PAN Europe

Pesticides Action Network Europe

Methyl Bromide- phase out and alternatives

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Phase out under the Montreal Protocol – a concrete opportunity to ban a hazardous pesticide

It is well established that some widely used man-made chemicals are destroying the stratospheric ozone layer, which shields the earth from ultraviolet radiation. A strong international consensus on protection of the ozone layer developed and was given form in the *Montreal Protocol on Substances that Deplete the Ozone Layer* that came into force in January 1989. Methyl bromide has been identified as one of the chemicals depleting the ozone layer and its phase out was considered a very important step, although pre-shipment and quarantine uses (about 22% of global methyl bromide use) are exempt from the controls of the Protocol. In non- Article 5(1)[1] countries, which includes EU, the ban is in effect from 1 January 2005 onwards with quotas allocated for "critical use exemptions". In the European Union the legal framework is set by Regulation EC 2037/2000, which is slightly stricter.

But despite the stricter regulation in terms of phasing out and ceasing the production, the EU fails in getting rid of methyl bromide as it should. Allocation for critical use exemptions in EU countries was 4,032t in 2005 despite the existence of feasible alternatives. This represents roughly 27% of the consumption registered in 1993. This quota allocation for the EU countries represents 27.8% of the total allocation to non Article 5(1) countries in 2005. In addition, a 59.0% quota was allocated to the USA, 7.2% was allocated to Israel and 4.8% was allocated to Japan (1). Within the EU, eight countries have requested critical usage: Belgium, Spain, France, Greece, Italy, Poland, Portugal and the UK. The other countries do not use methyl bromide as soil fumigant but only Denmark, Finland and Sweden seem to have taken their commitment more seriously, with either no quarantine and pre-shipment uses or critical exemption uses.

Methyl bromide not only depletes the ozone layer; it's also a hazardous pesticide classified as a Bad Actor by PAN North America due to its acute toxicity, moderate aquatic toxicity and for being a developmental or reproductive toxin (2). Methyl bromide is toxic to the central and peripheral nervous systems and exposure is known to cause skin, kidney, respiratory, liver and neurological damage resulting in severe or permanent health effects (2), (3), (4), (5). Acute exposure can also cause death (6), (7) and serious effects such as pulmonary edema, congestion, and haemorrhage (8). The risks are not confined to workers and applicators but also include other workers not actually involved in the fumigation and the general public in the vicinity (9), (10), (11).

Table 1: Phase out of methyl bromide under EU Regulation EC 2037/2000 and Montreal Protocol

EU Regulation EC 2037/2000	Non Article 5(1) countries	Article 5(1) countries
▪ 25% reduction by 1998	▪ 25% reduction by 1999	▪ Freeze by 2002 at average 1995-1998 base level
▪ 60% reduction by 2001 and freeze quarantine and pre-shipment uses	▪ 50% reduction by 2001	▪ Review of reduction schedule in 2003
▪ 75% reduction by 2003	▪ 70% reduction by 2003	▪ 20% reduction by 2005
▪ End of production by 31/12/2004		
▪ Phase out by 2005 except for critical use exemptions	▪ Phase out by 2005 except for critical use exemptions	▪ Phase out by 2015 except for critical use exemptions

Source: UNEP (1998) (12)

[1] Article 5(1) countries are, according to the Protocol [*Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A is less than 0.3 kilograms per capita…]*

Uses of Methyl Bromide

About 71,500t of methyl bromide are used annually worldwide and around 97% is used as a fumigant for pest control, mostly in developing countries (75%) (12). Methyl bromide is used as an insecticide, acaricide, rodenticide and soil sterilant. Its properties were first described in 1932 and were introduced by Dow AgroScience, who no longer manufacture or market it. It is extremely phytotoxic and is used as a multi purpose fumigant used for pest control in mills, warehouses, grain elevators, *etc.*; in stored products; soil fumigation for control of insects, nematodes, soil-borne diseases, and weed seeds; and glasshouse and mushroom-house fumigation (13).

Soil Treatments

Soil fumigation is the single largest use category, accounting for about 76% of global use. Most is used for the fumigation of horticultural crops including tomatoes, strawberries, melons, cucumbers, peppers, tobacco and cut flowers (14). In the fumigation process methyl bromide is applied either to the soil surface or by mechanized injection. For surface applications, the area to be treated is covered with plastic sheeting and the gas is released into the space between the soil surface and the sheet.

