

SUMMARY AND RECOMMENDATIONS

1. INTRODUCTION

This International Conference on Alternatives to Methyl Bromide, held in Sevilla 5-8 March 2002, was attended by almost 300 researchers, extension workers, farmers and industry representatives from 40¹ countries. The conference was sponsored by the Spanish Ministry of Agriculture, Food & Fisheries; The Spanish Ministry of the Environment; The Spanish Ministry of Science & Technology; The Consejería of Agriculture & Fisheries of the Junta of Andalusia; and The European Commission DG Environment.

Senior government officials representing the major sponsors remarked on the unprecedented integration of private and public effort underway to identify and adopt technically and economically viable alternatives to methyl bromide (MB) before its phase out in 2005 in developed countries. They noted that alternatives were required to maintain Europe's compliance with the Montreal Protocol and with national obligations under Regulation EC2037/00 on the phase out of ozone depleting substances.

Drawing on the experiences of 72 experts from 26 developed and developing countries from around the world, these Proceedings contain the papers and case studies discussed in plenary and workshops. Four workshops discussed the use of non-chemical alternatives; and alternatives to MB for strawberry fruit and mother plant production, cut-flowers, and quarantine and pre-shipment uses. Commercial enterprises displayed material and information on alternatives to MB. Participants saw pest control methods used in a rice packing facility and viewed alternatives in use or under development for producing strawberries, cut-flowers and vegetables.

This summary and recommendations was drafted and discussed with participants in plenary on the final afternoon of the conference.

2. OZONE DEPLETION

Experts on ozone depletion noted that the ozone layer is not yet showing signs of recovery. Ozone changes observed over the last two decades have led to an increase of 5-15% in the year-round, biologically relevant UV radiation doses over large parts of Europe. The increases have been greatest in springtime and in northern and central Europe. Climate-chemistry models, which include changes in the concentrations of greenhouse gases and halogenated compounds, indicate that UV radiation may continue to increase in the coming 10-20 years during springtime at high latitudes. Higher UV radiation contributes to further risks to human health. There is scope for a UV forecasting system for Europe which, when coupled with advice on how to avoid damaging UV-radiation, would reduce health risks to citizens.

Control measures under the Montreal Protocol have established phase out schedules for MB except for QPS uses. Regulation EC2037/00 has also set a cap on the amount of MB that could be placed on the EC market for QPS. In 2001, the amount licensed to be placed on the market in the EC was 14% below the cap for QPS uses and 17% below the cap for non-QPS uses. A recent survey of Member States (MS) still consuming MB reported that most MS expected to have alternatives in place for most of the MB uses by 2005.

3. FRUIT, VEGETABLE AND CUT-FLOWER PRODUCTION

Strawberry, tomato and cucurbit production in Europe was reported to consume about 60% of the MB in the EC, predominantly in Spain, Italy, France, the UK, Belgium, Greece and

¹ Australia, Austria, Belgium, Bulgaria, Canada, China, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Denmark, Egypt, France, Germany, Greece, Guatemala, Honduras, Hungary, Israel, Italy, Jordan, Kenya, Latvia, Lithuania, Macedonia, Malaysia, Malta, Morocco, Mexico, Philippines, Netherlands, Poland, Portugal, South Africa, Spain, Turkey, United Kingdom, United States of America and Uruguay

Portugal. Other crops important to many MS are peppers, eggplants, cut-flowers, and tobacco which consumed about 40% of the MB in the EC.

3.1 Strawberries

About 80% of the fresh-market strawberries produced in Spain are sold within the EC. Strawberry production is the single largest consumer of MB in Spain. Trials carried out in the past 4 years have shown the following treatments as the most promising alternatives for fruit production in Spain: 1,3-D + chloropicrin under polyethylene film (PE) or Virtually Impermeable Film (VIF), dazomet alone, solarization + shank-application or drip irrigation of metam sodium, solarization + biofumigation using chicken manure. Efficacious treatments require careful application techniques and soil preparation. For mother plant production in Spain, the most promising alternative was 1,3-D with chloropicrin broadcast shank-applied under PE or VIF.

Combination treatments were considered the most promising in the USA using 1,3-D + chloropicrin, or chloropicrin alone sometimes followed by metam sodium, but the future availability of fumigants depended on the result of periodic regulatory reviews.

