VIF IMPROVES THE EFFICACY OF EDN ® FUMIGAS IN THE AUSTRALIAN STRAWBERRY NURSERY INDUSTRY

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Introduction

Early studies with EDN® FUMIGAS **(**Ethanedinitrile, EDN) in the Australian strawberry nursery industry showed that it has the potential to disinfest soil as efficaciously as mixtures of methyl bromide (MB) and chloropicrin (Pic) (Mattner et al., 2006). EDN is highly volatile (boiling point -21°C), and recent trials have demonstrated that retention of EDN in soil is an important factor needed to ensure efficacy against target pests.

Barrier films, such as virtually impermeable films (VIFs), can retain fumigants in soil longer than standard low-density polyethylene films (LDPE) (Fennimore & Ajwa, 2011). The ability of films to retain fumigants can vary with the fumigant used, environmental conditions, and method of field application (e.g. Papiernik et al. 2011). We conducted a field trial on the efficacy of EDN under VIF and LDPE for soil disinfestation compared with other fumigants in the strawberry nursery industry at Toolangi, Australia.

Methods

Soils (Red Ferrosol, clay-loam) at the trial site were fumigated in Sept 2014 (Spring) with the treatments listed in Table 1, using broad-acre, shank injection at 15 cm (R&R Fumigation, Bayswater). Soil moisture and temperature at fumigation was 18.2% (w;w) and 14.1°C, respectively. Barrier films remained on the soil for 1 wk. At 4 wks after fumigation, plots were planted with a single row of strawberry mother plants (cv. San Andreas). Total concentrations of selected strawberry pathogens (*Pythium* spp. I & F, *Verticillium dahliae*, *Meloidogyne hapla*, and *Pratylenchus penetrans*) were measured in soil at planting (Nov 2014) and harvest (May 2015) at soil depths of 0-10 cm and 40-50 cm using qPCR (SARDI, Adelaide). In addition, populations of *Phytophthora* spp. and *Fusarium* spp. were determined at planting (0-10 cm depth) using soil dilution techniques. Weed emergence was measured through the season, and final runner yields taken at harvest. The trial was conducted as a randomised complete block design, with four blocks. Individual plots were 70 m long × 2.7 m wide. Data were analysed by ANOVA using Genstat 16th Ed.

Results

Pathogen control: At planting, EDN significantly reduced total DNA concentrations of the selected pathogens by up to 90% compared with the untreated control at a depth of 0-10 cm, but not at 40-50 cm (Table 2). There was no significant difference in the total concentrations of pathogens in soils treated with EDN LDPE and EDN VIF. Only MB/Pic reduced pathogen concentrations at depths of 40-50 cm compared with the untreated control. At planting, pathogen concentrations were significantly lower (by up to 90%) in the MB/Pic treatment than in the EDN treatments.

DNA concentrations of pathogens increased in soil from planting time to harvest time. At harvest, only MB/Pic-treated soil had lower DNA concentrations of pathogens (by up to 98%) in comparison with the untreated control (Table 2). Populations of *Phytophthora* spp. and *Fusarium* spp. in soil at the trial site at planting were extremely low. Under conditions of low inoculum, EDN significantly reduced populations of these fungi in soil compared with the untreated control, by up to 100% (Table 3).

Weed control: EDN significantly reduced total weed emergence by up to 95% compared with the untreated control, and soils treated with Pic (Table 4). Sealing EDN-treated soil with VIF significantly reduced weed emergence by 70% compared with LDPE. In particular, sealing soil with VIF increased the control of the weeds *Solanum* spp., *Trifolium* spp., *Lotus corniculatus*, *Lolium* spp. and *Stellaria media* by EDN (data not shown). There was no significant difference in weed emergence between the EDN VIF and MB/Pic treatments.

Runner yield: Soil fumigation with EDN significantly increased runner yields compared with the untreated control (by up to 530%) and Pic-treated soils (by up to 250%) (Table 4). Sealing EDN-treated soils with VIF significantly increased runner yields by 40% compared with LDPE. There was no significant difference in runner yields in soil treated with EDN under VIF, and MB/Pic.