Of the quantity allocated to EU under the critical use exemption in 2005, Italy receives 2,133t, Spain 1,059t, France 431t, Greece 200t, UK 74t, Portugal 50t, Belgium 45t and Poland 40t. The use in crops is divided up into: 1,544t in strawberry production, 452t for cut flowers, 394tfor peppers, 230t for cucurbits, 227t for aubergines and 58t for other crops (1).

Durable commodities and structures

Some economically important commodities including dried fruit and nuts, cereal grains and flour and timber use methyl bromide as a principal means of pest control. Pests that infest durable commodities often establish in the buildings or structures where the food is stored or processed. Wood destroying insects can also infect the wooden parts of the building. The UN Methyl Bromide Technical Options Committee (MBTOC) estimated that the treatment of durables is responsible for 13% of methyl bromide used worldwide – 19% in developing countries – and the treatment of structures and vehicles is responsible for 3% (14).

Perishable commodities

Methyl bromide is the most widely used treatment for disinfestation of perishable commodities. About 9% of global methyl bromide consumption is used for disinfestation of perishable commodities, with about half used for disinfestation of fruit for quarantine purposes (14).

Chemical alternatives in the Europe Union

Although the EU has been making progress in phasing out methyl bromide, the chemical alternatives in consideration are mostly hazardous for health and the environment and should be avoided. They are currently going through review under the Pesticides Authorisation Directive (Directive 91/414/CEE) and many of them will see a final decision about their authorisation for the EU market during 2005.

On the one hand the Montreal Protocol contributed to phase out the use of a hazardous fumigant; on the other hand it's not clear whether Europe will take this opportunity to replace it for better alternatives for health, environment and farmers' economies. We might be committing a new error, one that will take many years to solve and lead to considerable costs for health and the environment. Due to the serious hazards and environmental fate associated with the chemical alternatives, all efforts should be made to encourage non-chemical alternatives to methyl bromide.

Table 2: Chemical alternatives classified by hazard, stage in the Directive 91/414 review and possible date of decision

Chemical alternatives	Hazard	Stage	Possible data of decision
1,3 - D	AT, C, GWC	2nd	2005
Metam (sodium or potassium)	AT, C, DFT, AAT	3B	2008
Sulfuryl fluoride	AT	New active substance	2006
Chloropicrin	AT, potential GWC	3A	2008
Sodium tetrathiocarbonate	Not listed	3B	2008
Cadusafos	AT, CI	2nd	2005
Oxamyl	AT, CI, moderate AAT	2nd	2005
Carbofuran	AT, CI, AAT	2nd	2005
Phenamiphos	AT, CI, potential GWC	2nd	2005
Malathion	Moderate AT, possible C, CI, suspected ED, AAT	2nd	2005
Pirimiphos-methyl	AT, CI	2nd	2005
Deltamethrin	Moderate AT	1st	Included in Annex I 14/01/2003
Propamocarb	Not listed	2nd	2005
Etridiazole	Slight AT, C	3B	2008

Source: PANNA database (2), Tomlin (2003) (13), Proceedings of 5th International Conference (15)

Notes: AT – Acute toxicity; C – Carcinogen; DRT – Developmental or reproductive toxin; AAT – Acute aquatic toxicity; CI – Cholinesterase inhibitor; ED – Endocrine disruptor; GWC – Ground Water Contaminant

Non-chemical alternatives to methyl bromide

MBTOC, which is made up of experts from all over the world, and which oversees the search for alternatives, defined alternatives as "those non-chemical or chemical treatments and/or procedures that are technically feasible for controlling pests, thus avoiding or replacing the use of methyl bromide". "Existing" alternatives are those in present use in some regions; "potential" alternatives are those in the process of investigation and development. Although in some regions a high number of dispersed small users can make the transition difficult, experience in Multilateral Fund projects (projects funded under the Montreal Protocol) shows that very large numbers of methyl bromide users can be trained and prepared for alternatives within a relatively short period of time and that adoption of alternatives can occur rapidly (16).