Some experts stressed the importance of disease-free mother plants in order to maintain profitability in the production areas while others thought that production of mother plants using MB after 2005 might be considered as a future Critical Use application if further research was not successful. Poland reported Integrated Fruit Production as the most promising technique for eliminating the use of MB and other soil fumigants in strawberry production. Experts from Spain and Poland considered soilless culture without MB had potential for fruit and mother plant production. Soilless culture is widely used in some countries e.g. The Netherlands. In Spain, the substrate material could be peat, coconut fibre, grape bagasse compost or composted cork.

Experts from Morocco reported solarization alone, or combined with metam sodium or 1,3-D, were similar to MB for nematode and weed control, yield, and profitability in strawberry production. Morocco aimed to phase out all major uses of MB well before 2015 in order to avoid further dependency on MB and possible importer boycott of products grown with MB.

Azides, iodomethane and other products under development were considered potential alternatives for the control of fungi, bacteria, nematodes and weeds.

3.2 Tomatoes

Tomatoes were reported to occupy 14% of the horticultural land and to contribute 23% of the value of Spain's horticultural production. About 25% of the fresh production and 50% of the canned fruit are shipped out of Spain. Experts commented that Spain does not rely on MB for tomato production. Crop management systems for tomato production require hybrid varieties with resistance to pathogens and soil fumigation with other conventional fumigants. New "long life" varieties that contain the *Mi* gene are resistant to *Meloidogyne* spp. Almeria province, a major production region, does not use MB for the production of vegetables.

The existing and potential alternatives to MB in Mediterranean countries to control tomato soilborne pathogens were summarised and included the use of resistant cultivars, grafting, organic amendments (biofumigation), crop rotation, soilless culture, physical treatments (solarization, steam, flaming) biological control (e.g. *Verticillium* fungus used to control *Meloidogyne javanica* nematodes in unheated plastic houses for tomato production), chemical alternatives (chloropicrin, 1,3-D, dazomet, metam-sodium), and combinations of these treatments. The success of the alternative depends on its use within an integrated pest management (IPM) programme that includes sanitation, pathogen-free seeds and seedlings, weed control and other activities.

Impermeable plastic, singularly or combined with biocontrol agents or chemicals during solarization in Greece, reduced the disinfestation period on land for tomato crop production from six to three weeks.

In Italian-grown tomatoes, soil solarization alone or in an IPM programme with chicken manure (biofumigation), biological antagonists, resistant/tolerant varieties and rootstocks, or

by reduced dosages of chemicals, resulted in good pest and pathogen control with profitable yields for specific crops and situations.

In Turkey solarization, alone or in combination with other treatments such as metam-sodium, 1,3-D, dazomet and biofumigation, were reported to be used as part of an IPM programme for managing soilborne pests in tomato and cucumber production.

In Cuba weeds were controlled non-chemically in vegetables by disrupting their seed development or by drying them. Crop rotation, solarization, crop resistance, biological control, limited chemical intervention, and organic substrates were used to control nematodes. Grafted plants and bio-fumigation were reported to be under evaluation for use on protected crops such as tomato, pepper, water melon and cucumber. The floating tray system is being adopted widely in Cuba and is successfully eliminating MB in the tobacco sector.

3.3 Peppers

In Spain, greenhouse sweet pepper grown in soil treated with 1,3-D + chloropicrin applied by drip irrigation under PE plastic produced results similar to MB. Biofumigation with solarization, using fresh sheep manure and chicken manure or soybean flour, was reported to give satisfactory pathogen control and production similar to MB. When the applications were repeated there was an improvement in efficacy against pathogens, yield and physico-chemical characteristics of the soil. This was considered to be a viable alternative for sustainable and organic agriculture. Grafting was another alternative which provided satisfactory soilborne pathogen control and acceptable yield.

3.4 Other vegetable crops

France reported a decline in the use of MB in vegetable crops due to increased production areas using substrates, and due to increases in the price of MB compared to the alternatives dazomet, 1,3-D, metam sodium, solarization and steam. Grafting as an alternative to MB provided satisfactory soilborne pathogen control and acceptable yield.

Belgium reported a reduction in the use of MB due to adoption of substrates such as rockwool, grower fears about exceeding bromide residues in MB-fumigated crops, exclusion of MB from crops grown organically and a decline in intensive agricultural land. New horticultural methods under development tried to eliminate MB from the production system but MB is currently used as a 'correction tool' for otherwise uncontrollable situations.

