EVALUATING NOVEL SOIL FUMIGANTS FOR AUSTRALIAN HORTICULTURE

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Australian horticulture, in conjunction with the Department of Primary Industries, Victoria, has successfully implemented a program over the last 13 years to phase out the use of methyl bromide (MB), in accordance with the Montreal Protocol. While growers have adopted chemical and non-chemical alternatives to MB, there remains a pressing need to further develop these alternatives, and evaluate several new products recently imported or developed in Australia (e.g. methyl iodide – MI, ethanedinitrile – EDN, propylene oxide – PPO). This paper reports on trials conducted with these fumigants to determine their suitability for Australian environments and optimise their application for pepper, strawberry and ornamental flower production. To assess their performance, trials monitored fumigant efficacy against weeds and nematodes, disease incidence, and their effect on crop growth and yields.

Vegetable Trials (Peppers)

A trial was established at Bundaberg, Qld (24°9' S, 152°3' E) to assess the comparative efficacy of MB:Pic (70:30, 500 kg/ha), MI:Pic (30:70, 250 kg/ha and 500 kg/ha), chloropicrin (Pic, 500 kg/ha), PPO (340 kg/ha), Telone C-35 (TC-35, 600 kg/ha) and an untreated control. All fumigants were applied (depth – 25 cm) into preformed beds (width – 0.65 m) through two tynes spaced 30 cm apart, except PPO, which was applied through drip tapes (emitter spacing – 20 cm, emitter flow rate – 0.9 L / hr). All treatments were covered with low density polyethylene barrier film (LDPE, 30–35 μm), which remained in place throughout the growing season. Treatments were applied in September 2004 (Spring) and planted in November 2004 (40 days after fumigation (DAF)) with *Capsicum annum* seedlings (var. Predator). The trial was conducted as a randomised complete block design with 3 replicates, each experimental unit containing 120 plants.

The most effective treatments against soil-borne pests in this trial were MB:Pic, MI:Pic, TC-35 and Pic. These treatments significantly reduced numbers of the weed species *Cyperus rotundus*, in comparison with the untreated control. Trends in results also indicated reduced levels of pathogenic nematodes (*Meloidogyne hapla*) and a significant reduction in non-pathogenic nematodes in MB:Pic, MI:Pic, TC-35 and Pic-treated soils, compared with the untreated control. These treatments also reduced the incidence of the disease, sudden wilt (caused by *Pythium myriotylum*), compared with the untreated control (Table 1).

Peppers grown in MB:Pic, MI:Pic and TC-35-treated soils showed increased vigour (growth assessments) and produced significantly greater yields than plants grown in untreated, PPO and Pic-treated plots (Table 3). This was probably due to the increased efficacy of these fumigants against weeds and nematodes and for controlling sudden wilt.

This trial demonstrated TC-35 and MI:Pic as viable alternatives to MB:Pic for pepper production in the sandy loam soils of Bundaberg, providing treated soil is given sufficient time to aerate and release fumigant residues prior to planting. Currently, the Bundaberg vegetable industry has adopted rotations (with sugar cane) and strategic fumigation with TC-35 and metam to phase out MB. However, the registration of new products with superior abilities to control *C. rotundus* (e.g. MI) will be important for sustaining high crop yields.

Strawberry Trial (Fruit)

A soil fumigation trial was established at Mornington Peninsula, Vic (38°4' S, 145°0' E) at a commercial strawberry fruit farm. Treatments included MB:Pic (50:50, 500 kg/ha), MI:Pic (30:70, 250 kg/ha and 500 kg/ha), EDN (250 kg/ha and 500 kg/ha), TC-35 (500 kg/ha), Pic (500 kg/ha) and an untreated control. All fumigants were applied (depth – 20 cm) into preformed beds (width – 0.8 m) through 2 tynes spaced 20 cm apart, and covered with LDPE (30 – 35 μm). Treatments were applied in October 2003 (Spring), and planted with *Fragaria* x *ananassa* runners (var. Diamante) in November 2003, 42 DAF. The trial was conducted as a randomised complete block design with 3 replicates, each experimental unit containing 100 plants.

Trends in results indicated that MB:Pic, MI:Pic (500 kg/ha), TC-35 and EDN (500 kg/ha) were the most effective treatments against weeds, reducing their biomass by over 70 % compared with the untreated control. In addition, all fumigants were effective in suppressing disease symptoms (Pythium stunt, caused by *Pythium ultimum*) in comparison with the untreated control. However, owing to the variability in weed and disease pressure at the site there was no significant difference between treatments (data not shown), which resulted in equivalent yields across the trial (Table 3).

Results from the trial suggest that optimal rates for MI:Pic and EDN lie toward the higher end of the evaluated rate range (250 kg/ha - 500 kg/ha), but due to the low weed and disease pressure further trials are required to confirm this. Currently, the majority of the Australian strawberry fruit industry has adopted TC-35 as an alternative to MB, but are awaiting the registration of new products (e.g. MI and EDN) so that commercial evaluations can begin.

Ornamental Flower Trial (Bulb Production)

A trial was established at Silvan, Vic (37°8' S, 145°5' E) to evaluate the efficacy of MB:Pic (50:50, 350 kg/ha and 500 kg/ha), MI:Pic (30:70, 350 kg/ha and 500 kg/ha) and TC-35 (500 kg/ha) for soil disinfestation and ornamental bulb production. All fumigants were applied using a broad-acre rig with 8 tynes, spaced 20 cm apart (depth – 20 cm) and covered with either LDPE or a virtually impermeable film (VIF, Orgalloy, 51.9 μm). Treatments were applied in March 2004 (Autumn) and planted with *Iris hollandica* bulbs (var. Telstar) in April 2004, 38 DAF. The trial was conducted as a randomised complete block design with 3 replicates, each experimental unit containing 60 bulbs.