Alternatives can be identified for virtually all uses of methyl bromide and many of them are in use in different countries around the world. However, there is no single substance that can replace methyl bromide in all its applications. Many of the alternatives consist of a combination of practices and techniques to achieve pest control.

1. Alternative soil treatments

In most cases an Integrated Pest Management approach is necessary for soil-borne control of pest to be effective, safe and environmentally benign. A number of non-chemicals are in use and potential alternatives are under investigation.

- **Cultural practices**

Crop rotation and cover crops: are used effectively in many parts of the world as part of a successful IPM approach. For example, oilseed rape produces isothiocyanate and related mustard oils, which kill fungi and nematodes and is used in many crop rotation schemes (12). A number of crops including castor (*Ricinus communis*), oat (*Avena sativa*), sorghum (*Sorghum bicolour*), crotalaria (*Crotalaria spectabilis*), sunn hemp (*C. juncea*) and various grasses are known to suppress root-knot nematodes. Although less effective than solarisation or soil fumigation, the efficacy of cover crops might be improved by combining with other methods such as the use of nematode-resistant crops (17).

Fertilization and plant nutrition: if properly managed can reduce significantly pests and diseases. For example, pod rot in peanut can be reduced by enhanced calcium nutrition by application of lime to the soil (12).

Plant growth substances/organic amendments: composted soft wood and hard-wood bark reduce the incidence of soil pathogens such as *Pythium ultimum*, a fungus that causes damping-off disease under green-house and field conditions. Soil amendments with composted olive and fresh grape pomace caused a significant reduction of root-knot nematodes in melon in Italy. Limitations however include lack of large-scale manufacturers, inconsistency in product characteristics, high transportation costs, *etc.* (17). Rock wool, tuff stone, clay granules, waste grain hulls, forestry and industry waste can provide clean soil substitutes allowing good nutrition and enhancement of natural predators (12). Strawberry growers in Scotland are successfully using a mixture of 40% white peat and 60% black peat and lately adding coconut fibre, completely free from pests so that the use of fumigants is not necessary. The farmer is also able to manage more efficiently water and nutrient inputs, maximizing crop yields and quality (18). The downside, in this case, is the likely destruction of valuable habitats caused by the extraction of the materials.

Resistant varieties and grafting: plant breeding and grafting can produce crop species resistant to nematodes, pathogenic fungi and specific pest problems. For example, presently, 100% of the watermelon crop in Spain is from grafted plants, a technique that eliminated the use of methyl bromide. It is used with good results in the control of root-knot nematodes and fungal pathogens in peppers, fruit trees and citrus (17).

- **Biological control**

The fungus *Pochonia chlamydosporia* has been investigated as a potential biological control agent for use in integrated pest management strategies for control of root-knot nematodes in organic production**.** The fungus significantly reduced nematode infestations in soil following a tomato crop, in a strategy that combined the use of the fungus with crop rotation (17). The introduction of rhizobacteria (*i.e.* bacteria that develop in and around plant roots) that are antagonistic to plant pathogens and develop along with the seedling roots to form a biological shield around the roots, can help protect the plant in the early growth stages (12).

- **Physical methods**

Steam: is the introduction of vapour at 100° C into the soil where it kills soilborne pests with the latent heat released when it condenses into water. Under appropriate conditions it can be as effective as methyl bromide. In the Netherlands where methyl bromide was banned as early as 1992, this technique is successfully used as an alternative (12). Steaming is suitable as an alternative in protected cropping systems and small-scale, open-field production, *e.g.* bulbs, strawberries, cut flowers or ornamental plants (17).

Solarisation: consists of trapping sun heat under clear plastic sheeting to elevate the temperature of moist soil to temperatures lethal to soil-borne pests including pathogens, weeds and insects. It is most successful in dry climates with low number of cloudy days and intense solar heat. It is used by farmers in Jordan, Israel, Italy, Spain and other Mediterranean countries (12). It is more effective in combination with other techniques, especially when dealing with other mobile organisms such as nematodes that will move deeper into the soil with solarisation. Solarisation is used successfully in Israel to produce peppers and eggplant in winter to control nematodes, weeds, fungi, bacteria and parasitic plants, providing the same yields and costing substantially less than methyl bromide (18).