3.5 Cut-flowers

Results on alternatives to MB for cut-flowers produced in Europe (Hungary, Italy, Spain, Portugal and Greece) and Latin America (Colombia and Guatemala) indicated that the main pests requiring control are fungi such as *Fusarium oxysporum f.s. dianthi* (F.o.d), *Phytophthora* spp, *Pythium* spp., *Sclerotinia* sp., *Verticillium dahliae* or *Rhizoctonia solani*, weeds, nematodes especially *Meloidogyne* sp., pests and bacteria such as *Agrobacterium* spp. Crops such as carnation, gerbera, roses, chrysanthemum and snap dragon were grown mostly in greenhouses in soil, but more recently there was increased production using soilless culture.

Depending on circumstances related to environmental conditions, supplies, available infrastructure and other factors, experts reported on a number of MB alternatives used around the world to grow cut-flowers. Alternatives include steam, solarization, biocontrol, substrates, organic amendments, crop rotation, resistant varieties, biofumigation, metam-sodium, 1,3-D, dazomet and chloropicrin. The best results are obtained by an integration of these alternatives. An expert from Colombia described the advantages and disadvantages of steam, compost, soilless cultivation and fumigants for cut flower production. Colombia is the second largest cut-flower exporter in the world and does not use MB for their production.

In Spain, a mixture of 1,3-D + chloropicrin controlled F.o.d in carnations to a similar level of efficacy as MB. The method of application was important for ensuring treatment success. Inconsistency in results was attributed to poor application technique or susceptibility of the particular cultivar to this disease. Shank application covered with VIF film controlled

nematodes, insects and some fungi and weeds. Solarization + poultry manure reduced F.o.d but did not control the disease below the threshold required. Other results showed good control of diseases and nematodes and productivity was maintained. Resistant cultivars were effective but presented a limited spectrum of resistance and there was a high cost of selection for acceptable marketable quality and yield.

Metam sodium and dazomet controlled weeds, fungi and nematodes, but did not control sufficiently Fusarium and Verticillium Wilts. Metam sodium with VIF plastic controlled *Phytophthora cryptogea* in gerbera but the requirement for a plastic cover reduced acceptance to growers.

Steam was considered a good disinfestation system but could be cost-effective depending on the circumstances. Steam was considered economically feasible as an alternative when it was included as part of a sanitation programme. Organic amendments using composted plant material remaining from the cut-flowers was used at some locations. Biological control using non-pathogenic *Fusaria*, *Agrobacterium radiobacter* or parasites of pests was reported to control specific problems in cut-flower crops. Integration of two or more alternatives such as resistant cultivars, soil less culture, steam, solarization, biocontrol agents and chemicals should be considered as a global strategy for replacing MB in cut-flower production.

4. NON-CHEMICAL TREATMENTS

Many papers and most posters provided information on non-chemical alternatives to MB such as steam and soilless systems. For example, strawberries, sweet peppers, carrots and carnations were produced using non-chemical methods in Spain; strawberries in Australia and Turkey; tomatoes in Morocco and Italy; vegetables in Cuba, Uruguay, Australia, Poland, Turkey and the USA; melon in Italy; and tobacco in Cuba, Spain and other countries.

Experts reported research on agricultural waste e.g., rice hulls, almond hulls, coconut fibre, seaweed in Spain, as well as research on biofumigation, organic amendments, solarization, grafted plants and biological control products. Some techniques provided good control of pathogens, while other techniques required further development. Apart from steam and soilless systems, most techniques are used in combination to control a range of pests/diseases. Combination treatments were more knowledge-intensive and required more skill than application of MB.

Solarization is being used by about 80% of farmers in Jordan Valley. Biofumigation, alone or in combination with solarisation, in appropriate circumstances was reported to be as effective as conventional pesticides in the control of fungi, nematodes, insects and weeds. Gross income in tomato and melon crops in Uruguay was greater using biofumigation than conventional pesticides. It was recommended that biofumigants should be produced locally in order to reduce costs.

Solarization + biofumigation or organic amendments are being used in Spain (Murcia region) to produce sweet pepper, some specific types of tomato and outdoor lettuce.

Plants grafted onto resistant rootstock, and normally combined with other techniques, is used to produce some tomatoes and most of the watermelon crop in Spain.

Substrate systems are used to produce 3,800 ha of tomato, 270 ha sweet pepper about 40 ha of greenhouse sweet pepper in Spain. An expert from Jordan reported limited use of substrates to grow unprotected crops cheaply.

Steam is used in Spain on ornamentals such as carnations as an alternative to MB.

