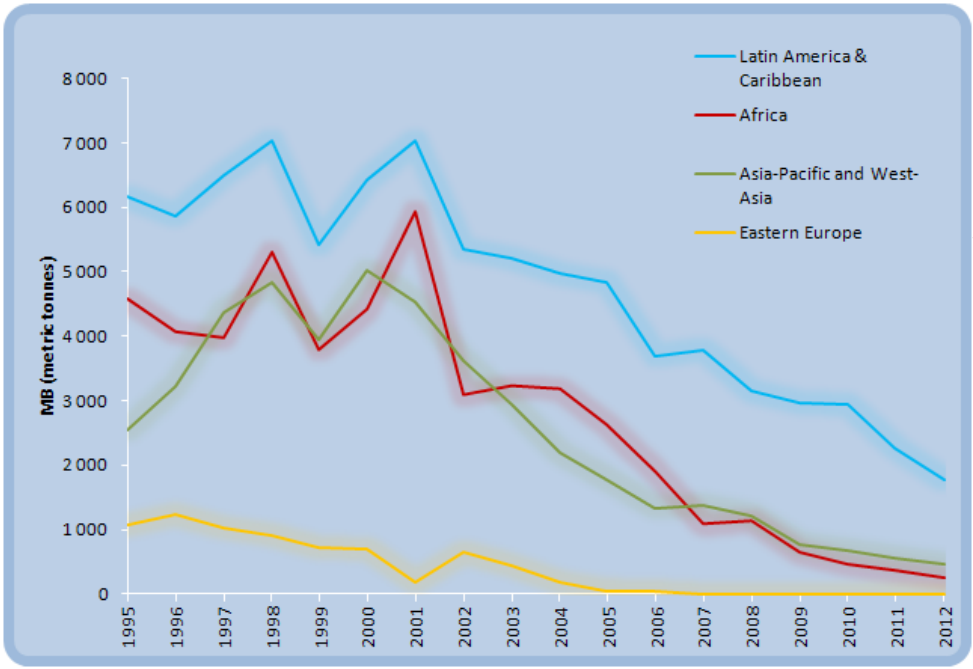
Ozone Secretariat Database, 2014

Fig 1. Global MB consumption for controlled uses 1992 - 2012

Phase-out trends in A-5 countries

Although total MB phase-out has progressed substantially in A-5 countries in all regions of the world, this has occurred at different speeds as seen in Fig 2. This is in direct relation to the consuming sectors involved, as well as the particular circumstances present in individual countries, including developments concerning new crops (with challenging requirements, pests or diseases) or large expansion of existing crops where newcomers to such sectors (growers and other stakeholders) are not sufficiently trained on the use of alternatives. Regulatory issues (e.g. registration of alternatives) and political issues (e.g. difficulties in restricting MB imports and tracking their final use) may also contribute to this.

Phase-out achieved in each of the regions is presented in Fig 3 below.



Ozone Secretariat Database, 2014

Fig 2. MB consumption for controlled uses in A-5 countries by region 1995 - 2012

Region	Baseline (metric tonnes)	2012 consumption (metric tonnes)	% phase-out (as per baseline)
Africa	4,471	246.6	94.5%
Asia	4,104	464.3	88.7%
Latin America & Caribbean	6,391	1,771.3	72.3%
Eastern Europe	900	0	100%
Total	**15,866**	**2,482.2**	**84,4%**

Table 3. Reported MB consumption for controlled uses in A-5 regions at the end of 2012 and phase-out achieved with respect to the baselines (Ozone Secretariat Database, 2014)

Small, medium and small consumers

Of the 147 A-5 countries that are Parties to the Protocol, 59 never used methyl bromide and so their baselines were zero. The remaining 88 Parties can be classified as follows according to their baselines:

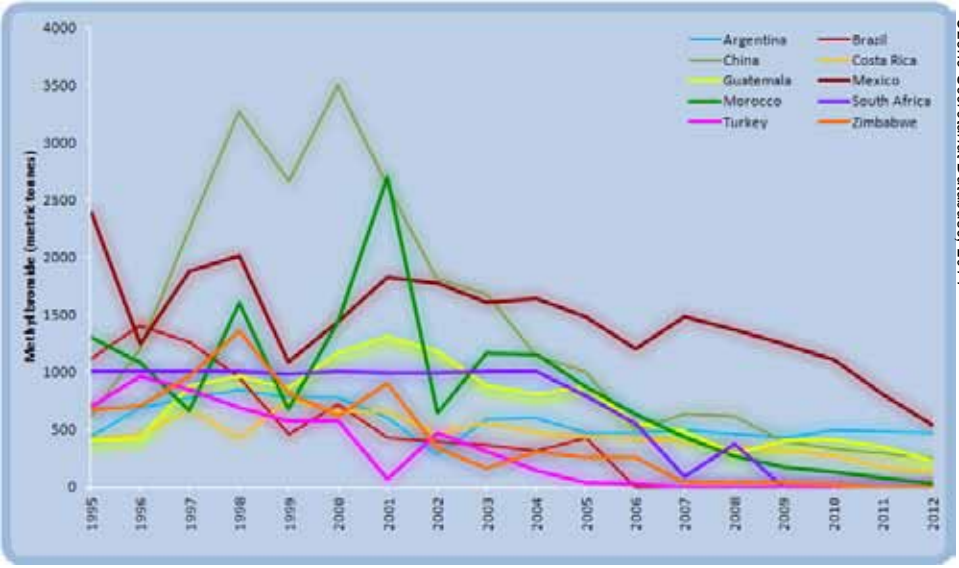
• 39 low volume consumers – consumption < 8.3 metric tonnes (5 ODP tonnes)

• 23 small consumers – consumption < 100 metric tonnes

• 15 medium consumers – consumption between 100 and 500 metric tonnes

• 10 large consumers – consumption > 500 metric tonnes

In aggregate, the group of large consumers added 10,726 metric tonnes or nearly 68% of the total A-5 consumption during the baseline years. The phase-out progress of these ten countries is illustrated in Fig 3. By the end of 2012, four had completely phased-out MB (Brazil, South Africa, Turkey and Zimbabwe) and only one (Mexico) remained in the >500 category. From the original 88, only 23 countries reported MB consumption in 2012, and of these, seven are now LVCs, seven small consumers, and eight medium consumers.



Ozone Secretariat Database, 2014

Fig 3. The phase-out schedule of the largest A-5 methyl bromide consumers (baseline > 500 metric tonnes)

Compliance

The majority of A-5 Parties were able to comply with the control measures set out by the Montreal Protocol. Some challenges have nevertheless been found along the way:

• 17 A-5 Parties did not comply with the 2002 freeze

• Eight did not achieve the 2005 20% reduction

• Three came into non-compliance in interim periods

• Some countries corrected baseline information, or re-negotiated phase-out schedules.