Biofumigation: is the amendment of soil with organic matter that releases gases which kill or control pathogenic micro-organisms. This technique, combined with solarisation, has provided good results in the production of bananas, tomatoes, grapes, melons, peppers and other vegetables (17). In Macedonia, a combination of biofumigation and solarisation for tomatoes and cucumbers in greenhouses provided similar yields to methyl bromide at lower costs. The technique consists of mixing moist soil with organic matter (*e.g.* manure) and covering it with a polyethylene sheet (19). The incorporation into the soil of residues of some brassicas and Compositae family plants gives excellent results as these release volatile chemicals such as methyl isothiocyanate and phenethyl isothyocianate which have herbicidal, fungicidal and/or nematocidal properties (12).

- **Integrated Pest Management (IPM)**

IPM is based on combination of strategies to prevent and manage pest problems in an environmentally sound and cost-effective way. Success of IPM is reported all around the world (17) and is should be a cross-compliance condition for support to farmers in the framework of the European Common Agricultural Policy. For example in France, farmers are increasingly using IPM to reduce and prevent the effects of pests and diseases in melon, tomato, strawberries and cucumber that includes the use of resistant tomato varieties suitable for grafting or soil-free culture for strawberries (17). IPM is successfully used in open field strawberry production in Poland, at lower costs when compared to methyl bromide and providing higher average yields. Key IPM elements include: crop rotation and planting of appropriate crops before strawberries; application of animal manure and sometimes green manure; use of healthy plantlets free from pests and diseases (19).

▪ **Alternatives that avoid the need for soil desinfestation**

Soil-free culture: is a method in which plant growth substrates provide a medium that allows water and nutrients to be absorbed by the roots. Most soil-free culture occurs in covered or protected agriculture and substrates include artificial and natural materials such as rock wool, tuff, clay granules, solid foams, glass wool, peat, coconut plant materials, volcanic gravel or pine bark. It is used for crops such as tomato, strawberries, cut flowers, melons, cucurbits or tobacco seedlings (17). Constraints include availability, water pollution from systems that do not recycle the nutrients and the vulnerability to pathogen attacks.

2. Alternative treatment for durable commodities and structures

▪ **Physical control methods**

Heat treatment: grain or other commodities are heated to temperatures of 60-70ºC and then cooled rapidly. At around 65ºC disinfestations from stored-products insects can be achieved in less than 1 minute (17).

Cold treatment: cooling is used to prevent damage and multiplication and reinvasion of pests. Cold treatments are now used as part of Integrated Pest Management for stored products such as grain, oilseeds and seeds (17).

Controlled and modified atmospheres: based on a high content of carbon dioxide or nitrogen offers alternatives to fumigation for control of arthropod insects and vertebrate pest control. Nitrogen based controlled atmospheres can also be used to control rancidity as well as pests in some nuts (17). An integrated control using low oxygen disinfestations and protective methods using pathogens, low oxygen and low temperatures proved effective in walnuts, almonds and raisins (17). In Germany, a combined atmosphere of nitrogen and carbon dioxide is used for the protection of wood and wooden items successfully (14).

▪ **Integrated Pest Management (IPM)**

An integrated pest management programme must begin with the identification of existing and potential threats, the cause of their presence, their vulnerability and consideration of chemical and non-chemical methods. A major component of the IPM is system is sanitation or “hygiene” which generally involves measures to remove pests and deny them access to the facilities. These measures include cleaning and removal of food debris to prevent pest multiplying and redesigning and modifying buildings and machinery to eliminate harbourage for pests. The IPM approach has been introduced successfully in food and flour processing facilities in many countries (17). In Canada, for example, the Canadian Methyl Bromide Industry Government Working Group has prepared an IPM strategy for use in food processing facilities (20).

▪ **Biological methods**

Insect pathogens: such as bacteria, viruses, protozoa, nematodes and fungi can be used to control pests. Commercial formulations of *Bacillus thuringiensis* provide control of almond moth and Indian meal moth when applied to grain in a suspension or in dust. *Bacillus thuringiensis* and other pathogens can also form part of an IPM approach (17).