In Spain, the floating tray technology is used to produce 98% of the tobacco seedlings without MB. Similarly, crop rotation avoids the requirement for MB in Spain (Almería) and is used in the production of 7,000 ha of pepper, tomato, cucurbits and broccoli. Direct seeding, animal manure + plastic mulch used for watermelon production in some areas in Mexico; growth promoters plus animal manure are also successful for producing water melon in other areas.

5. POSTHARVEST TREATMENTS

The advantages and disadvantages of alternative chemical fumigants, biological control agents and physical treatments were discussed as potential alternatives to MB for durable commodities, timber and timber products. Phosphine, controlled atmospheres and sulfuryl fluoride (separately) have been used for many years for disinfesting durable commodities, timber and structures. Sulfuryl fluoride was recently granted an experimental use registration in the US allowing its use to be extended to include food (walnuts and raisins). Trials were reported to be ongoing on food products and mills in a number of countries as part of the registration requirements for this product.

Experimental trials on microwave technology for rice disinfestation in Spain was reported. There was also reports on the development of two new fumigants - carbonyl sulfide and dimethyl disulfide.

The large range of products of relatively small volume and a highly fragmented industry presents difficulties for meeting registration costs of new chemicals. Research to preserve wood using biological agents or natural products that have low-environmental impact was considered a priority due to uncertainties in re-registration of chemical products under the EC Biocidal Products Directive 98/9/EC.

Often disinfestation treatments must be undertaken rapidly to minimise delays in marketing recently imported but insect-contaminated products, and many treatments were reported to be not as rapid as MB. Pre-export treatment or fumigation in-transit were considered to be possible ways to overcome the lack of speed of action of alternatives.

Under regulation EC2037/00 the quantity of MB that can be consumed within the EC for QPS purposes has been capped. Most Member States reported in an EC survey that research was being undertaken on QPS alternatives. An expert from the United States reported that the US has an active research programme for developing MB alternatives. About 30% of the MB consumed in the United States was used for postharvest and structural treatments. For perishable commodities, the United States permits heat, cold and irradiation as non-chemical treatments that would meet quarantine standards, provided monitoring and verification were carried out to high standards.

Humidified nitrogen and carbon dioxide with low oxygen levels, or heated and humidified air, were considered replacements for MB for controlling pests in artefacts in museums.

Fumigation using 2% phosphine and 98% CO₂ over 14 days was reported to successfully control pests in grain in Australia and Cyprus. Fumigation with low phosphine concentrations + 3-5% CO₂ + elevated temperatures over a 24 hour period is becoming more common in the United States. The cost of the fumigation is comparable to MB. Experts at the Conference reported on the importance of sanitation and inspection for all pest control operations, even for old mills where sealing was difficult, as these activities largely eliminated the need for pesticide treatments including disinfestation using MB.

Manufacturers of alternatives for stored products and structures pointed out that any annual critical use exemption to allow the continued use of MB in this sector after 2005 could delay manufacturer investment in facilities to manufacture alternatives.

An expert from Spain reported that MB was used as a quarantine treatment on imports of oak logs or wood packages that were not treated at origin, and on a minor number of exports such as garlic destined for Brazil and chestnuts to Mexico. MB fumigation of timber has been substituted with mechanical methods such as de-barking or heat treatment. Cold treatments are used on exports of citrus to meet the requirement for freedom from live Mediterranean fruit fly. Export grains are treated when necessary with phosphine instead of MB.

Similar disinfestation treatments were under consideration for use in developed and developing countries. However, the most applicable for developing countries appeared to be those that were low cost and easily-handled technology such as the flexible PVC cocoons that disinfest products in about 2-7 days at 30°C under vacuum; or the hermetic systems used extensively in Cyprus.

6. ECONOMIC AND SOCIAL IMPLICATIONS

The Spanish national project to find alternatives to MB was launched in 1997 with the short-term objective of finding alternatives to compensate for the reduction and ultimate cessation of the use of MB. Results achieved so far have overcome some of the fears expressed by the producers of strawberries and peppers under glass who were reported to be the main MB users in Spain. Despite this progress, an expert from Spain considered that further research would be required to ensure the economic viability and environmentally-friendly production of these and other crops.

Trials and demonstrations on MB alternatives that resulted in the phase out of MB can be accompanied by other useful activities such as the distribution of informational materials on alternatives, the use of economic incentives, encouragement for companies to review their policies and contracts relating to MB use, and the development of new industries to provide alternative products and services in rural areas.