All A-5 Parties have been able to return to compliance and are presently in full compliance with the Montreal Protocol commitments. Recently however a few Parties have had problems abiding by the reduction targets that were agreed with the Multilateral Fund's (MLF) Executive Committee and have exceeded the maximum allowable level of MB consumption set out in the performance based funding agreements made with the Executive Committee.

Achieving the Phase-out

The Multilateral Fund (MLF) responded rapidly and effectively in providing developing countries with financial assistance for the phase-out of MB. Some assistance was provided by the end of 1994 and projects to assess methyl bromide alternatives projects became eligible for support from the Fund in 1995. In 1997, the Executive Committee of the MLF convened a group of experts to develop a strategy and guidelines for MB phase-out projects. The guidelines adopted in 1998, and later revised in 2000, outlined the priority sectors for methyl bromide alternatives demonstration, investment and non-investment projects, and recommended approaches to project development. These inputs were instrumental for the MLF's four implementing agencies (UNEP, UNDP, UNIDO and the World Bank), to prepare and implement the different kinds of projects in conjunction with interested Parties. Project preparation and implementation followed a logical approach, with particular project types targeted at specific goals, as described in Table 4.

Training flower growers, Ecuador

Project Type	Goals and achievements
Technical Assistance and Training (TAS/TRA)	• Play a key role in improving data collection on MB consumption, integrating the National Ozone Units (NOUs) to phase-out activities and developing or strengthening policy packages aimed at sustaining the phase-out achieved. • Normally not aimed at replacing specific quantities of MB but this has on occasion been achieved.
Demonstration	• Instrumental in raising awareness on MB phase-out, identifying consuming sectors and evaluating suitability of alternatives. • Generally not aimed at phasing-out a specific amount of MB. • Served to identify problems hindering adoption of alternatives (inappropriate involvement of key stakeholders, lack of participation from NOUs, alternatives being inappropriate for specific sector etc.)
Investment	• Generally implemented once successful alternatives have been identified during the demonstration stage. • Carry agreement from the country to phase out MB consumption for controlled uses by a given deadline, and to support sustainability of the phase-out achieved with a policy package aimed at banning future MB use for controlled uses.

Table 4. Types of methyl bromide projects, their goals and achievements

As at the end of December 2013, the Executive Committee of the MLF has approved over US $120 million for 239 MB phase-out projects (excluding 15 global projects) as shown in Table 5. The amounts of MB committed for phase-out in each region compared to what had been achieved by the end of 2013, as illustrated in Fig.4.

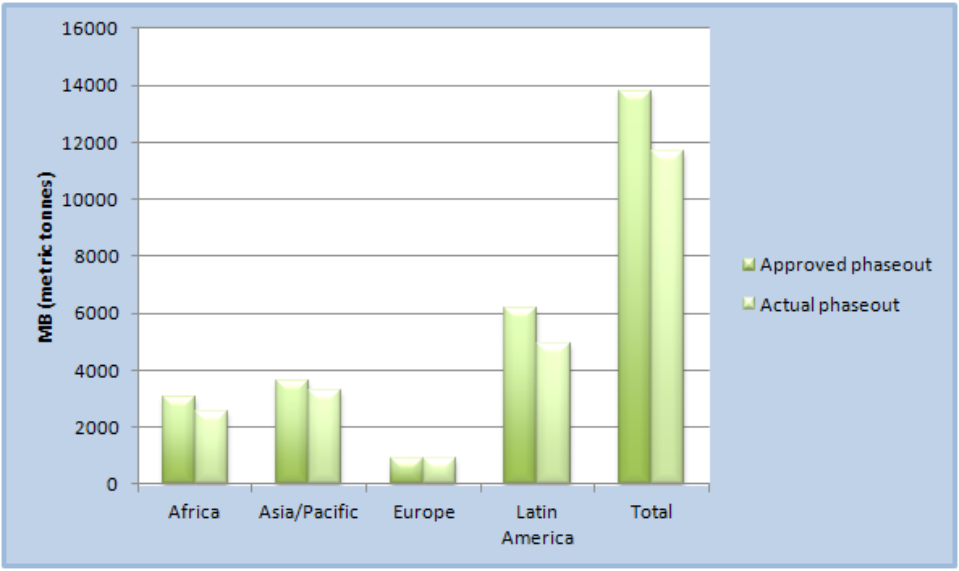


Fig. 4. Amount of MB phase-out with support from the Multilateral Fund by region (as at end 2013)

Agency	Investment projects	Demonstration projects	Technical assistance/ Training	Total
Bilateral	19	7	11	37
UNDP	20	10	9	39
UNEP			32	32
UNIDO	71	23	15	109
World Bank	10	2	3	15
Total	**120**	**42**	**70**	**232**

Table 5. Number and type of projects per agency Amount of MB phase-out with support from the Multilateral Fund by region (as at end 2013)

The evaluation study demonstrated that the economic feasibility of some alternatives to MB needed further validation and that in some cases, users were reluctant to change their approach to pest and disease management. Following the evaluation, the MLF made recommendations for new and ongoing projects to enhance involvement of all key stakeholders in a given country during their preparation and implementation, particularly in the case of investment projects. Assistance to government authorities to develop policy measures from the onset of project implementation was also strengthened. MB issues and projects were further analyzed in an evaluation of cases of non-compliance or potential non-compliance aimed at identifying common causes or risks of countries' non-compliance with the Montreal Protocol's control measures, and possible ways to overcome them.

An extended desk study was carried out in 2007 to examine the specific situation of MB projects for countries with an MB consumption of less than 8.3 metric tonnes (equivalent to 5 ODP tonnes), the so-called low volume- consuming (LVC) countries, as the particular circumstances of such countries can be different and a small consumption does not necessarily lead to an easy phase-out. Although the quantities of MB phased out through projects conducted in LVC countries are small, their impact in terms of preventing the increase of consumption and sustaining compliance with the Montreal Protocol is important. In 2012 a desk study examined the sustainability of MB alternatives adopted through investment projects and the risk of returning to MB use in African countries. The full evaluation carried out subsequently concluded that in general, the risk of returning to MB use for controlled uses was low, but that actions should be taken to strengthen the phase-out achieved to ensure the that countries do not return to MB.

During the course of the MB phase-out process, benefits specifically related to each gender have been identified. MB is a substance which is acutely toxic to humans, and various studies conducted over the past 15-20 years link it to an increased cancer risk and other health problems. Since there is increasing evidence linking this fumigant to the development of prostate cancer, it could be a particularly dangerous substance for men, who generally conduct the fumigations in most countries.

