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Efficacy of methyl bromide in nurseries

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ABSTRACT

This study was conducted to determine factors affecting application of methyl bromide in avocado nurseries. The properties of methyl bromide have to be kept in mind when preparing for fumigation. Nursery medium preparation and its moisture level is important, as they influence distribution of the gas through the medium. Fumigation bins and their impermeable covers keep enough methyl bromide in the nursery medium to create a high CT value, which results in effective fumigation. A special applicator is used to apply the methyl bromide in evaporation pans under a transparent low density poly-ethylene (LDPE) plastic sheeting.

INTRODUCTION

Gaseous methyl bromide (MBr) is widely used as a preplant soil fumigant for the effective control of soilborne pests, insects and weeds (Brown & Rolston, 1980; Gandy & Chanter, 1976; Milne, 1974; Munro, 1964). It is an odourless, highly toxic fumigant which is sold in cans or pressurised cylinders. The cans contain a mixture of methyl bromide (98%) and chloropicrin (2%), where the chloropicrin acts as a warning gas, for exposure to it causes the eyes to water and burn (Technical brochure, Landkem).

MBr is in a liquid form when under pressure and boils at 3,6°C. The gas has a specific gravity of 3,27 at 0°C (air=1). It is a powerful solvent of organic materials, especially natural rubber and corrosive to metals, when impure (Technical brochure, Landkem; Munro, 1964). Because of its toxicity, it has to be applied with great care and not used close to living plants (Milne, 1974).

MBr is used in avocado nurseries to sterilize nursery medium for the control of *Phytophthora cinnamomi* Rands, causing severe root rot of avocado (*Persea Americana* Mill) (Zentmyer, 1980), as well as other soil-borne fungi and pests.

A large portion of the fumigant applied during fumigation eventually diffuses into the atmosphere (Brown & Rolston, 1980). The transportation of MBr during fumigation is caused by mass flow and molecular diffusion, but is also influenced by sink processes occurring at the same time (Brown & Rolston, 1980). These processes can be reversible or irreversible. Reversible sink processes include physical adsorption-desorption, chemical adsorption-desorption and dissolution-distillation from the soil water.

MBr undergoes a lot of changes after it has been applied as a soil fumigant. During fumigation, MBr moves away from the point of application. Some of it decomposes in the soil water which results in the production of Br-anion (Brown & Rolston, 1980).

It was reported that dry soils (less than 5% moisture) have greater sink capacities than soils at field capacity (Chrisholm & Koblitsky, 1943). Furthermore, they found that the sink capacity decreased in the following sequence: peat, clay, sand. This indicates that a higher dosage of methyl bromide will be necessary when fumigating organic material, compared to sand, to obtain the same result.

Despite the fact that MBr and its applications are well documented in literature, a survey of avocado nurseries revealed that common root pathogens like *Pythium spp, Fusarium spp* and *P cinnamomi* occurred regularly. This investigation, which includes a literature review, was undertaken to find out why these pathogens survived fumigation.

NURSERY MEDIUM

Nursery medium preparation is important to ensure the best results when fumigating. When using organic material like pine bark or mila (composted sugar cane fibre), it should be composted very well and milled to form an even composite and then sifted to remove all the larger pieces. Riversand that is used in the nursery medium must also be sifted to remove clots and rocks. The two components should be mixed thoroughly before fumigation. Better disease control was obtained in fine than in coarse-textured soil (Goring, 1962).

MOISTURE LEVEL

Movement of methyl bromide depends also on the moisture level of the nursery medium. It is demonstrated that fumigation of soil for the control of fungi, weed seeds, nematodes and insects is routinely optimum under "not too wet" and "not too dry" soil moisture conditions (Munnecke *et al,* 1971).

MBr gives increased disease control with increasing moisture (Goring, 1962), but saturated soils are not likely to be fumigated since all the pores are blocked with water (Kolbezen *et al,* 1974). Diffusion of MBr in the water phase (dissolved phase) is extremely slow, estimated at up to 30 thousand times slower than in the vapour state for the same concentration (Kolbezen *et al,* 1974). It is suggested that ⅔ field capacity is an ideal moisture level for fumigation (Technical brochure, Landkem).

FUMIGATION BINS

When not using seedbeds in the nursery, bins could be used to fumigate the nursery medium. These bins may consist of wood or be built with bricks. These bins must have a concrete floor or be placed on a gastight plastic tarp for methyl bromide movement, due to gravitation (Brown & Rolston, 1980), which can greatly reduce the concentration in the nursery medium. For the same reason the bins should be placed on a level area. The sizes of the bins depend on the requirements of the nursery.

BIN COVERING

Due to diffusion, a great amount of methyl bromide applied is lost to the atmosphere (Brown & Rolston, 1980) and therefore gastight covers are needed (Quayle & Knight, 1921; Munnecke & Ferguson, 1953; Code of practice for the application of fumigants, SABS).