Bulbs grown in MB:Pic (350 kg/ha, VIF) and MI:Pic (350 kg/ha and 500 kg/ha) treated soils produced significantly longer stems than those grown in untreated, TC-35 and MB:Pic (500 kg/ha, LDPE) treated soil (Table 2). In addition, all fumigants significantly reduced the biomass of grass weeds from 175.8 g/m^2 in untreated plots to zero.

All treatments significantly reduced the incidence of sclerotium rot (caused by *Sclerotium rolfsii*), compared with the untreated control (Table 2). As a result, bulb yields were significantly higher in all treated soils (except TC-35), compared with the untreated control (Table 3).

Identifying diverse alternatives to MB for ornamental bulb production in the Silvan district is of high importance, largely due to the continued persistence of *S. rolfsii* (~ 20 years). Results indicate that MI:Pic has great potential as an alternative to MB, because it effectively reduced disease levels, while also increasing vegetative growth and yields. The higher rate (500 kg/ha) of MI:Pic was more efficacious than the low rate. However, reduced rates of MI:Pic (350 kg/ha) under VIF gave equivalent efficacy to MB:Pic and may be a more economical and environmentally responsible option once MI:Pic is registered.

Conclusion

Propylene Oxide The efficacy of PPO (340 kg/ha) against common soil borne pests and weeds was significantly below the industry standard MB. However, research by Gilreath et al. (2004) suggests that rates between 620 kg/ha and 775 kg/ha are required to obtain equivalent control to MB. Further trials are thus required to optimise rates under Australian conditions.

Ethanedinitrile In strawberry trials, EDN produced equivalent weed control and yields to all other chemical treatments, however results were not conclusive due to insufficient weed and disease pressure. While results from other Australian trials evaluating EDN show great promise (Ren et al., 2003; Mattner et al., 2003; Waterford et al., 2004), further research is required to improve application and retention in the soil, as well as optimising rates.

Methyl Iodide The broad spectrum of activity of MI was evident in all Australian trials, along with its ability to increase vegetative growth and final yields. All results were equivalent to MB suggesting that MI would be an effective alternative to MB for Australian horticulture. However further research is required to evaluate higher concentration formulations of MI, EC formulations and assess the economics of application for different Australian industries.

References

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Table 1. The effect of fumigants against the weed species *C .rotundus*, non-pathogenic nematodes and the incidence of sudden wilt (caused by *P. myriotylum*) in peppers. Values followed by different letters in each column are significantly different, where p = 0.05.

	Weeds - *C.rotundus* (# / m^2)	**Nematodes (# / 200 mL soil)**	**Sudden Wilt Incidence (# dead plants / 30 m)**
Untreated	81.8 a	733 a	11.67 b
MB:Pic 70	3.0 c	198 b	3.00 a
MI:Pic 30 (250 kg/ha)	7.3 c	70 b	1.00 a
MI:Pic 30 (500 kg/ha)	10.7 c	21 b	4.33 a
TC-35	19.9 c	8 b	1.33 a
Pic	26.4 c	35 b	5.67 ab
PPO	80.7 ab	273 b	6.67 ab
LSD (p = 0.05)	**43.8**	**420.6**	**7.00**

Table 2. The effect of fumigants on the incidence of Sclerotium rot (caused by *S. rolfsii*) and the vegetative growth (stem length) of dutch iris. Values followed by different letters in each column are significantly different, where p = 0.05.

	Stem Length (cm)	**Diseased Bulbs (% of harvested bulbs)**
Untreated	56.4 ab	83.1 % a
MB:Pic 50 (350 kg/ha, VIF)	61.5 d	13.5 % b
MB:Pic 50 (500 kg/ha)	56.6 abc	18.6 % b
MI:Pic 30 (350 kg/ha)	61.4 d	21.5 % b
MI:Pic 30 (350 kg/ha, VIF)	59.6 bcd	12.6 % b
MI:Pic 30 (500 kg/ha)	63.8 d	18.1 % b
TC-35	53.7 a	20.7 % b
LSD (p = 0.05)	**4.5**	**21.8**

Table 3. Relative yields of different horticultural crops when grown under varying fumigant regimes, in comparison to MB. Values followed by different letters in each column are significantly different, where p = 0.05.

	Peppers (04 / 05)	**Strawberries (03 / 04)**	**Flower Bulbs (04)**
MB:Pic 70 (500 kg/ha)	100.0 % d (26,494 kg/ha)		
MB:Pic 50 (500 kg/ha)		100.0 % (424 g/plant)	100.0 % bc (1.3 kg/plot)
MB:Pic 50 (350 kg/ha, VIF)			106.6 % c
Untreated	27.6 % a	93.8 %	70.3 % a
MI:Pic 30 (250 kg/ha)	88.4 % d	82.4 %	
MI:Pic 30 (350 kg/ha)			107.7 % c
MI:Pic 30 (350 kg/ha, VIF)			95.1 % bc
MI:Pic 30 (500 kg/ha)	87.6 % d	99.4 %	117.6 % c
TC-35 (500 kg/ha)		100.4 %	80.6 % ab
TC-35 (600 kg/ha)	93.6 % d		
Pic	65.4 % c	94.1 %	
PPO	46.5 % b		
EDN (250 kg/ha)		72.8 %	
EDN (500 kg/ha)		92.9 %	
LSD (p = 0.05)	**15.7 %**	**46.0 %**	**24.8 %**