3 KEY SECTORS AND THEIR ALTERNATIVES

Where MB was used

Compost preparation, Morocco

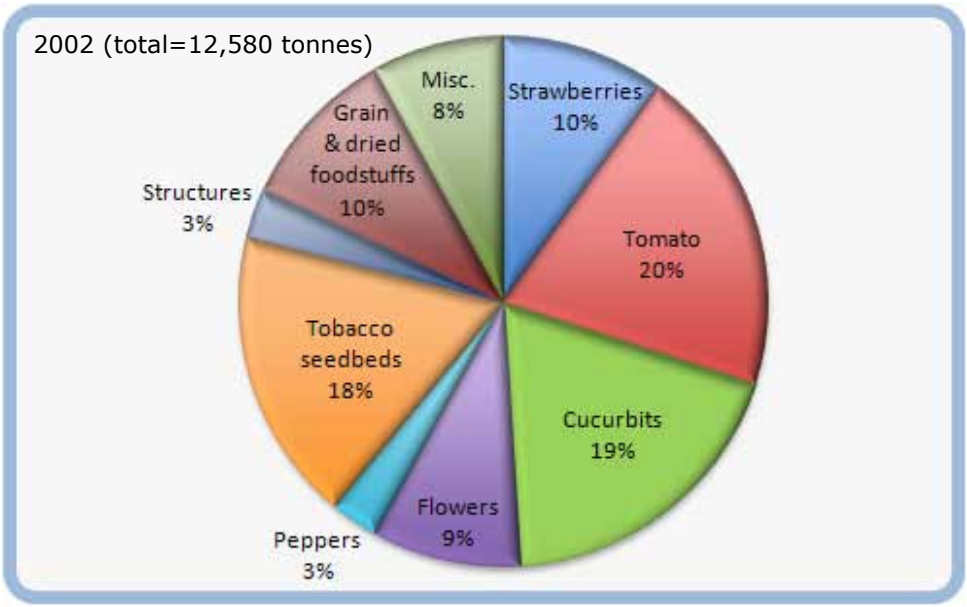
Since the beginning of the MB phase-out process some key sectors using this fumigant which clearly needed alternatives became apparent. Sectors such as tomatoes, strawberries, peppers, eggplants, cucurbits, flowers and stored grain of different kinds were particularly impacted by the MB phase-out in some countries. The tobacco industry in general used large amounts of MB for seedling production. In many countries, structures such as mills and warehouses were often disinfested with MB fumigation. Soil uses were generally much larger than uses for postharvest and structures (about 90% vs. 10% of total consumption) but technically and economically feasible alternatives were equally important for both sectors.

Table 6 describes historic uses of MB for both controlled and exempted uses.

As project implementation in A-5 countries progressed, the proportion of MB used in the key sectors has changed as seen in Fig 5.

Application	Usage
In soil	• As a preplant treatment to control soil-borne pests (nematodes, fungi and insects) and weeds of high-value crops such as cut flowers, tomatoes, strawberry fruit, cucurbits (melon, cucumber, squash), peppers and eggplant; • As a treatment to control 're-plant disease' in some vines, deciduous fruit trees or nut trees; • As a treatment of seed beds principally against fungi for production of a wide range of seedlings, notably tobacco and some vegetables; • As a treatment to control soil-borne pests in the production of pest-free propagation stock, e.g. strawberry runners, nursery propagation materials, which in some cases need to meet certification requirements;
In durables	• As a treatment to control quarantine pests in import-export commodities or restrict damage caused by cosmopolitan insect pests in stored products such as cereal grains, dried fruit, nuts, cocoa beans, coffee beans, dried herbs, spices, also cultural artefacts and museum items; • As an import-export treatment to control quarantine pests and in some cases fungal pests in durable commodities such as logs, timber and wooden pallets, artefacts and other products;
In perishables	• As an import-export treatment to control quarantine insects, other pests and mites in some types of fresh fruit, vegetables, tubers and cut flowers in export or import trade;
In "semi-perishables"	• As a treatment to control cosmopolitan or quarantine insects, to prevent fermentation or inhibit sprouting and fungal development in products that have high (>25%) or very high (>90%) moisture content, for example high moisture dates and fresh chestnuts, and also some stored vegetables, e.g. yams, and ginger;
In structures and transport	• As a treatment to control insects and rodents in flour mills, pasta mills, food processing facilities and other buildings; • As a treament to control cosmopolitan or quarantine insect pest and rodents in ships and freight containers, either empty or containing durable cargo.

Table 6. Historic uses of methyl bromide worldwide (MBTOC 2006 Assessment Report)



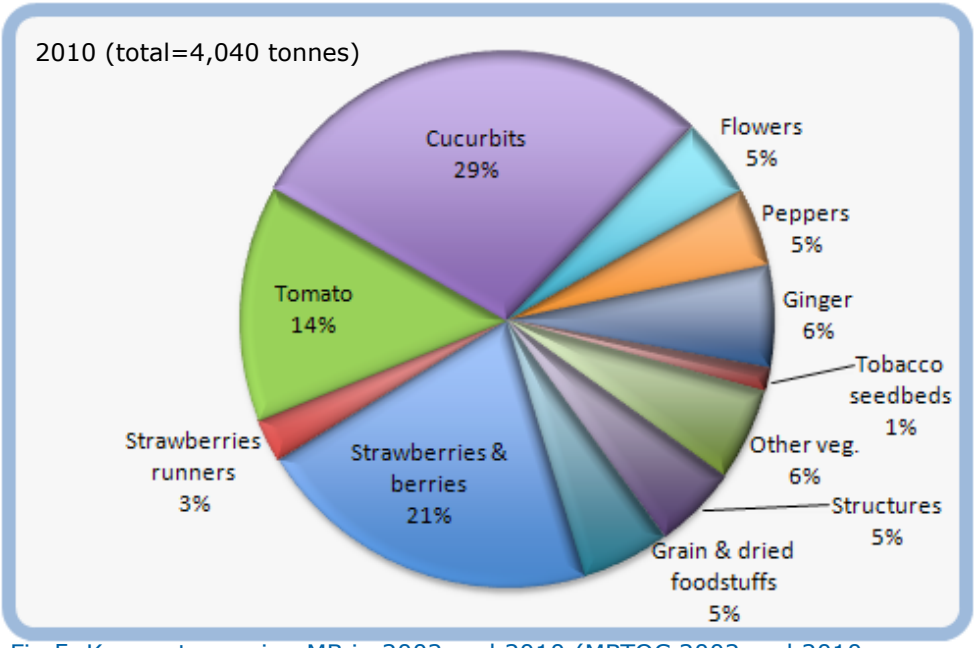


Fig 5. Key sectors using MB in 2002 and 2010 (MBTOC 2002 and 2010 Assessment Reports)

In some sectors such as tobacco seedlings, successful replacement occurred rapidly; other sectors have taken more time or faced more challenges when attempting to replace MB. A key difference influencing the process was the political willingness to implement alternatives.

In the tobacco sector for example, some large producers, particularly in Brazil, started adopting and adapting alternatives very early, around 1993/4. The technical and logistical changes needed in the tobacco sector were very substantial because the entire system and approach had to be changed. The change was much greater than shifting from one soil fumigant system to another fumigant system.

