ALTERNATIVE SOIL FUMIGANT TRIALS IN NEW ZEALAND STRAWBERRY PRODUCTION

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INTRODUCTION: The New Zealand strawberry industry currently relies on methyl bromide as a pre-planting soil fumigant. With a slightly more rapid methyl bromide phase-out schedule than that under the Montreal Protocol, there is an urgent need to find a suitable alternative. Field trials with alternative chemical fumigants are now progressing in commercial strawberry gardens and on Research Orchards.

Many field studies are limited by a lack of pest and disease pressure, or very patchy disease distribution. The current study aimed, in part, to test various alternative fumigants on land where major strawberry pathogens were artificially introduced in the soil, and to test the depth of effective fumigation and pathogen kill using current application techniques. This paper reports the first year's results from an alternative fumigant trial on the HortResearch Orchard in Hawkes Bay, New Zealand.

METHODS: In April 1998, a trial was established on a 0.4 ha silty-clay-loam site, fallowed for two years following apples. *Phytophthora cactorum* was naturally present in the soil. The entire site was artificially infested with inoculum of *P. fragariae* (bulked on alpine strawberry [*Fragaria vesca* var. *alpinus*] roots in seed trays) and *Verticillium* (bulked on agar, and microsclerotia mixed with sand before spreading on the field). Inoculum was rotary hoed into the soil to a depth of 20 cm before fumigant application. Nine treatments were assigned in a randomised complete block design to 27 plots (three replicates of each treatment), each measuring 7x10 m. Plots were separated by 5.5 m headlands that were subsequently fumigated with methyl bromide to minimise contamination of plots. Treatments were:

1. Untreated control.
2. Methyl bromide/chloropicrin (MBC) 67:33, 500kg/ha
3. Methyl bromide/chloropicrin 30:70, 500kg/ha
4. Fumasol™ (metam sodium) (low rate), 400L/ha
5. Fumasol™ (high rate), 800L/ha
6. Chloropicrin, 500 kg/ha
7. Telone C35 (telone/chloropicrin 65:35) 500 kg/ha
8. Basamid® (dazomet) 500 kg/ha
9. VIF (Virtually Impenetrable Film), methyl bromide/chloropicrin 67:33, 333 kg/ha

Treatments 2,3,6,7&9 were injected into the soil to a depth of 15-20 cm, with tines 25 cm apart. Treatments 4,5&8 were applied to the soil surface and cultivated in to a depth of approximately 15 cm, using a tractor mounted rotary hoe. All treatments (except 1) were immediately covered with clear plastic (35 μm low density poly-ethylene for treatments 2 to 8, VIF film for treatment 9). The fumigated plots were planted with a crop of 'Pajaro'

strawberries (630 plants per treatment). Fruit yield was measured throughout the harvest season. Plant health was assessed in Feb. ’99, following the final fruit harvest.

After the final cultivation and before fumigant application, 4x4 cm muslin bags containing inoculum of either *P. cactorum*, *P. fragariae*, or *V. dahliae* were buried at depths of 5, 12, 20 and 30 cm, with one bag of each type of inoculum within each plot. *P. cactorum* inoculum consisted of apple orchard soil with moderate natural populations of *P. cactorum* oospores. For the *P. fragariae* inoculum, approximately 1 g of strawberry roots artificially infected with *P. fragariae* (Race 3) was placed in each bag. *Verticillium* inoculum consisted of filter paper discs soaked in a slurry of microsclerotia prepared on PDA, then subsequently air-dried for one week prior to burying.

Muslin bags were retrieved from treated plots 14 days after fumigant application. *P. cactorum* survival was assessed by baiting with apple cotyledon leaves. The retrieved strawberry roots previously infested with *P. fragariae* were macerated and mixed with seedling potting mix. Alpine strawberry seedlings (10-15 leaf stage) were planted in each pot, and grown at 10 - 24°C. Plants were harvested after 15 weeks, crowns were sectioned longitudinally, and both root and crown health were scored visually. Individual microsclerotia of *Verticillium* were retrieved from filter paper discs, and 20 from each sample were plated on a selective agar medium. After 4 and 8 weeks, plates were assessed for presence of actively growing *V. dahliae* cultures.