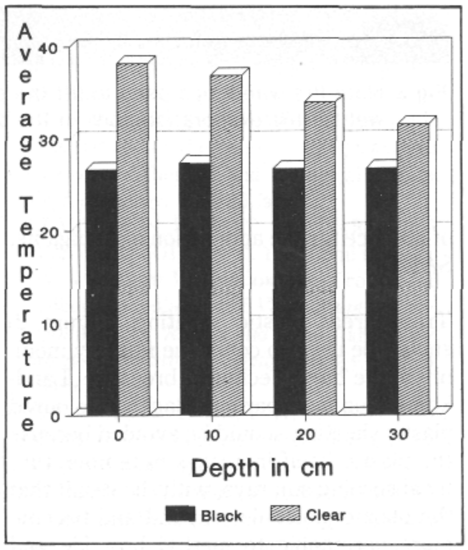

Fig 1 Temperature differences between black and clear plastic at different depths in nursery medium.

Fig 2 Fumigation bins covered with transparent LDPE plastic sheeting. The plastic is lifted from the nursery medium's surface.

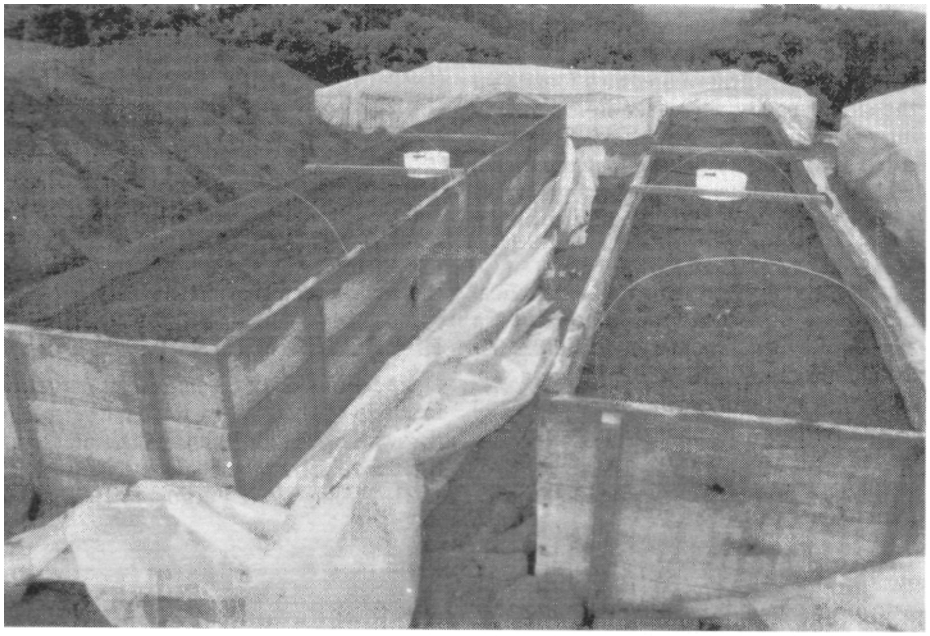

Fig 3 Note the wire loops used to lift the plastic from the nursery medium's surface, as well as the evaporation pans in the centre of the bins.

Transparent plastic sheeting (Figure 2) should be used to cover the nursery medium in the bins (Technical brochure, Landkern). Non-transparent, black or coloured plastic sheeting should be avoided because the plastic itself increases in temperature by absorbing sun rays, with the result that the plastic molecules expand and become more permeable to methyl bromide and more vulnerable to wind damage (Code of practice for the application of fumigants, SABS).

Low density polyethylene (LDPE) clear plastic sheeting is currently being used in commercial fumigations (Technical brochure, Landkem) with the thickness varying from 30 μm up to 180 μm. Sun rays go through the transparent plastic cover resulting in a greenhouse effect (Mahrer, 1979) and the nursery medium increases in temperature (Figure 1). It is seen in Figure 1 that the bin temperature for the black plastic cover was moderate and constant throughout the depth of the nursery medium. The transparent plastic sheeting shows an increase in temperature in the nursery medium at different depths.

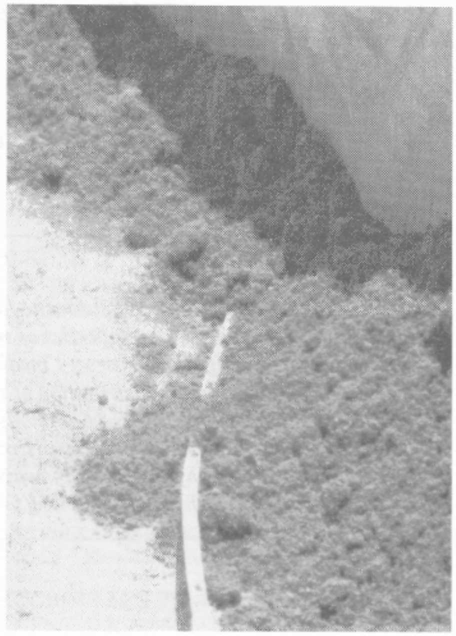

Fig 4 Wet sand is used to seal off the plastic sheeting on the concrete floor. In the foreground is the nylon tubing that is used to apply the methyl bromide in the evaporation pan.

