DRIP FUMIGATION OF IODOMETHANE IN THE AUSTRALIAN PROTECTED HORTICULTURE INDUSTRY

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The Australian protected horticulture industry has struggled to identify soil disinfestation options following the global phase out of methyl bromide (MB) in 2005. Although researchers have trialed alternative disinfestants, application issues have limited their adoption. For example, structural limitations of glasshouses often prevent conventional application (shank injection) of alternatives. Also, the low volatility of some alternatives means that they require more strategic application to optimise distribution.

Horticultural industries worldwide are utilising drip irrigation systems for applying soil fumigants (drip fumigation). Drip fumigation is an attractive alternative for protected horticulture because:

i. Users can apply fumigants from outside the glasshouse, increasing human safety.
ii. A wider range of fumigants can be applied using this method, including those with low volatility.

This paper reports on the first trials applying fumigants (iodomethane:chloropicrin, IM:Pic) through drip irrigation systems in Australia. Trials aimed to (a) configure drip irrigation systems for optimal distribution of carrier water through a sandy clay soil, and (b) evaluate the movement and efficacy of drip fumigation, compared with traditional application methods.

Configuring irrigation systems for drip fumigation

Microplot trials evaluated the movement of carrier water from drip irrigation lines through the soil profile over time (0 – 4 hours) using a Hydrosense soil moisture monitor (Campbell Scientific) and the triarylmethane dye 'Brilliant Blue FCF'. Treatments included emitter flow rates (1 L / hr and 2 L / hr) and emitter spacings (20 cm and 30 cm). Trials were conducted as randomised complete block designs with 3 replicates. Results from the water movement trials included:

- Emitter flow rates of 1 and 2 L / hr provided even water distribution through the profile.
- The optimal emitter spacing was between 20 - 30 cm.
- A 2 hr irrigation was required to evenly distribute water through the profile (Figure 1).
- The total amount of water required to sufficiently wet the soil profile was 35 - 50 L / m^2.

Monitoring the movement of chemicals following drip fumigation

A microplot trial evaluated the movement and efficacy of the fumigant IM:Pic (50:50, 50 g / m^2), following drip fumigation and traditional shank injection. Controls consisted of MB:Pic (98:2, 100 g / m^2, surface applied as a hot gas) treated and untreated soils. Concentrations of IM were measured through the soil profile (depth: 10 & 30 cm; distance: on & between point of application) over time (0 – 5 days) using detector tubes (Gastec^{TM} 121L). Results from the movement and efficacy trial included:

- Concentrations of IM in drip-fumigated plots were equivalent to those in shank-injected plots (Figure 2).
- An emitter spacing of 20 cm or 30 cm evenly distributed IM throughout the soil profile.
- Drip fumigation evenly distributed IM through the profile, to the edge of the treated area and to a depth of 30 cm (Figure 3).

Evaluating the efficacy of drip fumigation

In the movement and efficacy microplot trial weed seeds (*Vicia sativa, Trifolium subterraneum*) and plant pathogens (*Fusarium oxysporum, Sclerotium rolfsii*) were buried into soils at various depths and distances. Test species were recovered 5 days after fumigation and their viability determined using germination and cultural techniques. The trial consisted of 3 replicates of each treatment. Results from the movement and efficacy trial included:

- Drip fumigation of IM:Pic controlled pathogens and weeds as effectively as shank injection and MB (Table 1).
- Drip fumigation of IM:Pic controlled pathogens and weeds buried at depths of 10 cm and 30 cm, on and between the emitters.
- Sclerotes of *S.rolfsii* and hyphae of *F.oxysporum* were effectively controlled by drip fumigation with IM:Pic.

Conclusions

Overall, drip fumigation appears a good prospect for soil disinfestation in protected horticulture and an alternative to MB. This preliminary study found that drip irrigation systems running 2-hrs, with emitter flow rates of 1 L/hr and spacings of 20 cm were effective in delivering water and fumigant evenly through a sandy clay soil; and this was effective for pathogen and weed control. Water use in this system is 50 L/m^2, which is similar to that for steam disinfestation of soil (60 L/m^2).