RESULTS AND DISCUSSION: Results of the buried inoculum retrieval following fumigation are given in Table 1. Results were reasonably consistent across the fumigant treatments for the three pathogens tested, *P. fragariae, P. cactorum* and *Verticillium.* All survived in the untreated control at all depths tested. The standard methyl bromide treatment (#2) was consistently the best, with no isolation of either *Phytophthora* or *Verticillium*. In contrast, either *Phytophthora* or *Verticillium* were at least occasionally isolated from each of the other fumigants at the 30 cm depth, suggesting that depth of effective penetration may be a limiting factor with these products. The low rate of Fumasol was the weakest of all the products tested, and did not give effective pathogen control.

Table 1. Effect of fumigation on survival of inoculum of *P. cactorum*, *P. fragariae*, and *Verticillium* enclosed in muslin bags buried at various depths.

	***P.cactorum*[1]** Baiting success				***P. fragariae*[2]** Rot severity				***Verticillium*[3]** % germination			
Depth (cm)	5	12	20	30	5	12	20	30	5	12	20	30
Treatment												
1. Untreated	+ + +	+ + +	+ + +	+ + +	5.0	5.0	4.5	5.0	40	48	33	36
2. MBC 70:30	- - -	- - -	- - -	- - -	0	0.2	0	0	0	0	0	0
3. MBC 30:70	- - -	- - -	- - -	+ - -	0	0	0	0	0	0	0	0
4. Fumasol™ low	- - -	- - -	+ + -	+ + +	0	0	4.3	5.0	8	33	22	10
5. Fumasol™ high	- - -	- - -	- - -	+ + +	0	0	0.8	4.0	7	0	29	13
6. Chloropicrin	- - -	- - -	- - -	- - -	0	0	0	4.7	0	0	0	7
7. Telone® C35	- - -	- - -	- - -	+ + -	0	0	0	0	0	0	0	0
8. Basamid®	- - -	- - -	+ - -	+ + +	1.3	0	0	5.0	0	0	0	0
9. VIF	- - -	- - -	- - -	+ - -	0	0	1.0	0	0	0	21	3

[1] '+' = *P. cactorum* retrieved, '-' = *P. cactorum* not retrieved. Results from three replicate plots.

[2] Mean crown rot scores of strawberry plants (six plants per treatment per depth) grown in soil mixed with retrieved inoculum of *P. fragariae*. 0 to 5 scale, where 0=healthy, 5=dead. Root rot results were similar to those of crown rot (data not shown). *P. fragariae* was consistently isolated from diseased plants but not from healthy plants.

[3] Percentage germination of *Verticillium* microsclerotia on agar.

Fruit yield and plant health results (table 2) were closely correlated, and treatment trends were consistent with those observed in the burial experiments. Treatments which included methyl bromide performed well. Untreated, Fumasol and Basamid treatments appeared inferior. Chloropicrin and Telone C35 were the closest to standard methyl bromide treatment.

Table 2. Mean fruit yield and plant health of 'Pajaro' strawberries grown in field plots treated with various fumigants.

Treatment	Fruit weight (kg/row m)	Relative yield (% of Tr 2)	Plant disease rating[1]
1. Untreated	2.65*	- 17.0 *	2.00*
2. MBC 70:30	3.19	-	0.31
3. MBC 30:70	3.22	+ 0.9	0.32
4. Fumasol™ low	2.71*	- 15.2 *	1.68*
5. Fumasol™ high	2.99	- 6.3	0.99
6. Chloropicrin	3.17	- 0.8	0.46
7. Telone® C35	3.09	- 3.4	0.69
8. Basamid®	2.92	- 8.7	0.90
9. VIF	3.14	- 1.8	0.58

[1]630 plants in each treatment rated on a 0 – 4 scale, where 0=healthy and vigorous, and 4=dead.

Means significantly ($P<0.05$) different from the std methyl bromide treatment (2) are indicated by an asterisk.

Results from these trials suggest that of the fumigants tested, Telone C35 and straight chloropicrin are the most promising alternatives to methyl bromide. If metam sodium or Basamid are to be successfully applied, application techniques (especially depth of incorporation) will need to be addressed.