METHYL BROMIDE ALTERNATIVES FOR RASPBERRY NURSERIES

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Raspberry nurseries must produce plants free from disease to meet marketplace and export requirements. Minor infestations in nurseries can cause severe epidemics in production fields. Raspberry nurseries presently qualify for critical use and quarantine and preshipment exemptions to use Methyl Bromide (MB), but there is increasing pressure to find alternatives.

Root rot caused by *Phytophthora rubi* (PR) is the most serious root disease of red raspberries in many growing regions. Spread of the disease was associated with infected nursery stock in Scotland [1], and soil fumigation with MB to prevent PR infection remains a high priority for raspberry nurseries. MB is also valued by raspberry nurseries for its role in eliminating nematodes, weeds and other pathogens.

Crown gall (*Agrobacterium tumefasciens*) is common in the coarse-textured soils favorable to raspberry nursery production. Infected plants are unmarketable, and nurseries in California, Washington and British Colombia have been abandoned because of crown gall. Soil fumigation with MB does not consistently eliminate crown gall, but soil solarization has reduced *Agrobacterium* populations [2, 3]. Improved *Agrobacterium* control would be a very attractive feature of a MB alternative for raspberry nurseries.

Our objective was to evaluate alternatives to MB:chloripicrin fumigation for reduction of pathogens and weeds in raspberry nursery production. A field trial was established July 2007 on a Skagit silt loam soil at WSU-NWREC, Mount Vernon. Replicated treatments (Table 1) were established in five randomized complete blocks, with each plot 10 ft x 100 ft. Additional treatments were also evaluated in non-replicated plots.

For weed evaluations, quackgrass rhizomes and nutsedge nutlets were buried at 15 and 30 cm prior to fall treatments. The propagules were removed 20 October and germinated in the greenhouse. For pathogen survival evaluation, two sets of inoculum bags were buried at 15, 30 and 45 cm prior to treatment. Bags were removed 20 October and 10 March. *Agrobacterium* inoculum survival was evaluated by bioassay (30 cm depth) and by dilution plating (all depths). For PR, survival was evaluated by bioassay for all depths. Nematode samples were taken prior to treatment and one month after treatment.

Results

Perennial and Annual Weeds. MB:pic, and Midas® killed all the quackgrass and nutsedge propagules ($P<0.001$, Fisher's protected LSD). Inline killed the majority of quackgrass rhizomes, but was less effective against nutsedge nutlets. Among non-replicated treatments, bed (shank) fumigation with C-35 and Midas® were highly effective using both HDPE and VIF tarps.

The most common native weeds were white clover, common chickweed, common lambsquarters and pepperweed. MB:pic and Midas® controlled these well, except for white clover (data not shown). Solarization controlled weeds well, except for chickweed.

Crown Gall. MB:pic and Midas® gave excellent control at 15 and 30 cm, but were not effective at 45 cm, as measured by dilution plating (Figure 1). The bioassay confirmed that control of crown gall by MB:pic was significant but not complete at 30 cm. Solarization + Inline gave consistently good control at all depths as measured by both assays. In the dilution plating assays, solarization + Inline was less effective in controlling crown gall than MB:pic and Midas® at 15 and 30 cm, but more effective than these treatments at 45 cm. In the bioassay (30 cm depth) solarization + Inline was the most effective treatment. Inline alone was ineffective at all depths.

Phytophthora rubi. In the first bioassay, solarization and solarization + Inline were moderately effective, but disease pressure was insufficient to draw conclusions about the effectiveness of MB:pic, Midas® and Inline (data not shown). In the second bioassay, MB:pic and Midas® controlled PR, but solarization, solarization+Inline and Inline alone did not (Figure 2).

Nematodes. Inline, MB:pic and Midas® were all effective in eliminating plant parasitic nematodes. Solarization alone did not control nematodes, but control was adequate in solarization+Inline plots (Table 2).