An important benefit of drip fumigation is that the water seal it creates can reduce emissions of fumigants to the atmosphere compared with shank injection. Combined with low-permeability barrier films, drip fumigation has the potential to minimise the adverse impacts of fumigants on the environment. Furthermore, modified drip systems can apply biofumigants and biological controls more evenly to the crop root zone, potentially increasing their efficacy.

Drip fumigation is an excellent application method for flat land, but may be more difficult on steep slopes. Future research will investigate pressure compensating emitters and inline pressure regulators to overcome these issues in commercial trials in protected horticulture.

Table 1 - Mortality of 2 weed species and 2 soil-borne plant pathogens following fumigation with varying application techniques

Treatment	Weeds		Plant Pathogens	
	V.sativa	*T.subterraneum*	*S.rolfsii*	*F.oxysporum*
Drip – IM:Pic 50	99.7% a	99.1% a	100.0% a	95.6% a
MB:Pic 98	99.6% a	98.3% a	100.0% a	91.7% a
Shank – IM:Pic 50	97.1% a	98.6% a	100.0% a	100.0% a
Untreated	0.0% b	25.6% b	3.3% b	0.0% b

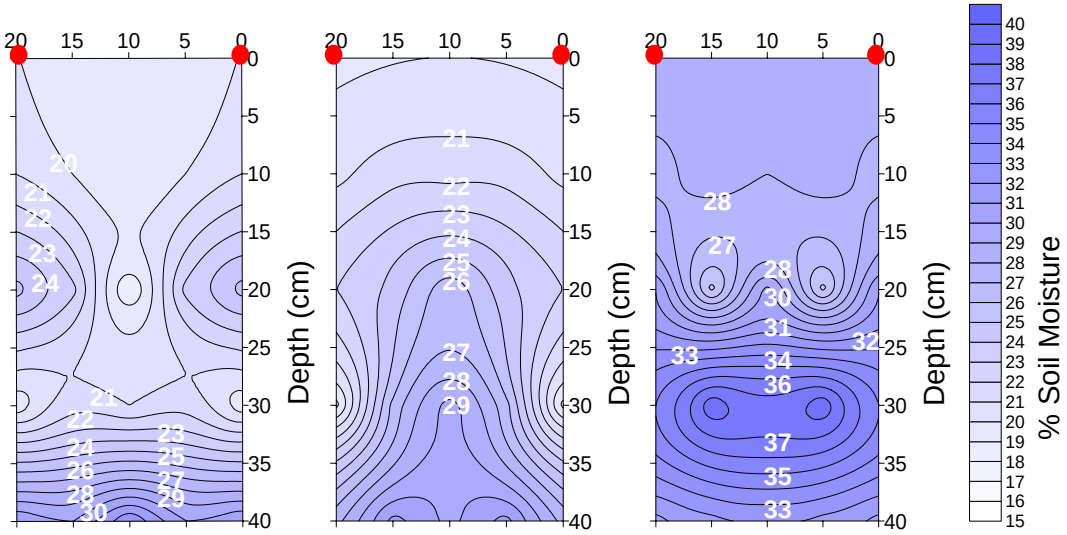

Figure 1 - Contour plots showing the distribution of water through the soil, after 0.5 hrs, 1 hr and 2 hrs of irrigation from emitters (1 L / hr) spaced 20 cm apart (circles represent emitters at the soil surface).