The floating tray system (see p. 33) needed a lot of ancillary technical developments, such as devising small tools for hand-sowing tiny seeds, seed pelleting technologies, technical developments in seed trays, addressing fungal growth in float systems, and addressing cold temperatures in some regions. There were many technical challenges, as well as advantages or disadvantages for different parts of the tobacco industry. Strong political willingness, which started in Brazil and slowly spread across the world to most tobacco growing regions was a decisive factor in achieving successful implementation of this alternative.

In 2013, remaining key sectors are strawberries - especially strawberry runners - ginger and some stored grain.

Rose propagation in substrates, Uganda

Selecting the best alternatives

Two broad categories of alternatives to MB can be considered: 1) *In-kind* alternatives or systems, consisting of replacing MB with another fumigant having similar or comparable effects (e.g. dichloropropene, chloropicrin, phosphine and others) and 2) *not-in-kind* systems including soilless substrate systems, hermetic storage, heating systems and other similar options.

Not-in-kind alternatives: IPM - the path towards sustainability

Substituting MB often requires a different approach to pest and disease control, sometimes even a change in attitude. There are many systems and approaches that can produce the same effect as MB in particular situations. The challenge is to be able to implement these at acceptable economic cost and in a sustainable way. A combination of measures is often the best approach.

Integrated Pest Management (IPM) is proven and effective for crop protection around the world, and an excellent option for replacing MB as well as other fumigants, which may still be available but with an increasing perspective of being restricted and even banned in some regions of the world due to their toxicity and environmental impacts.

At the same time, growers around the world are looking for ways to achieve sustainable production, that is, ensuring that they can produce profitably and efficiently at the same location, without exhausting non-renewable natural resources.

IPM requires growers or pest control staff to collect and use essential information on pests and diseases causing trouble, including:

- Identifying the causal organisms (fungi, insects, nematodes, etc.)
- How their life-cycle takes place
- How they disseminate and reproduce
- What is the optimum environment for them
- What cultivars are most susceptible and if resistant ones exist

It is essential to detect pests or pathogens as early as possible through a robust scouting or monitoring programme. This will allow for rapid spot treatment to prevent or reduce dissemination, and for choosing the most suitable control option. IPM requires growers and pest control staff to recognize symptoms of pest or pathogen attack, and understand their life cycle, epidemiology, dissemination and survival, and be aware of any alternate hosts, etc. With this kind of information, it will be possible to develop a strategy to maintain populations of

noxious organisms at a minimum, by using different tools. In essence, IPM entails using all available resources in a rational way - not just chemical control - to reduce and prevent the presence and effects of a particular pest or disease. Each one of such resources will contribute to some degree in achieving control. Pesticides may still be needed, but in lower (and clearly justified) quantities. In its practical application, IPM has shown excellent results all over the world, not only by achieving good pest control but also by improving the efficiency of the business, very often with an associated reduction in costs if compared to pest control with chemicals alone. The IPM concept is equally applicable to the control of soil borne diseases and pests as it is for pest control in postharvest and structures.

Not-in-kind alternatives for soil uses

Different kinds of alternatives were trialed in the course of MB projects aimed at identifying the best options for the particular circumstances of the sectors involved. Going on a case-by-case basis was important, as an alternative proving successful in one location could fail in another due to different costs, environmental conditions or other factors. The following sections provide a general description of the most important alternatives adopted for soils (pre-plant) uses of MB in A-5 countries around the world.

Steam

Pasteurisation or steam sterilisation is a process using heat to kill pests, diseases and weeds that are present in the soil. In simple terms, steam pasteurisation involves injecting or otherwise diffusing hot water vapour into the soil with the aid of a boiler and conductors such as injectors or pipes, in order to kill soil borne pests and pathogens.

If carried out properly, steam is probably the best technical alternative to MB in protected agriculture, proving equally effective and sometimes even better. However, many variables influence the success and cost effectiveness of steam such as: the boiler and the fuel on which it runs, the diffusers used, soil type and structure, soil preparation, whether treatment is applied to ground beds or raised benches and other factors.

Steam is more effective and less expensive when a limited amount of substrate is treated and is less effective and more costly for in-ground treatments requiring heat to penetrate much deeper. Heating the soil at depths of more than 30 cm require much longer use of the boiler, more manual labour and fuel quantities that may render steaming an economically unacceptable alternative.

Steam can be economically feasible if it makes part of an IPM system that helps maintain diseases and pests at a low level of incidence. Just like any broad-spectrum soil fumigant steam is a general biocide potentially killing all living organisms present in the soil. This can leave space for organisms either left in the soil or reintroduced, to reproduce

from naturally occurring microorganisms. For this reason, steam works best when beneficial organisms and/or organic matter (i.e. compost) are added to the soil immediately after treating.

An area or substrate that has been steamed may not remain that way for very long afterward if it comes into contact with diseased planting material or is left without planting for prolonged periods, or if general hygienic measures (also involving employees) are not observed. The fact that high temperatures can increase the solubility of some minerals, for example manganese, which may become available in excessive amounts that become phytotoxic, also needs to be considered. Very high temperatures can be further detrimental to beneficial organisms. It is thus important to not over-steam the soil. In addition, high levels of ammonia can be released from soils or substrates high in organic matter after pasteurisation, and this can also be toxic to plants. For reasons like these, it is important to add organic 'amendments' after and not before steaming.

Substrates

Many crops such as tomatoes, peppers, strawberries, cut flowers, melons, cucurbits, nursery-grown vegetable transplants, strawberry plants and tobacco seedlings are grown in soilless substrates around the world.

This production system, sometimes called hydroponic production, offers several advantages, including avoiding the need for soil sterilization. Most of the soilless culture occurs in covered or protected environments (greenhouses). A wide variety of substrates is used including artificial and natural materials such as rock wool, tuff (volcanic scoria), clay granules, solid foams (e.g. polyurethane), glass wool, peat, coconut husk materials, volcanic gravel (lapilli), pine bark, grape industry waste, sugarcane bagasse and others.

Although initial investment is generally higher than that typically associated to traditional production in soil, increased productivity and yield due to higher planting densities and better quality, usually compensate the higher cost. Experience shows that soilless substrates are a good alternative to MB especially if used as part of an IPM program. Simply isolating plants from the soil does not prevent the occurrence of soil-borne diseases and pests, as these can also become established on substrates.

A key issue in the success of soilless culture is the identification of suitable, locally available and inexpensive substrates that keep costs of this technique within reasonable levels. Plant/ water relations, pest management and planting density need to be closely monitored and adequately managed. One constraint of this technique is potential ground water contamination from systems that do not recycle the nutrient solutions.

Substrates have replaced MB for example in Kenyan rose production, in the Turkish carnation and tomato industry, in Moroccan strawberry plant production and in many other sectors.

Examples where substrates have replaced methyl bromide

In Kenyan rose production

In Turkey for carnation and tomato production

In Moroccan strawberry plant production and many others

Floating trays

The floating seed-tray technique was developed in the late 1990s and was adopted by many thousands of tobacco growers around the world who previously used large amounts of MB for seedling production. To set up the system, a shallow pool is built on leveled ground and a low wall of brick or wood (12 cm high) is constructed around the bed, which is then covered with thick black polyethylene. The pool is filled with clean water, and fertilizers and algaecides may be added. Tobacco seedlings are planted in polystyrene trays of 288 cells or less (according to particular site conditions) which are filled with substrate. The trays are placed inside the pool where they float.