Summary and Future Directions

MB:pic and Midas® were the most effective treatments overall, but the expense of Midas® is a barrier to adoption. We will evaluate efficacy of Midas® at reduced rates under a VIF film to reduce costs. Solarization+Inline reduced crown gall better than MB:pic as measured by bioassay. However, this treatment failed to provide adequate control of PR, and is probably not appropriate for nursery production.

Bed fumigation, although atypical for raspberry nursery production, has potential for effective soil fumigation. Less fumigant is required, which reduces expense, emissions and buffer zone size. Because the film remains in place for months after fall fumigation, worker exposure at film removal is minimal. VIF films can be used without the need for specialized glues (further reducing buffer zone size). We were able to plant raspberry cut roots in these treatments earlier than flat-fumigated treatments. Soil friability was excellent, unlike the saturated soil in the surrounding flat-fumigated plots.

References

1. Duncan, J.M. and L.E.M. Cooke, Work on raspberry root rot at the Scottish Crop Research Institute. Acta Horticulturae, 2002. **585**: p. 271-276.
2. Stapleton, J. and J. DeVay, Effect of soil solarization on populations of selected soilborne microorganisms and growth of deciduous fruit tree seedlings. Phytopathology, 1982. **72**(3): p. 323-326.
3. Pinkerton, J.N., et al., Effect of soil solarization and cover crops on populations of selected soilborne plant pathogens in western Oregon. Plant Disease, 2000. **84**(9): p. 952-960.

Table 1. List of Treatments in 2007 field trial

Treatment**	**rate**	**film**	**Comments**
Replicated Treatments			
Non-fumigated check		none	
Solarization + Inline	35 gal/A	clear HDPE	Film applied July 5, 2007. Inline applied Sept 20
Solarization		clear HDPE	Film applied July 5, 2007.
Inline	35 gal/A	black HDPE	Film and Inline applied Sept 20, 2007
MB:pic 67:33	350 lb/A	clear HDPE	Treated Sept 20, 2007
Midas® (MI:pic 50:50)	350 lb/A	clear HDPE	Treated Sept 20, 2007
Non-replicated Treatments			
Solarization + mustard meal		clear HDPE	*Brassica carinata* meal incorporated at 0.5% in the upper 8" of the bed
C-35 (1,3-dichloropropene:chloropicrin 65:35) bed fume,VIF	35 gal/A	Clear Pliant Blockade	Treated Sept 20, 2007
C-35 bed fume, HDPE	35 gal/A	black HDPE	Treated Sept 20, 2007
Midas® bed fume, VIF	350 lb/A	Clear Pliant Blockade	Treated Sept 20, 2007
Midas® bed fume, HDPE	200 lb/A	black HDPE	Treated Sept 20, 2007
Non-fumigated, black HDPE	P	black HDPE	Film applied Sept 20, 2007
Inline,VIF	35 gal/A	Clear Pliant Blockade	Treated Sept 20, 2007

Table 2. Root lesion nematodes /100g soil, October 2007.

Replicated treatments			**Non-replicated treatments**	
Inline	0.0	a	solar + Mustard meal	55.0
MB:pic	0.0	a	C-35 bed fume VIF	6.0
Midas®	0.0	a	C-35 bed fume HDPE	22.0
Solar+Inline	8.0	a	Midas® bed fume VIF	0.0
Solar	82.8	b	Midas® bed fume HDPE	0.0
Non-fumigated check	142.2	b		