Pheromones: are chemicals produced by one member of a species that are transmitted to influence the behaviour and physiology of another member of the same species. Pheromones can be used as trap baits or employed in direct control via mass trapping, pathogen dissemination and disrupting mating. Synthetic versions of pheromones are commercially available for many of the most important pest species (16). The use of pheromone traps for

Indian meal moth and warehouse beetle is reported as part of an IPM approach for the protection of food processing facilities in USA. The traps are used either for monitoring purposes or for mass trapping (18).

▪ **Botanicals**

Botanicals are components derived from plants. Nowadays they are likely to form part of an IPM approach or for small on-farm use in developing countries. The only botanical in use in developed countries for protection of durable goods is pyrethrum extract, which has toxic and repellent properties. Others, such as azadirachtrin (active ingredient from neem tree) are registered for plant protection and under continuous investigation for the protection of durable goods (12, 17).

3. Alternative treatment for perishable commodities

A constraint on the development of alternatives for treatment of commodities before the export is that they need to be suited to the combination of pests and commodities, which can make the transfer of technologies between countries difficult (12). Treatments for controlling quarantine pests have to be approved by the authorities of importing countries and this usually requires scientific data to demonstrate that the treatment is virtually 100% effective. Historically, this process for gaining approval has been very slow (14).

▪ **Pre-harvest**

Cultural practices: such as harvesting when pests are not active or planting/grafting resistant varieties can be used.

Certified pest-free zones and pest-free periods: is also accepted in some countries as an adequate treatment. Certification of pest-free zones requires constant monitoring, reporting and enforcing but is already in practice in a number of countries (12). For example: melons from the Netherlands free from Mediterranean fruit fly exported to Japan; orange, grapefruit, clementine and mango from Mexico exported to USA (14).

▪ **Post-harvest**

Inspection and certification: is a way to avoid treatment. Samples of the produce are inspected prior to the shipment and certified based on finding no pests of quarantine importance. It is used, for example in: cut flowers from the Netherlands exported to Japan; apples from Chile and New Zealand exported to USA; green vegetables exported to many countries (14).

Cold treatment: temperatures are typically reduced to between -1 and + 2ºC. It is used for a number of fruits such as apples, cherries, grapes, citrus and generally applied to a number of fruits from tropical and subtropical countries (14). Cold treatment is approved for use as quarantine treatment in at least 55 countries that export perishable commodities mainly to USA and Japan, including many European countries (17).

Heat treatment: hot water immersion, high temperature forced air, and/or vapour heat are three heat treatment technologies that can be used for post-harvest insect control for perishable commodities such as fresh fruits, fresh vegetables, bulbs, and cut flowers. Heat treatments for disinfestation of fruit have been used since 1929 in the USA when a vapour heat treatment against the Mediterranean fruit fly was developed. However, interest in heat treatments waned with the development of chemical fumigants, notably methyl bromide (21). Heat treatment is a quarantine treatment approved, for example in: mangoes exported to Japan; orchids, plants and cuttings exported to USA; several vegetables exported to USA (14).

Controlled atmosphere: uses lack of oxygen to kill pests, either raising carbon dioxide or nitrogen to replace a normal atmosphere for a period of several weeks or even months. Due to the long period of treatment, this technique is suitable for produce into long storage periods, such as apples or pears (17).

Final remarks

To overcome the possible economic consequences of withdrawing the use of methyl bromide, the Montreal Protocol has created a technical advisory committee to oversee the search for alternatives, the MBTOC (Methyl Bromide Technical Options Committee). In Europe, substantial efforts have been invested into finding and implementing alternatives. PAN Europe questions why after such a long transition period, methyl bromide is still used for certain “critical use exemptions”.

Chemical alternatives under review in the framework of pesticides authorisation policy in Europe offer reasons for concern. Many of these chemicals present more than two of the following hazards: acute toxicity, carcinogen, developmental or reproductive toxin, acute aquatic toxicity, cholinesterase inhibitor, endocrine disruptor and/or ground water contaminant. An array of viable non-chemical alternatives exists and have been tested, many of them with economic advantages for farmers in comparison with methyl bromide. PAN Europe demands that non-chemical alternatives should be promoted and implemented as the best options to benefit health, environment and rural economies.

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