Tobacco seedlings grow quickly, and the resulting plantlets are more uniform and of higher quality grade than those produced with MB fumigation.
The system is also very efficient with regards to space or land needed to develop a nursery. Floating trays were adopted through MB projects in Brazil, Croatia, the former Yugoslav Republic of Macedonia, Argentina, Zimbabwe, Malawi and others. Their economic feasibility has been challenging in some instances, particularly when necessary inputs such as substrates, trays or pelleted seeds cannot be locally sourced and need
to be imported. Training large numbers of growers is also necessary.

Tobacco seedlings, Argentina

Tobaccco seedling production in floating trays, Zimbabwe

Compost

Organic amendments such as composts, animal and green manures and various by-products from agriculture, forest and food industries, are used in many countries to manage certain soil-borne pests such as fungi and nematodes, in different crops. Although they cannot be considered a one-to-one alternative to MB, there is clear evidence that such organic amendments can alter populations of soil microorganisms, leading to the long-term decline of soil pathogen populations. This is a long-term approach that can help reduce the need for soil fumigation and is a relevant component of IPM.

Limitations for the use of compost include possible inconsistency of results due to variable processing techniques, the requirement for large amounts of compost needed for treatment to be effective, high transportation costs and the need to set up appropriate logistics at the farm. It has nevertheless been demonstrated that aside from providing beneficial mircoorganisms to the soil, compost is an excellent fertilizer and improves water retention capacity. Compost enriched with beneficial organisms such as *Trichoderma*, yeasts and beneficial bacteria provides good control of some soil fungi, which are often associated with monoculture, poor soil structure, poor soil aeration and deficient water management.

It is important to set up an adequate and carefully monitored composting site and routinely observe environmental conditions (temperature, pH, oxygen aeration, humidity). Depending on the plant types processed, composting can take between four and five months. Composting is yielding excellent results for example in Morocco, where research has been conducted to determine the ideal composition of different composts, the correct amounts to be applied to different crops, the timing of the application and other variables.

Compost site, Ecuador

Biosolarization, Ecuador

Biofumigation and solarisation

Solarisation is a process whereby solar heat is trapped under clear plastic film placed over moist soil, which increases soil temperature to levels that are lethal to pests and pathogens. It was originally developed in Israel and used there and in other arid and semi-arid regions with high radiation and minimal rainfall, as these conditions seemed essential for the appropriate amount of heat to accumulate in the soil. Its use is now being expanded into areas with different climates by combining it with other options, for example biofumigation. Biofumigation is defined as the emission of volatile compounds occurring during the decomposition of organic matter incorporated into the soil, which contributes to pathogen control. The process normally takes about four weeks, which may require appropriate planning of cropping schedules.

Soil solarisation has been studied in more than 50 countries around the world for different crops including tomatoes, tobacco, melons, peppers, strawberries and flowers. It has been successfully used in MB phase-out projects for example in Egypt, Jordan and Costa Rica, and more recently in Ecuador combined with biofumigation. An interesting adaptation of solarisation where relatively small amounts of substrate can be solarized inside a “solar collector” was devised and used in Brazil to replace MB used by thousands of pot plant growers.

Grafting

In simple terms, a graft is the union of two portions of plant tissue that grow together as a single plant. It is possible to successfully graft certain plants having characteristics that are commercially desirable, but which are susceptible to certain soil-borne pests or diseases, onto resistant roots that are not affected by such problems. The rootstock may be from a different cultivar, a different species and even a different genus from the same family as the susceptible plant. Grafting provides excellent protection against damage caused by soil-borne pathogens affecting some vegetables and fruit crops that are infested with root-knot nematodes and fungal pathogens. This technique initially became widespread in major agricultural sectors in Mediterranean countries, and also in Korea and in Japan.

It was successfully implemented through MB phase-out projects for example in Turkey, Morocco, Egypt, Mexico, Guatemala and Honduras, for crops like tomatoes, peppers, eggplants, melons and watermelons. Although the technique is labour-intensive and generally represents higher production costs than traditional production, these are usually offset by higher yields and improved quality. Grafted plants are often more vigorous and fewer plants are required per hectare to produce larger yields.

When combined with IPM, including alternative fumigants or fungicides, grafted plants provide a clear alternative to MB. Recent research is increasing the number of available rootstocks for most crops, and nurseries offering grafted plants of excellent quality have appeared in many countries.

Grafted tomato plant nursery, Honduras

In-kind alternatives for soil uses: Fumigants

In the search for a replacement for MB, many trials with alternative fumigants have been conducted around the world, in both developed and developing countries. Their efficiency varies with factors such as the pathogens to be controlled, soil characteristics, climate and the application method used. Various fumigants have been evaluated, with metham sodium, dazomet and a mixture of 1,3-dichloropropene and chloropicrin being the most widely adopted. Some factors to consider when using fumigants include:

• Their efficiency is highly dependent on soil conditions (temperature, soil type, moisture) and on the application system used. All these factors may impact the way in which a fumigant disperses throughout the soil.

• The combination of fumigants with other alternatives (e.g. biofumigation and metham sodium) often brings good results and allows for lower dosages of the fumigant.

Spading machines that inject metham sodium more efficiently have proven very useful to achieve better control of soil-borne pathogens for example in strawberry fields in Mexico and Chile.

Not-in-kind alternatives for postharvest uses

As with soils uses, alternatives to MB for postharvest uses had to be carefully evaluated, keeping particular circumstances in mind. High humidity and warm temperatures prevalent in some tropical countries, for example, can make pest control very challenging. The commodities in storage and the particular pests to be controlled also need consideration. The main alternatives adopted through the projects are described in the following section, starting by not-in-kind alternatives (i.e. alternatives which do not intend to replace MB directly with another comparable fumigant).

Heat

Various heat treatment methods are used to treat structures, museum artifacts and other items. Generally, a temperature of at least 55°C needs to be achieved, and in many cases this should not go beyond 60°C to avoid damaging the treated items. Humidity control may be needed for sensitive items. Simple and inexpensive solarization methods to heat treat artifacts have also been developed, and consist of wrapping artifacts in black plastic and placing them in the sunshine, while carefully monitoring temperature to ensure
the minimum required is reached and the maximum allowed is not exceeded.

There are two general types of heat treatments: structural (full-site) and spot treatments (performed when a pest outbreak is detected). Achieving successful structural heat treatment involves raising the building or site temperature to 50-60°C in a gradual manner to reduce risk of damage (i.e. at a rate of 5°C per hour, and then cooling at a rate of 5- 10°C per hour). Maximum temperatures should not exceed 60°C, and sufficient heaters should be available to ensure that the desired temperature is reached within six to ten hours.

