PLANT-BACK, IGR AND SOIL HEALTH INFLUENCES THE SELECTION OF MB ALTERNATIVES IN AUSTRALIA

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To date, horticultural industries in Australia have met methyl bromide, MB, reduction schedules by lowering the concentration of MB in products rather than changing to alternatives. The ease with which MB can be applied and the insurance afforded by its application is making it difficult for growers to accept other methods of soil disinfestation. Therefore, studies in Australia have been aimed at identifying factors which lead to the effectiveness of MB and developing methods that increase the performance of chemical and non-chemical alternatives.

Meeting the Montreal Protocol Requirements in Australia
Research across a range of horticultural industries has consistently demonstrated that MB/Chloropicrin formulations with lower concentrations of MB are as efficacious as the traditional 98:2 product. As a result of this, 24% of flower growers and 52% of strawberry fruit growers in Victoria now use lower formulations (50:50) of MB compared to two years ago. Less than 5% of growers have changed to other soil disinfestation alternatives, although several new methods (Telone C35, VIF films and aerated steam) are being considered for wider scale use.

Several major factors which are influencing the adoption of alternatives by growers are plant back times, consistency of the growth effect, ease of application and the perceived impact treatments may have on soil health.

Alternative Fumigants and Plant-Back Time
Currently, growers of high-value horticultural crops can use short plant-back times (the period between fumigation and planting) with MB due to its high volatility and this maximises their cropping opportunities. Longer plant-back times for alternative fumigants mean substantial changes to existing production schedules and possible market repercussions.

Trials on strawberry crops in South Eastern Australia evaluated the performance of crops planted into fumigated beds at intervals ranging from 1-12 weeks. Yields in fumigated plots were compared to those in non-fumigated plots (where no fumigant residues were present) to determine when plant-back requirements had been met. Results (Table 1) showed a large variation in the plant-back requirements of some fumigants which could be explained by a wide range of environmental factors such as soil type, temperature, organic matter, soil moisture, etc. For example, trials indicated no difference in the plant-back requirement (ie. 2 weeks) of fumigants in summer when soil temperatures were between 20-30°C. In winter when soil temperatures were less than 10°C, however, the plant-back requirement of fumigants generating MITC increased to between 8-12 weeks.

In addition to demonstrating the effect on yields, the concentrations of fumigant residues in soil were determined at different plant-back times in several trials. Soil was collected and fumigants extracted in the laboratory with ethyl acetate, following which

their concentration and identity were determined with GC/MS. Two contrasting responses of strawberries were consistent when fumigant residues were present in soil. (1) In plots fumigated with dazomet, the relative yield of strawberries (Fig. 1) decreased as the concentration of MITC in soil at planting increased (r = 0.99). (2) In contrast, strawberries appeared more tolerant of residues of 1,3-dichloropropene (1,3-D) applied as Telone C35, with an independent relationship between relative yield and fumigant concentration in soil at planting. Yields in these plots significantly exceeded those in non-fumigated treatments after a plant-back time of just 2 weeks (Fig.1).

These results demonstrate the difficulty growers face when using fumigants generating MITC. For growers to adopt these fumigants, researchers must develop models, bioassays or residue assays to predict when it is safe to plant their crop. In contrast, evidence suggests that plant-back periods for chloropicrin and Telone C35, will only be marginally extended for strawberry crops, compared to that currently recommended for MB.

Soil Health and Increased Growth Response (IGR)

In order to gain a greater understanding of the increased growth response IGR obtained with MB fumigation, a series of studies have looked at the biological and nutrient changes in MB fumigated soils.

Increased soil nutrient status: Over the past 2 years studies have confirmed that fumigation causes a decrease in nitrate-N and a flush of ammonium-N. Fumigation also causes significant changes in specific bacterial populations (particularly gram negative bacteria) and this may have a significant impact on nitrogen conversion in soil (eg. nitrification). A pot study also demonstrated that there was a positive correlation (r=0.815) between the concentration of ammonium in soil and the total fresh weight of *Calendula* at 48 days after fumigation. The result suggests that the IGR observed with *Calendula* may be partly attributable to the altered N levels following fumigation and the effect the altered microbial population has on conversion of nitrogen in soil.

Changes in soil microflora composition: In a separate series of experiments, the influence of fumigation on microbial populations and recolonisation (eg. fungi, gram negative bacteria, pseudomonads, "total" aerobic bacteria and actinomycetes), and pathogen proliferation were measured over a period of 12 months using the dilution plate method on a range of selective media.