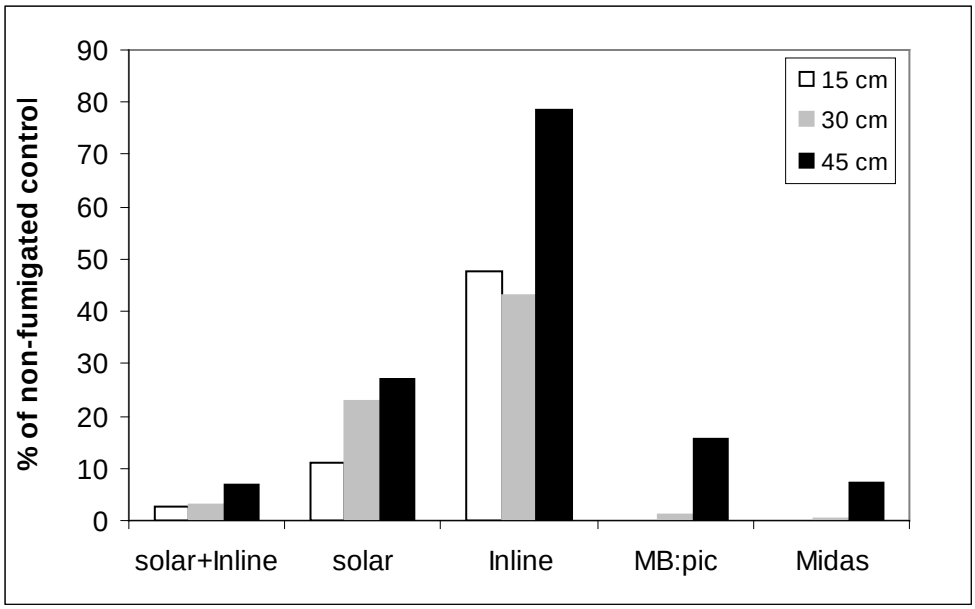

Figure 1. *Agrobacterium* survival measured as colony forming units/g soil relative to counts in nonfumigated plots. Inoculum bags were buried in all plots at 15, 30 and 45 cm prior to solarization or fumigation. Bags were removed March 10 just prior to planting. Inoculum survival was evaluated by bioassay and by dilution plating.

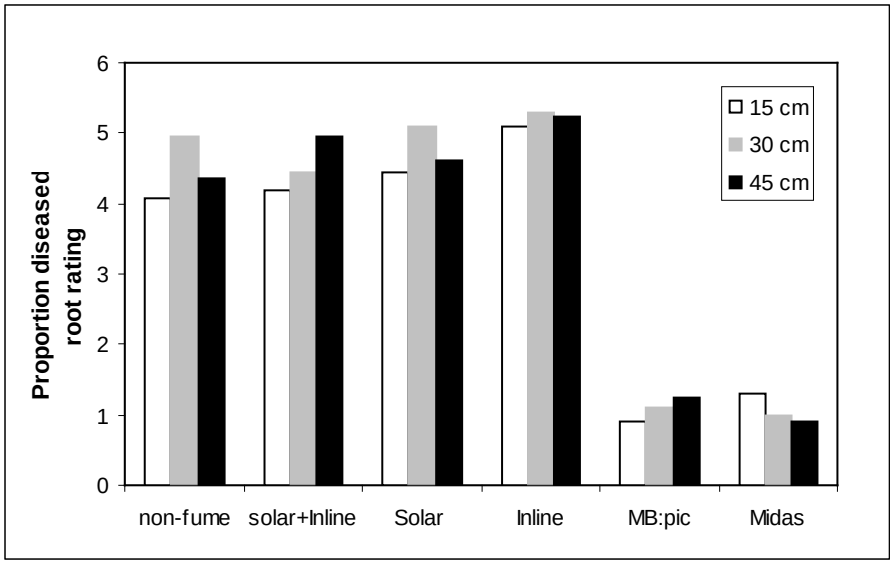

Figure 2. Proportion of roots affected by raspberry root rot in greenhouse bioassays of *P. rubi* inoculum bags buried in plots at 15, 30 and 45 cm. Bags were removed on March 10, just prior to planting. Proportion of diseased roots were rated on a 1-7 scale, with 1= 0-12.5% roots affected, and 7=87.5-100% roots affected. MB:pic and Midas® treatments were consistently the most effective in eliminating root rot inoculum.

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