Important issues associated with heat treatment include:

• Calculating the amount of energy required after accounting for heat losses (for example, from exposed surfaces, equipment and infiltration)
• Use of air movers or fans to ensure uniform heating

• Monitoring temperature during treatments to ensure adequate temperature is achieved everywhere.

Although pests present in stored products typically die in less than one hour at 56°C, heat-treated structures should be maintained at this temperature for periods of 24-36 hours to ensure uniform heat distribution throughout. Walls or floors in basements of concrete construction may prove difficult or impossible to heat to the required level because they act as heat sinks. Insulated floor mats, diatomaceous earth and/or insecticide sprays may thus be needed to complement treatment on such surfaces.

Spot heat treatments are applied to pieces of equipment, or an area in a processing facility. Hot air is moved by fans or forced hot air (creating a high pressure zone) until a temperature of 55°C or more is reached for the required time. A barrier of diatomaceous earth, insecticide sprays or food-grade mineral oil applied in a thick drip line should to be put in place in order to kill pests before they escape from the heated area in search of cool refuge. Spot treatments are a good option for situations where a full site treatment is not practicable, or to delay the need for a full site treatment. It can be used as an efficient component of an IPM program.

Flour mill, Jamaica

Cold

Cold is widely used for storing seeds, dried fruit, and grain (primarily thorough aeration). It is also extensively used for fibre-containing museum artefacts (such as carpets) under very controlled conditions. Cooling applied after a disinfestation process such as fumigation, can give long-term protection against pest damage. Temperatures and exposure times to achieve adequate control have been extensively researched and are known for a wide variety of pests. Typically stored grain insect pest reproduction stops at about 14°C, though a few pests such as mites can reproduce, though slowly, at lower temperatures under suitable humidity.

Modified atmospheres

Vacuum systems and cocoons that create modified atmospheres (high CO_2, low oxygen through hermetic sealing) have increased in commercial use in many countries. The low oxygen environment prevents the development of many pests in grain, dried fruit and other commodities. The technology is generally inexpensive and easy to use and has proven successful for example in Turkey for treating dried fruit and in Viet Nam for rice, coffee beans and other commodities. It is also available and in use in China.

Controlled atmospheres are applicable to a large variety of products like nuts, rice, dried fruit, tobacco, and also long-term storage of paddy rice.

The technique is based on providing a low oxygen environment under which the insects die; it is reported as very effective with complete kill of all insects in all stages of development with appropriate exposures.

Contact insecticides

Contact insecticides can provide residual protection against stored product insects in bulk stored grain, wood and wood products, museum artefacts, and in storage buildings and transport vehicles. They are also used as surface, crack and crevice treatments to the floors and walls of grain storage bins, flour mills, food processing facilities, and food warehouses, and as space treatments to open areas inside storage sites. Where permitted, and where pest resistance is not a problem, they can provide a useful insect control method that avoids extensive infestations.

Stored-product insects vary considerably in their susceptibility to insecticides and individual life stages of insects may also respond differently, so accurate species identification, and selection of insecticides or treatment strategies based on the target pest species is always recommended.

Organophosphorus compounds are still an important group of grain protectants for many A-5 countries; however there are concerns with their toxicity and persistence and pest resistance status. Pyrethroids are a group of synthetic insecticides with a chemical constitution based on that of the active ingredients of natural pyrethrum. In contrast to organophosphates, residues from applications of synthetic pyrethroids are very stable on grain and do not break down with increases in temperature. Pyrethroid insecticides used in different countries as grain protectants include resmethrin, bioresmethrin, deltamethrin, pifenthrine and cyfluthrin.

Another class of grain protectants is the insect growth regulators (IGRs). An IGR used extensively on stored grain is methoprene.

Pheromones

Pheromones are chemicals produced by one member of a species that are transmitted externally to and influence the behavior or physiology of another member of the same species. Sex pheromones, including those of many storage-related pests, both beetles and moths are the chemicals in this group that have been subjected to the most research.

Pheromones have been used successfully for example in Mexico and Jamaica, as trap baits to monitor stored product pests or they may be employed, particularly as moth pests, as direct control agents via mass trapping, pathogen dissemination or mating disruption. In general, they lead to suppression, but not total disinfestation of such pests, but are considered and important tool for locating infestations, which make them an important component of IPM programs, and can reduce some pest infestation to levels below economic thresholds.

In-kind alternatives for postharvest uses: Fumigants

Phosphine

Phosphine is registered worldwide for disinfestations of durable commodities and is in wide use mainly for cereals and legumes, dried fruits and nuts as well as herbs and spices. Countries where it has successfully replaced MB include Turkey, Indonesia, Iran, Jamaica, Viet Nam, the Philippines, Thailand and Cameroon. It is also used to disinfest structures such as warehouses and mills in some situations, and even to treat museum objects made of wood or paper. Phosphine has the potential to act as a direct replacement of MB in many situations, but can also act as a component of an IPM programme. It is a highly toxic fumigant, but is used at low concentrations. Its action against pests is generally slower than MB, with longer exposure times required, particularly under low temperatures so different treatment logistics may need to be put in place. It is generally ineffective below 15°C.

Phosphine penetrates well into commodities and can be rapidly removed by aeration after treatment. However, it reacts with metals such as copper, and in some situations this may limit its use, especially when electrical equipment is present as it could become corroded. The combination of phosphine, CO_2 and heat is sometimes used to avoid this problem. Phosphine with CO_2 has been successfully adopted, for example, in Egypt to disinfest stored cereals and in Turkey for treating dried fruit.

Most solid formulations of phosphine contain aluminum phosphide or, less commonly, magnesium phosphide, formulated with ammonium carbamate or urea to lessen the risk of flammability. Recently generators and cylinderised phosphine have become available, allowing controlled release of the phosphine gas and avoiding some problems such as residue disposal associated with tablet formulations.

Guidelines for the use of phosphine include:

• The temperature of the commodity should be higher than 15°C in most cases, although certain post-harvest grain pests are susceptible to phosphine down to 10°C with long exposures;

• Prolonged exposure treatments are often necessary for effective action against all developmental stages of pests, typically at least five days but may be 15 days or longer, depending on the method used for distributing the phosphine, the temperature and the target species;

• Appropriate techniques must be used to avoid the development of resistance. Insect populations are capable of developing resistance to phosphine relatively easily. High levels of resistance have been observed, particularly in tropical areas, following frequent use of phosphine in conditions of poor

gas-tightness, leading to deficient pest-control. Correct exposure times and appropriate application technology are essential to prevent resistance.

Phosphine resistance poses a major threat to sustainable use of this fumigant in A-5 countries. There is thus an urgent need to develop and register non-MB alternatives as a precaution, if phosphine should become no longer effective.