Results showed an initial reduction in numbers of colony forming units (cfus) in most microflora groups following fumigation, with soil fungi and gram negative bacteria being reduced over 1000 fold. Recolonisation by actinomycetes and gram negative bacteria was extremely rapid showing equivalent or higher propagule numbers in soils compared to untreated soils within 7 weeks of fumigation. Fungal propagule numbers, however, took up to 7 months to return to normal (Fig. 2). Incorporation of a green crop or spraying of microbial suspensions of saprophytic organisms immediately after the fumigation period were identified as effective means of speeding up microbial recolonisation. The green crop and crop debris, however, promoted recolonisation by *Sclerotium rolfsii*, the causal organism of Sclerotium rot of flower bulbs (Fig. 3).

Conclusions

In the short term, it is likely that Australian horticultural growers will adopt the next best fumigant to MB following phase-out. Yet, grower's concerns over the uncertain future of fumigation is stimulating research into integrated methods of soil disinfestation. For example, a new biocidal dip (1,bromo-3-chloro-5,5 dimethylhydantoin) applied to strawberry runners prior to planting has doubled root growth in preliminary trials. Current trials are integrating this treatment with pre-emergent herbicides and supplementary nutrient treatments.

Understanding the influence that alternative soil disinfestation techniques have on nutrients and microbial biomass is critical to the selection of treatments that replace MB. MB fumigation results in a change in the balance of soil nutrients and biomass, that not only reduces plant pathogens, but favours plant growth. In our studies, increased ammonium concentration in soil and a flush of gram negative bacteria (including nitrifying bacteria) which rapidly recolonise fumigated soils, possibly leads to an increase in nitrate-N in soil and an increased growth response. The challenge for researchers is to develop alternative soil disinfestation systems that also give enhanced crop growth, such as the use of controlled production systems using soilless media.

Table 1. Summary of the plant-back requirements of fumigants for strawberries.

Fumigant	Trials Conducted	Plant-Back Determined in Field Trials	Plant-Back Recommended by Manufacturers
MB:Pic (50:50)	4	1-2 weeks	3 weeks
MB:Pic (30:70)	5	1-2 weeks	3 weeks
Chloropicrin (Pic)	5	2-3 weeks	3 weeks
Dazomet (98% MITC)	5	2-12 weeks	2-4.5 weeks
Metham (42.5% MITC)	4	2-8 weeks	2-3 weeks
1,3-D:Pic (65:35, as TeloneC35)	1	2 weeks	4 weeks
1,3-D:MITC:Pic (35:15:13, as Vorlex)	1	8 weeks	Not Available

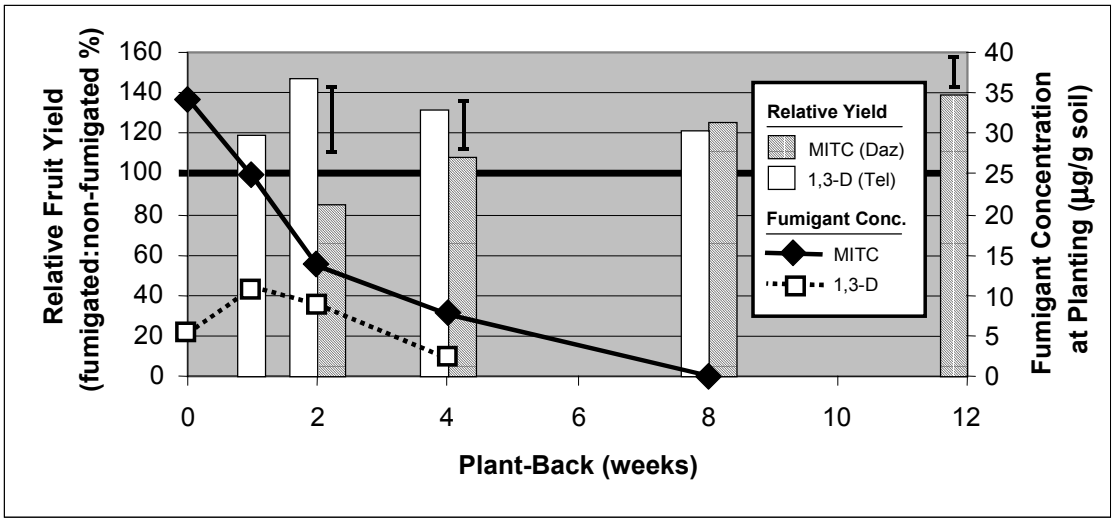

Figure 1. Relative fruit yield of strawberries and fumigant concentration at planting over different plant-back times. Fumigants included Telone-C35 (containing 1,3-D) and dazomet (generating MITC). Error bars (P= 0.05) shown where yield differences are significant.