As research has progressed on alternatives to MB, the estimate of the economic impact of the ban in the United States on its use have been revised from about \$1.5 billion to \$624 million annually using a value of marginal product approach. Sixty-nine percent of the economic impact will be incurred when the final 30% reduction is required in 2005 in the USA. Permitting quarantine uses and critical use exemptions in the United States may lessen the economic burden until new pest control strategies are adapted for use.

The most important vegetable crops grown in Hungary are white-yellow sweet paprika, tomatoes, hot green paprika and cucumber. These crops are grown year-round using thermal energy from natural underground springs. Rockwool and grafted plants are being adopted in Hungary. They are cost-effective and offer the best promise for eliminating the remaining uses of MB in this sector by 2005.

A questionnaire sent to 504 strawberry growers in Spain asked questions on the structure of farms, aspects concerning the adoption of innovation and management, sociocultural characteristics of the grower, soil disinfection procedures, and their willingness to pay for an alternative to MB. About 70% of growers were willing to pay extra for MB alternatives. Owners of properties more than 8 ha, those involved in IPM production practices, and those that attended seminars on alternatives to MB were more likely to be willing to pay for an alternative.

EUREPGAP was set up by retailers to provide global agricultural production standards and a verification framework for fruit and vegetables to retailer and supplier members. Written evidence from growers is required for the use of soil fumigants such as MB including information on the pest problem, location, date, active ingredient, doses, method of application and operator. EUREPGAP recommends that growers demonstrate to the certifier that alternatives to MB have been explored by showing their technical knowledge and written evidence of alternatives to soil fumigation. Chemical fumigation of soils needed to be justified and used only as a last resort, and recommended alternatives to MB such as crop rotation, planting of break crops, use of disease resistant cultivars, solarization, conversion to soil-free cultivation and similar techniques. EUREPGAP recommendations are currently voluntary but may become compulsory in the future.

Almeria produces 70% of Spain's vegetable exports. Eighty per cent of both producers and exporters in Almería, are represented by the Association of Harvesters and Exporters of Fruit and Vegetables (COEXPHAL). Growers since 1997 had been requested not to use MB. Alternatives have successfully replaced MB based on a new agreement on the appropriate measures to be taken reached jointly by COEXPHAL and different chains of supermarkets that aim for a balance of environmentally sound alternatives, quality products and profitable production methods for growers. Growers must fulfil specific requirements that comply with rules in order to be certified.

More than 40 demonstration projects on alternatives to MB have been carried out in developing countries by UNIDO, UNDP, the World Bank and GTZ. More than 10 alternatives had been tested for their usefulness as both soil fumigants and for the treatment of

commodities. The most suitable alternatives to MB had been selected by local farmers and other stakeholders in order to initiate phase-out programmes in more than 22 developing countries e.g, Morocco, Jordan and Turkey. Partial phase-out of MB had already taken place in certain developing countries based on financial assistance provided by the Montreal Protocol's Multilateral fund.

7. RECOMMENDATIONS

Discussions over four days showed that significant progress has been achieved in the identification and development of alternatives to MB. In some countries, alternatives are widely used. In most other countries alternatives are used to some extent and can be adopted much more widely. The conference organisers received recommendations from some conference participants and can therefore support the following:

1. That measures need to be put in place to train growers on how to use alternatives, in order to ensure the adoption and sustainability of alternatives by 2005. This could include, for example, growers with experience of alternatives training other growers in the adoption of alternatives;
2. That work on MB dosage reductions should be discontinued unless justified because MB will not be permitted in 2005 for non-QPS uses and instead all further research should focus on alternatives;
3. That application techniques for alternatives should be improved in order to enhance efficacy and consistency, simplify procedures for the grower, improve the accuracy of the technique, improve worker efficiency and safety, and improve profitability;
4. That methods to avoid the need to apply chemical fumigants, and combination methods that minimise chemical input, should be given high priority;
5. That development of 'fast-track' registration procedures for MB alternatives is established in the European Community;
6. That each Member State should maintain records of the adoption of alternatives including hectareage covered, grower adoption and quantity of ODS replaced by the alternatives in order to set priorities for further research and grower training;
7. That agricultural verification and certification systems should be encouraged as they can effectively promote the use of alternatives to MB by more growers and organisations;
8. That manures and other animal-derived products that can contain contaminants should be used only within strict guidelines for environmental protection and human safety;
9. That research should be undertaken to better understand the mode of action of non-chemical alternatives in order to use them more effectively in the future for controlling pests in more crops and climatic situations; and
10. That examples drawn from countries that already have alternatives to MB in use in the flour and milling industries and other sectors that are seen as 'challenging' in order to develop sustainable systems for all countries.