Fumigation of grain stacks with phosphine, Egypt

Sulfuryl fluoride

Sulfuryl fluoride (SO_2F_2) is a non-flammable, odourless and colourless gas. It has a very high Global Warming Potential (GWP). Due to its low boiling point and high vapour pressure, it readily vaporizes under normal fumigation conditions, with rapid dispersion through spaces and stored products. It is usually non-corrosive, so can be used where sensitive equipment and electronic devices are present. This fumigant was developed in the late 1950s in the USA as a structural fumigant, mainly for termite control. It has been marketed since 1961 for control of wood and structure pests and since 2003 for controlling pests affecting the food industry in some developed economies.

Sulfuryl fluoride has been trialled successfully in Mexico and Egypt, but registration of this product is not yet widespread in developing countries. The fumigant was considered as a replacement for remaining uses of methyl bromide in grain storage in China, but was not adopted despite China being a sulphuryl fluoride manufacturer.

Sulfuryl fluoride can be used for treatment of buildings, furnishings,

construction materials, and transport vehicles to control a wide range of pests including dry wood termites, Formosan subterranean termites, longhorn beetles, powder post beetles, furniture and carpet beetles, clothes moths, cockroaches and rodents. It is highly toxic to post-embryonic stages of insects, but the eggs of many moths and beetles are difficult or impossible to control fully at permitted dosages, especially at lower temperatures. Effective dosages for all life stages can usually be obtained by varying concentration and exposure time, but in general higher temperatures (over 27°C) are needed to obtain satisfactory control at practical dosage levels.

Grafting, Mexico

4 LESSONS LEARNED AND CHALLENGES

The methyl bromide phase-out process has been instrumental in raising awareness about the fragility of the ozone layer and the steps necessary for its protection. It has also generated a wealth of information, expanded knowledge and expertise among key stakeholders in various sectors and often provided them with better and more modern pest management practices and production techniques.

As a result, many growers around the world have been able to improve yields and quality of their products; business efficiency has been improved; and a clear path towards sustainable production has been set.

Those that are able to sustain the phase-out further make market headway, since environment-friendly production practices are increasingly important, especially in developed (non A-5) countries where importing markets for many A-5 countries are located.

These great achievements, however, have not always come by easily, and challenges still remain, as described in the following sections.

Silos for grain storage, Zambia

Factors influencing adoption of alternatives

A major hurdle when introducing alternatives is that this process often needs to be carried out against the background of an established system, with infrastructure, equipment, supply chains and reputation already in place.

The process followed for selecting the most suitable alternatives, where these were first trialed and demonstrated and where key stakeholders were involved, contributed to creating a good level of acceptance towards the alternatives proposed. Although technically feasible alternatives have been identified for virtually all uses of MB, it quickly became clear that each alternative system needed to be judged against the local biological and commercial environment. It was also evident that various issues beyond the economic feasibility of alternatives impact the long-term sustainability of the proposed alternatives, for example:

• Market drivers - specific market windows requiring precise technical and business skills

• Consumer issues - preference for certain certification schemes or eco-labels

• Installed capacity - sufficient and economically feasible airfreight and/or cold storage

• Regulatory factors – registration and commercial of alternatives

• Sufficient consumption volume of a given input to develop a market and ensure availability of an alternative.

In summary, a wide approach is necessary, including registration and commercial availability of successful alternatives, at feasible costs.

Adoption of alternatives may also require changes in production systems and process management, with associated investments that may be significant. As a consequence, willingness, commitment and a proactive approach are necessary and there are instances where reluctance to change appears to be the major barrier to successful adoption of alternatives.

One of the lessons learned from the phase-out process is that being able to adapt alternative technologies to local conditions is very important to ensure their success. Experience with similar sectors in similar regions or countries proved critical for the commercial adoption of alternatives but so is adaptation to local circumstances. Successful adoption of alternatives has occurred in periods of two to three years, which sometimes even included registration of chemical alternatives.

Training, information exchange and stakeholder involvement

Appropriate involvement of key stakeholders and a strong political willingness were critical to the success of projects aimed at replacing MB. Proactive growers were instrumental in leading others to trial and later to adopt alternatives, and in helping reduce reticence to change. Involving technical staff and consultants from a given sector as well as researchers and instructors proved very important to support project activities. Involving government institutions – including agriculture and the environmental authorities, customs and pesticide registration officials ensured further support. Participation of suppliers of alternatives and even MB importers also contributed to the success of many projects.

Training has been an essential component of the phase-out process, and needs to be a continued effort. Training updates and capacity building in the changing scenario of MB alternatives are needed continually, as some alternatives are knowledge-intensive. It is also necessary to provide information on new developments and improved techniques and to support newcomers in the field. New or updated technical skills are often required to implement alternative technologies and correct identification and understanding of the specific pests or diseases affecting a crop are always required. In addition, various sectors have experienced significant expansion at a time when some projects were already well advanced and even new sectors, which are potential MB users, have appeared. Disseminating information, providing educational materials and promoting ample information exchange among stakeholders (not only locally but also regionally) should be a continued priority.

5 THE WAY FORWARD: SUSTAINING THE PHASE-OUT

Methyl bromide phase-out has come a long way in developing countries and, given that all countries still reporting consumption have ongoing projects to support and finalize the adoption of alternatives, it is expected that the remaining usage will be able to transition smoothly, in time for the 2015 deadline. However, MB is unique amongst ODS in that it is always theoretically possible to return to this fumigant after having used alternatives, as production capacity will remain after phase-out to supply exempted QPS uses. In contrast, other ODS (for example refrigerants) generally require production plants to undertake significant technological conversions and going back to previous system would rarely be justifiable.

Inspecting tropical flowers before shipping, Costa Rica

Factors impacting sustainability

As already described, efforts to replace MB have made it clear that a "drop in" replacement for MB is not the goal but rather that an integrated approach combining different alternatives provides the best results. Selected alternatives need to be cost-effective, technically feasible, and commercially available and these factors should be considered when assessing long-term viability of alternatives.

Technical feasibility refers to whether the selected alternative provides the required level of pest and disease control; further, the application technique or the process followed, the dosage used, climatic factors when using alternatives and other factors can impact the effectiveness of alternatives and the consistency of results.

Economic feasibility goes beyond the mere cost of an alternative, and requires thorough analysis. For example, an alternative that is more expensive than MB may be justifiable if it does not lead to significant market disruption; it could actually achieve higher yields and quality, offsetting the extra cost and even improving commercial acceptance and market penetration of a given product. There are examples of this such as when using substrates or grafting. In the case of IPM, setting up and implementing an appropriate programme may require special training and infrastructure, which could increase costs initially, but later lead to substantial savings through rationalized pesticide, water and fertilizer usage.

Market issues include consumer acceptance of alternatives, but also adequate market access and ability to reach market windows. Availability of inputs and services in a timely manner and at affordable costs is also essential and directly influences economic feasibility.

Institutional capacity to support the phase-out achieved is very important. Technical assistance and extension services, research and training capacity have often been improved through projects. In addition, integrating National Ozone Units and country authorities which are key partners to ozone layer protection need to be continuously involved.