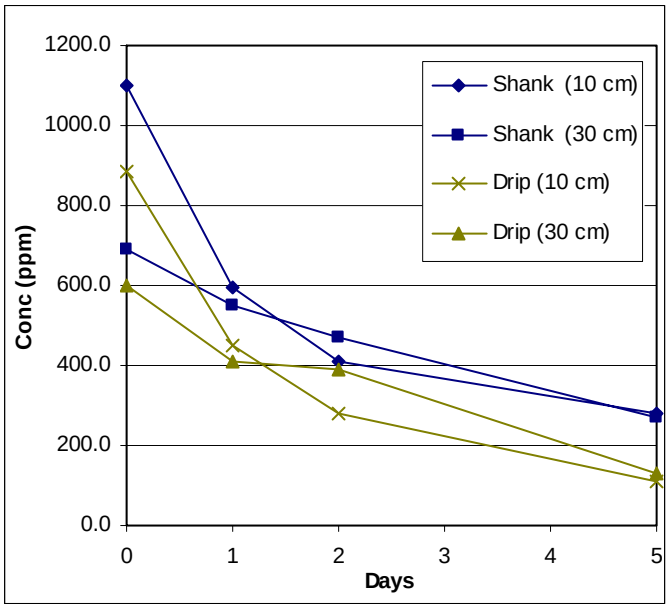

Figure 2 - Distribution (vertical) of IM (ppm) in soil following application via drip fumigation and shank injection (Not significant, p = 0.05).

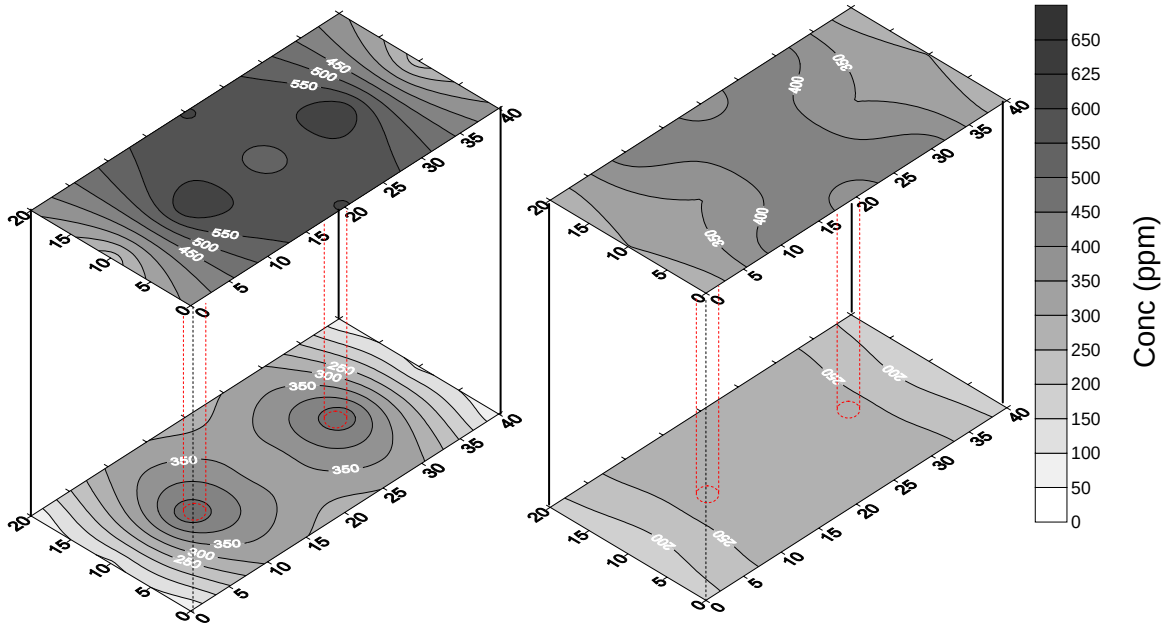

Figure 3 - Contour plots showing the lateral distribution of IM through the soil at depths of 10 cm and 30 cm, following drip fumigation - 2 hrs (A) and 24 hrs (B) after application (red cylinders represent the position below the emitter - 1 L / hr, 20 cm spacing).