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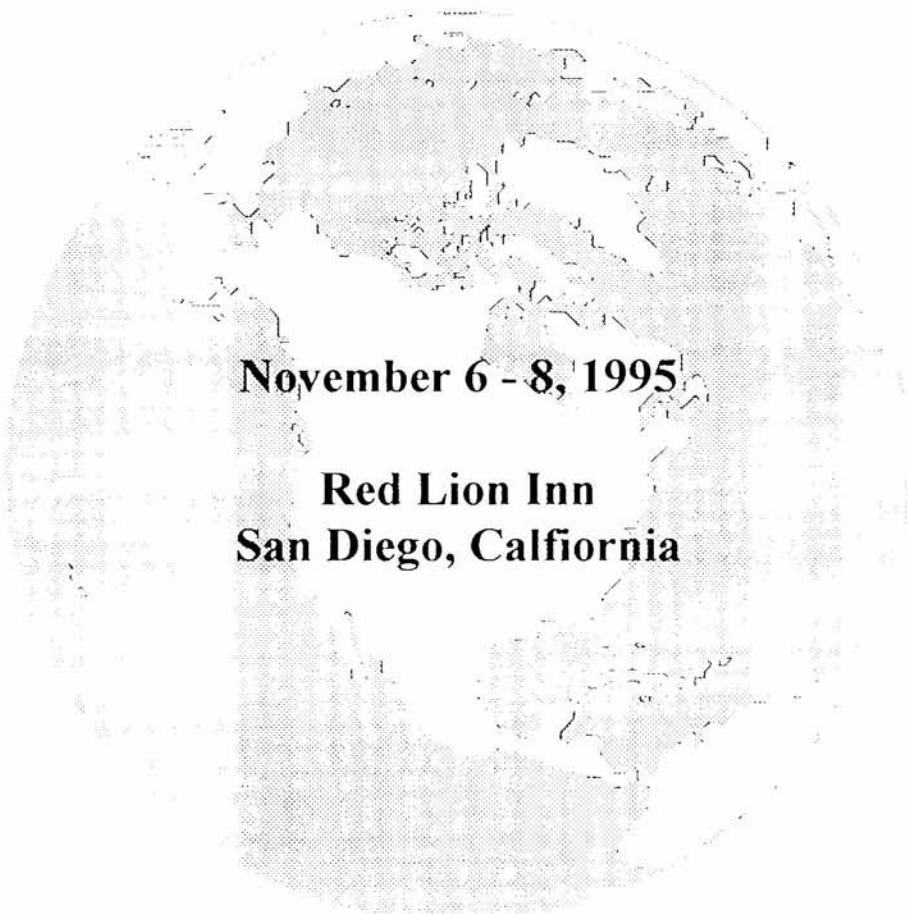

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ALTERNATIVES TO METHYL BROMIDE FOR CONTROL OF SOIL-BORNE DISEASES IN BARE ROOT FOREST NURSERIES

Jeffrey K. Stone[1], Diane M. Hildebrand[2], Robert L. James[3], Susan M. Frankel[4], and David S. Gernandt[5]

The objective of the project is to develop alternatives to methyl bromide and other chemical soil fumigants through implementation of comprehensive integrated pest management practices in bareroot forest nurseries. Within this broad objective we are conducting field experiments to evaluate the basis for fumigation in nurseries with respect to cropping and soil treatment practices in order to develop effective alternative management practices which minimize incidence and severity of disease. Together with field studies, greenhouse and laboratory studies are aimed at better understanding the genetic basis for pathogenicity of *Fusarium oxysporum* f. sp. *pini*, and the dynamics of pathogen populations in nurseries to better predict disease potential.