Political and regulatory issues directly impact the sustainability of the phase-out. The majority of investment projects carry an agreement from the country involved to phase out MB for controlled uses entirely and to support the phase-out with a policy package banning MB imports for controlled uses. The capacity to track actual use of MB imported into the country, specifically that MB intended for QPS uses does not end up used for controlled applications is also important. Supporting the registration of alternatives to ensure their availability for users should also be ensured.

In summary, the issue is not just about replacing MB, but rather it is about developing long-term successful pest management strategies, with the options available and with an aim to ensure sustainability.

Some remaining concerns

Continued supply of methyl bromide and promotion of use

The 2015 phase-out comprises controlled uses of MB and excludes QPS, as these are presently exempted under the Protocol. Comprising just about 10% of total global MB uses in 1992, QPS uses of MB have now become the largest uncontrolled ODS emission of the Montreal Protocol. Since 2008, exempted (QPS) uses of MB became greater than controlled uses, and this gap widens substantially each year, as controlled usage nears complete phase-out.

As long as no controls are in place, continuing, plentiful production of MB for allowable QPS purposes provides a base production capacity and scale for the industry that can keep MB prices at a level where it is still attractive for non-QPS users, with no scarcity pricing. This situation, often combined with well-funded promotional efforts for MB use, negatively impact the MB phase-out achieved and may put its sustainability at risk. Initiatives taken by the Parties in previous years to evaluate the feasibility of adopting alternatives for QPS have shown that it is easily possible to replace MB at least for some such uses.

Controlled vs. exempted uses of MB and possible illegal trade

Many A-5 countries have expressed concern over illegal trade and/or use, and in particular, the diversion of MB imported for QPS uses into controlled applications. Consumption for QPS has shown an upward trend in many A-5 countries over the last 10 years. Although there may be various explanations for this, including increased trade, the reason which is often cited is the difficulty in tracking actual final use of imported MB. Continued efforts to implement and strengthen tracking systems combined with training and other options to ensure that MB imported for QPS is indeed used for this purpose, seem well justified.

Long-term viability of some alternatives

Pest and disease management is an interactive process that can present many challenges. An alternative that has been successfully implemented may face problems. Restrictions and bans on alternatives as a result of environmental or health concerns may arise (particularly in the case of chemical alternatives) or necessary essentials may become unavailable.

The change in control methods (from MB to alternative systems) may allow for the more frequent presence of pests or diseases that were secondary in the past (or controlled to a very large extent with MB). Pest resistance to alternatives may also arise; this is for example a very real possibility when fumigating grain with phosphine, as stated earlier.

Cocoa beans in storage, Cameroon

Continuity of training and awareness-raising activities

The high turnover of ozone officers and customs officers taking place in some countries, or an increased number of growers arriving at expanding sectors after projects have finished may increase the need for training and dissemination. Poor inter-institutional integration and communication and lack of robust systems for detecting and tracking MB imports and their final use destination can also challenge the sustainability of the phase-out achieved.

The continuity of programs established through projects - particularly technical assistance and awareness–raising needs consideration. These should further include health-related risks associated with both MB phase-out and its chemical alternatives, in particular the specific effects on men and women.

Securing funding options to sustain the phase-out once projects are completed may appear like a difficult task, but in many instances, creating linkages with other environmental/sustainability initiatives, promoting information exchange within productive sectors locally or at the regional level and others, can provide good options to help reach this goal. The fact that alternatives contribute to developing skills that increase working options for women for example, should not be underestimated.

Critical use exemptions

Article 2H of the Montreal Protocol provides for Critical Use Exemptions (CUE) for developing (non A-5) countries after the phase-out deadline. This option has been available to developed (non A-5) countries since 2005, and although hurdles to the adoption of alternatives were noted in some sectors initially, only four CUEs remain for 2015 (down from an original number of about 115 in 2005).

For 2015, three A-5 Parties have submitted CUNs, mostly in the same sectors for which non A-5 Parties requested these exemptions in the past.

Steam has replaced MB for example in the ornamental plant sector of Mexico, where growers pasteurize the growing medium before planting, with excellent results.

Annex 1
Further information

A wealth of information on alternatives to MB and how to implement them has become available during the last 20 years or so, over which this process has spanned. Below are some useful resources on this topic.

- The Protocol's Methyl Bromide Technical Options Committee (MBTOC) conducts very thorough work on methyl bromide use and its alternatives, for both controlled and exempted uses. Quadrennial Assessment Reports, yearly Progress Reports and other relevant publications can be accessed and downloaded at the Ozone Secretariat website: http://ozone.unep.org/new_site/en/assessment_docs.php?committee_id=6&body_id=6&body_full=Methyl%20Bromide%20Technical%20Options%20Committee&body_acronym=MBTOC

- UNEP's Ozonaction Programme also offers various reports and other kinds of information on methyl bromide, which can be accessed at: http://www.unep.org/ozonaction/Topics/MethylBromide/tabid/6221/Default.aspx

- Assistance to A-5 Parties of the Montreal Protocol is provided through Methyl Bromide Officers in UNEP's Compliance Assistance Programme (CAP). Regional offices and contacts may be found at: http://www.unep.org/ozonaction/AboutTheBranch/StaffContacts/tabid/6190/Default.aspx

- The Multilateral Fund for the Montreal Protocol offers reports on monitoring and evaluation activities conducted on ODS including MB. These can be consulted at: http://www.multilateralfund.org/Evaluation/evaluationlibrary/default.aspx

- Other Implementing Agencies – UNIDO, the World Bank and UNDP - also offer useful sources of information on their websites.

- The reader is further directed to the many scientific articles published every year reflecting studies conducted by many research teams around the world, as well as to workshops and scientific meetings periodically held in many countries (see for example www.mbao.org).

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

> The International Environmental Technology Centre - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.

> Sustainable Consumption and Production (Paris), which promotes sustainable consumption and production patterns to contribute to human development through global markets.

> Chemicals (Geneva), which promotes sustainable development by catalysing global actions and building national capacities for the sound management of chemicals and the improvement of chemicals safety worldwide.

> Energy (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.

> OzonAction (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.

> Economics and Trade (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information
see **www.unep.org**

www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel.: ++254-(0)20-762 1234
Fax: ++254-(0)20-762 3927
E-mail: uneppub@unep.org

UNEP

For more information, contact:
UNEP DTIE
OzonAction branch
15 rue de Milan, 75441 Paris CEDEX 09, France
Tel: +331 4437 1450
Fax: +331 4437 1474
ozonaction@unep.org
www.unep.org/ozonaction

Multilateral Fund
for the Implementation of the Montreal Protocol

As the 2015 deadline for final phase-out of methyl bromide in A-5 countries approaches, an important achievement of the Montreal Protocol has become evident: over 85% of the controlled uses of this once widely used fumigant have already been successfully replaced and remaining uses are being replaced. This booklet addresses the efforts undertaken to get there, the challenges involved, the lessons learned and ways to ensure the continuity and sustainability of the phase-out.

DTI/1794/PA