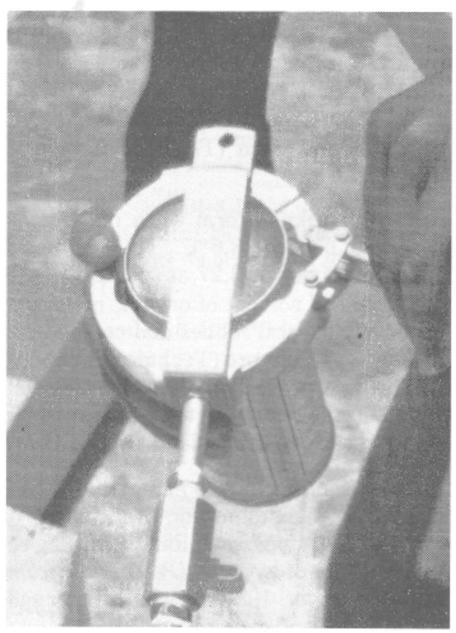

Fig 5 A special applicator is used to puncture the can containing methyl bromide. The fumigant is released through a nylon tube into the evaporation pan.

In Figure 1 the difference between the two types of covers is clearly demonstrated. It is necessary to increase the nursery medium's temperature to ensure better methyl bromide distribution during fumigation. The combination of moisture and temperature has a positive effect on the resting structures of soilborne fungi. High temperatures however kill most soilborne fungi and nematodes (Ashworth & Gaona, 1982; Barbercheck & von Broembsen, 1985; Pinkas *et al,* 1984; Pullman *et al,* 1981).

TABLE 1 The approximate colour reactions of a halide detector lamp

Concentrations of CH_3Br in air (ppm)	Reaction of flame
0	No reaction
10	Faint green tinge at edge of flame
20	Light green edge to flame
30	Light green flame
100	Moderate green
200	Intense green, blue at edge
500	Blue green
1 000	Intense blue

(Response of individual lamps will vary, readings below 30 ppm is unreliable) (Munro, 1964)

APPLICATION OF THE FUMIGANT

The plastic sheets used to cover the bins should be lifted above the growth medium surface to create an air space where in the MBr gas can distribute evenly (Figures 2 & 3). Wire loops can be put under the plastic to create the space (Technical brochure, Landkem) (Figure 3). The ends of the plastic must be sealed off with wet sand (Figure 4) and care should be taken to seal all holes that can occur in the plastic due to handling prior to fumigation.

MBr in cans are under natural pressure and in the liquid form. A special applicator (Figure 5) can be used which punctures the can and releases the liquid MBr through a nylon tube (Figure 4) with a inner diameter of 8 mm (Technical brochure, Landkem). This applicator is operated from outside the bin containing the nursery medium.

The MBr is then released into an evaporation pan where it evaporates from the liquid form into a gas and diffuses evenly through the air space and the nursery medium. The evaporation pan consists of either glass or *2,5ℓ* polyethylene buckets. A 20 cm pipe with a greater diameter than the nylon tubing is fitted in the one side of the bucket and acts as a guide for the nylon tubing to ensure the release of the liquid methyl bromide in the evaporation pan (Figure 3).

A halide detector lamp can be used to determine leaks in the applicator system (Monro, 1964). The flame colour of the lamp indicates an approximate value in parts per million of MBr in the air (Table 1). MBr should not be applied when the soil temperature is less than 8°C at a 100 mm depth (Technical brochure, Landkem; Code of practice for the application of fumigants, SABS).

MBr is more volatile at higher temperatures, which ensures better distribution. Growth medium depths of more than 50 cm should be avoided when using the cold application method (681 g cans). When deeper applications are needed, one should rather use the "hot gas" method which implies that the MBr is heated in a sealed water bath at 90°C and released through perforated polyethylene tubing under the plastic tarp (Technical brochure, Landkem). Distribution will be better because of the volatility of the gas.

The bins should stay covered after fumigation for 48 to 96 hours and then opened and aerated for at least 24 hours before being handled by workers. The whole basis of fumigation is to keep a high concentration of MBr in the nursery medium for a certain period of time (Quayle & Knight, 1921).

CONCLUSIONS

This investigation revealed that there is lack of information on the nature and application of MBr. Some of the facts about MBr were either ignored or never heard of.

The nurseries may act as important distributors of root pathogens like *Phytophthora cinnamomi.* When establishing a clean nursery, one of the vital things to do is sterilising the nursery medium and using clean plant material. It is important to avoid recontamination of the sterilised nursery medium. The very basis of fumigation is to obtain a constant CT value. This means holding a definite amount of methyl bromide in the nursery medium under the plastic cover for a certain period of time (Quayle & Knight, 1921; Munnecke *et al,* 1978).

High CT values can be obtained by using covers that are impermeable to MBr. These covers must be clear to create the glasshouse effect (Figure 1) and together with the moisture factor it will result in effective fumigations. The difference in nursery medium temperature can clearly be seen in Figure 1. It is therefore necessary not to use coloured plastic sheeting when fumigating with MBr. With more effective fumigations a lower concentration of MBr will be required which results in a lower cost as well as a healthier nursery medium. Bromide residues will be less and some nonpathogenic organisms which could be antagonistic towards *P cinnamomi* can survive.

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