Alternative management approaches aimed at reducing populations of *F. oxysporum* and potential for seedling infection in field studies have included: reduced input of green, fast decomposing organic matter (i.e. cover crops and green manures) through interrotational bare fallowing; use of more slowly decomposing soil organic amendments (e.g. sawdust, composts) to replace soil organic matter and enhance populations of natural microbial competitors and antagonists; use of modified sowing methods and timing, e.g. shallow sowing with non-soil seed covering to reduce seed exposure to inoculum, and mulching for erosion and weed control. The first cycle of the study was begun in spring of 1993 and seedlings were evaluated at the end of the first growing season (October 1994) and will be evaluated again at lifting in 1995. A second cycle of the study was begun in spring 1995 that is expected to run through fall of 1997.

Most disease losses in seedlings occur in the first growing season. Evaluations of treatments at the end of the first year show bare fallowing between production crop cycles reduced pre-plant *Fusarium* populations to levels comparable with those achieved through chemical fumigation, and may be a suitable replacement for routine methyl bromide fumigation to control *F. oxysporum*. Bare fallow with or without periodic tilling was equivalent to methyl bromide or other chemical fumigation treatments with respect to *Fusarium* and *Pythium* levels in nursery soil, seedling density, seedling mortality, and seedling quality/vigor (height, caliper, root biomass) in six of eight nurseries (two nurseries did not fumigate) with four coniferous species. Seedling density and mortality during the first growing season were also comparable, and in some nurseries significantly better, in bare fallow compared to fumigation treatments.

In Nursery A, bare fallow without till and bare fallow with till were both comparable treatments to the nursery standard practice of pea cover crop with methyl bromide/chloropicrin fumigation. High presow levels of *Fusarium* occurred in response to the pea cover crop without fumigation treatment but were significantly lower in pea cover crop with fumigation and the two bare fallow treatments. *Fusarium* levels increased over 4 times initial levels in the pea cover crop without fumigation treatment

but decreased in all other treatments. High levels of ponderosa pine seedling mortality occurred in the cover crop, non-fumigated treatment, resulting in significantly lower seedling density in that treatment. Seedling shoot length, caliper, and root volume were significantly larger in the fumigated treatment. Surviving seedlings in the control (pea cover crop, non fumigated) treatment were somewhat shorter, but had comparable root volumes to seedlings in other treatments because of reduced crowding and competition (data not shown).

In four nurseries (B, C, D, E) that do not use cover crops but routinely bare fallow and fumigate between main crop rotations, pre sow *Fusarium* levels in non fumigation treatments were not statistically different from fumigated treatments. At the end of the first growing season, seedling density and mortality in fallow with fumigation and fallow without fumigation treatments were also equivalent for four coniferous species: douglas-fir, lodgepole pine, ponderosa pine and red fir. Rich organic soil amendments, such as mushroom compost, were apparently detrimental. Early, shallow sowing treatments at Nursery F resulted in higher density and reduced mortality in red fir seedlings compared to the standard late sow with soil covering the seed, regardless of other presow soil treatments or seed cover mulches.

Modified cultural practices can provide inexpensive yet effective non chemical pest management options to growers. Elimination of fumigation should also lead to establishment of more stable soil microbial communities with natural antagonists to fungal pathogens. Elimination of interrotational cover crops and judicious choice of organic soil amendments to reduce the nutrient base available to pathogenic fungi can reduce pathogen populations and reduce disease. Modification of sowing time and seed cover can help temporal and physical barriers to seedling infection. Further modifications of nursery cultural practices, such as watering and fertilization regimes will be necessary to achieve optimum seedling quality, and problems associated with bare fallowing, such as wind erosion and soil structure may also need to be solved.

Genetic studies on pathogenicity of *F. oxysporum* are in progress to characterize *F. oxysporum* isolates from nursery soil and seedlings (both diseased and healthy) with respect to vegetative compatibility groups, biochemical genetic markers (ITS sequences, IGS and M13 fingerprinting), and pathogenicity. Such characterization is expected to improve our understanding of population dynamics of *F. oxysporum*, our ability to predict disease potential, and to aid in developing biological controls. Preliminary results indicate that populations of *F. oxysporum* in nursery soils and from infected seedlings are genetically diverse. For 30 isolates from representing two nurseries and two coniferous hosts, tentatively five VCG groups have been identified, including groups that include members from both nurseries and both hosts.