Discussion

EDN showed considerable potential in this trial as an alternative fumigant to MB/Pic for strawberry runner production. For example, soils treated with EDN under VIF provided equivalent weed control and runner yields to MB/Pic. However, EDN did not control pathogens to the same extent as MB/Pic in this trial. In particular, EDN did not reduce pathogen populations at low soil depths (40-50 cm). There was evidence that pathogens surviving at low depths in EDN-treated soils recolonised the upper soil by harvest. This may mean that EDN requires deeper injection (> 15 cm) than MB/Pic to be effective against pathogens. Alternatively co-application of EDN with Pic may improve pathogen control, since Pic is highly efficacious against fungi.

Results from this trial showed that sealing soil with VIF improved the efficacy of EDN for soil disinfestation and runner production, compared with LDPE. For example, sealing EDN-treated soil with VIF significantly increased weed control and runner yields compared with LDPE. It is likely that other films (e.g. totally impermeable films) may be more effective at retaining EDN in soil than the VIF used in this trial, and may further increase field efficacy. Future research is required to screen different films for their permeability to EDN using established procedures (e.g. Papiernik et al., 2011).

References

Fennimore & Ajwa (2011) Total impermeable films retain fumigants, allowing lower application rates in strawberry. *California Agriculture* 65: 211-215

Mattner et al. (2006) Ethanedinitrile (C_2N_2): A novel soil fumigant for strawberry production. *Acta Horticulturae* 708: 197-204.

Papiernik et al. (2011) A standardized approach for estimating the permeability of plastic films for soil fumigation under various field and environmental conditions. *Journal of Environmental Quality* 40: 1375-1382

Table 1. List of treatments applied in a field trial in the strawberry nursery industry at Toolangi, Australia in 2014/15.

Treatment	Application Rate	Barrier Film	Application Method
Untreated	0 kg/ha	LDPE[1]	Nil
Ethanedinitrile (EDN)	500 kg/ha	LDPE	Shank-injection
EDN	500 kg/ha	VIF[2]	Shank- injection
Chloropicrin (Pic)	340 kg/ha	LDPE	Shank-injection
MB/Pic (50:50)	500 kg/ha	LDPE	Shank-injection

[1]LDPE = low density polyethylene, Aperio; [2]VIF = virtually impermeable film, Guardian

Table 2. Total DNA concentration of selected pathogens (*Pythium* spp. I & F, *Verticillium dahliae*, *Meloidogyne hapla*, and *Pratylenchus penetrans*) at planting (Oct 2014) and harvest (May 2015) in soils treated with different fumigants (Sept 2014) in a trial at Toolangi, Australia. Soils samples were taken from depths of 0-10 cm and 40-50 cm. Values followed by different letters at each sampling time are significantly different, where $p < 0.05$.

Treatment	Total Pathogen Concentration (Log pg DNA / g soil)			
	October 2014 (Planting)		May 2015 (Harvest)	
	0-10 cm	40-50 cm	0-10 cm	40-50 cm
Untreated	2.36 a	2.09 ab	3.01 a	2.84 a
EDN LDPE	1.69 cde	2.17 ab	2.66 a	2.54 a
EDN VIF	1.35 ef	1.97 abc	2.78 a	2.80 a
Pic	1.55 de	1.82 bcd	2.80 a	2.49 a
MB/Pic	0.77 g	1.14 fg	1.32 b	1.29 b
LSD (p = 0.05)	**0.40**		**0.56**	

Table 3. Total populations at planting (Oct, 2014) of *Phytophthora* spp. and *Fusarium* spp. in soil following treatment with different fumigants in a trial at Toolangi, Australia. Values followed by different letters in each column are significantly different, where $p < 0.05$.

Treatment	Populations (Log CFUs / g soil + 1)	
	***Phytophthora* spp.**	***Fusarium* spp.**
Untreated	0.18 a	1.12 a
EDN LDPE	0.09 b	0.29 b
EDN VIF	0.00 b	0.33 b
Pic	0.00 b	0.12 b
MB/Pic	0.00 b	0.00 b
LSD (p = 0.05)	0.16	0.41

Table 4. Total weed emergence and runner yields in soils treated with different fumigants in a field trial in the strawberry nursery industry at Toolangi, Australia. Values followed by different letters in each column are significantly different, where $p < 0.05$.

Treatment	Weed Emergence (Log plants/m^2)	Runner Yield (runners/m of row)
Untreated	1.61 a	16.9 d
EDN LDPE	0.72 b	77.8 b
EDN VIF	0.21 c	106.6 a
Pic	1.49 a	34.4 c
MB/Pic	0.14 c	117.8 a

LSD (p = 0.05)	0.34	15.3