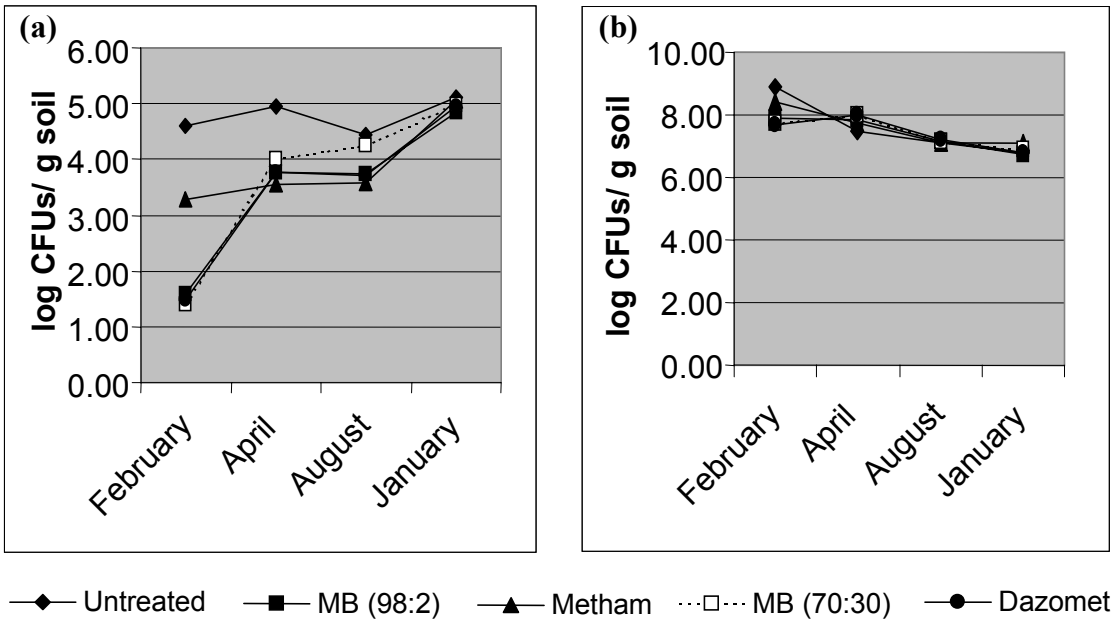

Figure 2. Effect of fumigant treatments on populations and recolonisation by (a) total soil fungi and (b) total aerobic bacteria.

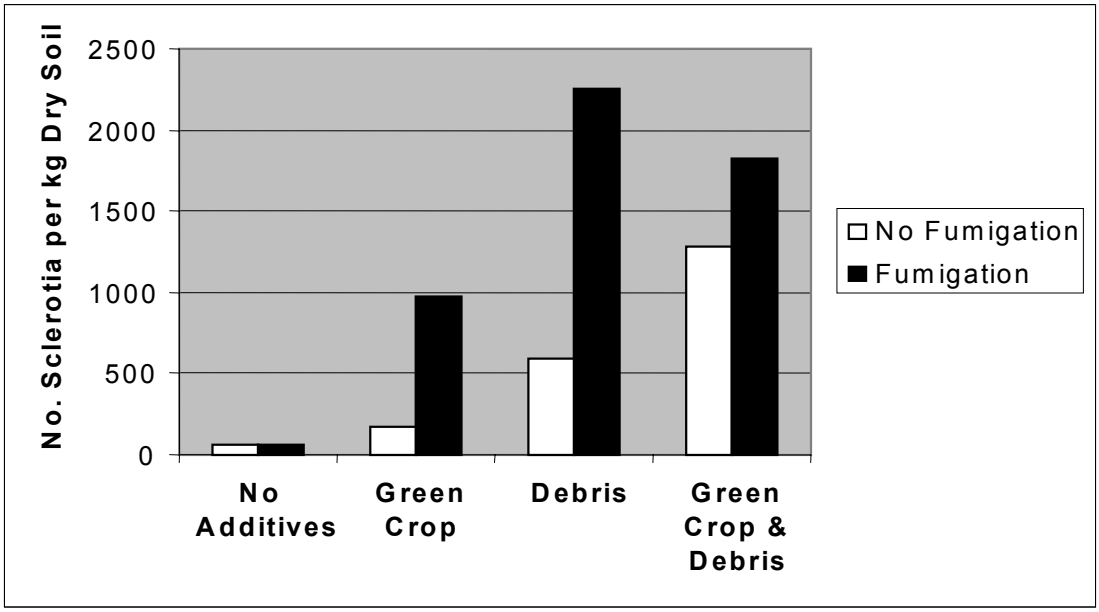

Figure 3. Recolonisation of fumigated and non-fumigated soil by *Sclerotium rolfsii* following the addition of various organic amendments.