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[1] Assistant Professor, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR
[2] Plant Pathologist, USDA Forest Service, Pacific Northwest Region, Portland, OR
[3] Plant Pathologist, USDA Forest Service, Northern Region, Coeur d'Alene, ID
[4] Plant Pathologist, USDA Forest Service Pacific Southwest Region, San Francisco, CA
[5] Graduate Assistant, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR

Ponderosa Pine	density		mortality		Fusarium	
Peas / MBC	21.35	a[4]	0.055	a	170.2	a
Bare fallow with till	22.30	a	0.114	a	618.2	a
Bare fallow no till	22.40	a	0.093	a	947.5	a
Peas, no fumigation	7.25	b	0.391	b	3711	b

Nursery B Douglas-fir	density		mortality		Fusarium	
Sawdust +N fall fum	19.53	ns	0.099	ns	135	ns
Sawdust + N till 3 wk	16.93	ns	0.131	ns	2194	ns
No sawdust, till 3 wk	19.07	ns	0.117	ns	1106	ns
Sawdust no N, till 3 wk	23.80	ns	0.098	ns	808	ns

Nursery B Ponderosa Pine	density		mortality		Fusarium	
Sawdust +N fall fum	19.93	ns	0.091	ns	135	ns
Sawdust + N till 3 wk	21.40	ns	0.027	ns	2194	ns
No sawdust, till 3 wk	20.87	ns	0.065	ns	1106	ns
Sawdust no N, till 3 wk	23.20	ns	0.060	ns	808	ns

Nursery C Douglas-fir	density		mortality		Fusarium	
Dazomet	30.00	ns	0.360	ns	72.5	a
Sawdust, no till	27.27	ns	0.390	ns	216.8	a
no sawdust w/till	27.00	ns	0.476	ns	171.5	a
Sludge, no till	26.40	ns	0.468	ns	2179.9	b

Nursery D Ponderosa pine	density		mortality		Fusarium	
Bare fallow with till	23.27	ns	0.141	ab	496	ns
Bare fallow no till	15.33	ns	0.172	b	241	ns
Mushroom compost	15.73	ns	0.114	ab	227	ns
Sawdust	20.10	ns	0.075	ab	215	ns
MBC fumigation	19.30	ns	0.040	a	80	ns

Nursery D Lodgepole pine	density		mortality		Fusarium	
Fallow with till	16.97	a	0.183	ab	456	ns
Fallow no till	20.43	b	0.160	ab	510	ns
Mush. compost	13.90	a	0.297	b	655	ns
Sawdust	16.47	a	0.210	ab	1020	ns
MBC fumigation	20.07	b	0.110	a	108	ns

Table 1 continued

Nursery E Red fir	density		mortality		Fusarium	
Bare fallow, no till	19.33	ns	0.073	ns	532.4	ns
Bare fallow till, compost	19.60	ns	0.050	ns	1176.8	ns
Bare fallow, till, hydromulch	21.60	ns	0.047	ns	845.6	ns
MBC fumigation	20.07	ns	0.011	ns	112	ns
Dazomet fumigation	20.13	ns	0.006	ns	31.6	ns

Nursery F Red fir	density		mortality		Fusarium	
Straw, deep, soil	18.46	a	0.41	a	5285	ns
Straw, shallow, hydromulch	29.88	b	0.07	b	4459.5	ns
Sawdust, shallow, sawdust	27.79	b	0.16	b	3244	ns
Hydromulch, shallow, hydromulch	25.92	b	0.11	b	5406.25	ns
Bare soil, shallow, hydromulch	24.08	b	0.12	b	3233.25	ns

[1] Seedlings/ sq ft, mean of five replicate measurements (average of three, 2 sq. ft. fixed plots) from field plots, October, 1994.
[2] Means of five replicate measurements, dead and missing seedlings, corrected for seedlings killed by non pathogens.
[3] CFU/ g soil, means of five replicate soil dilution samples (average of three plates per sample) corrected for soil moisture, plated on selective media.
[4] Letters denote statistically homogeneous groups, or no differences (ns)