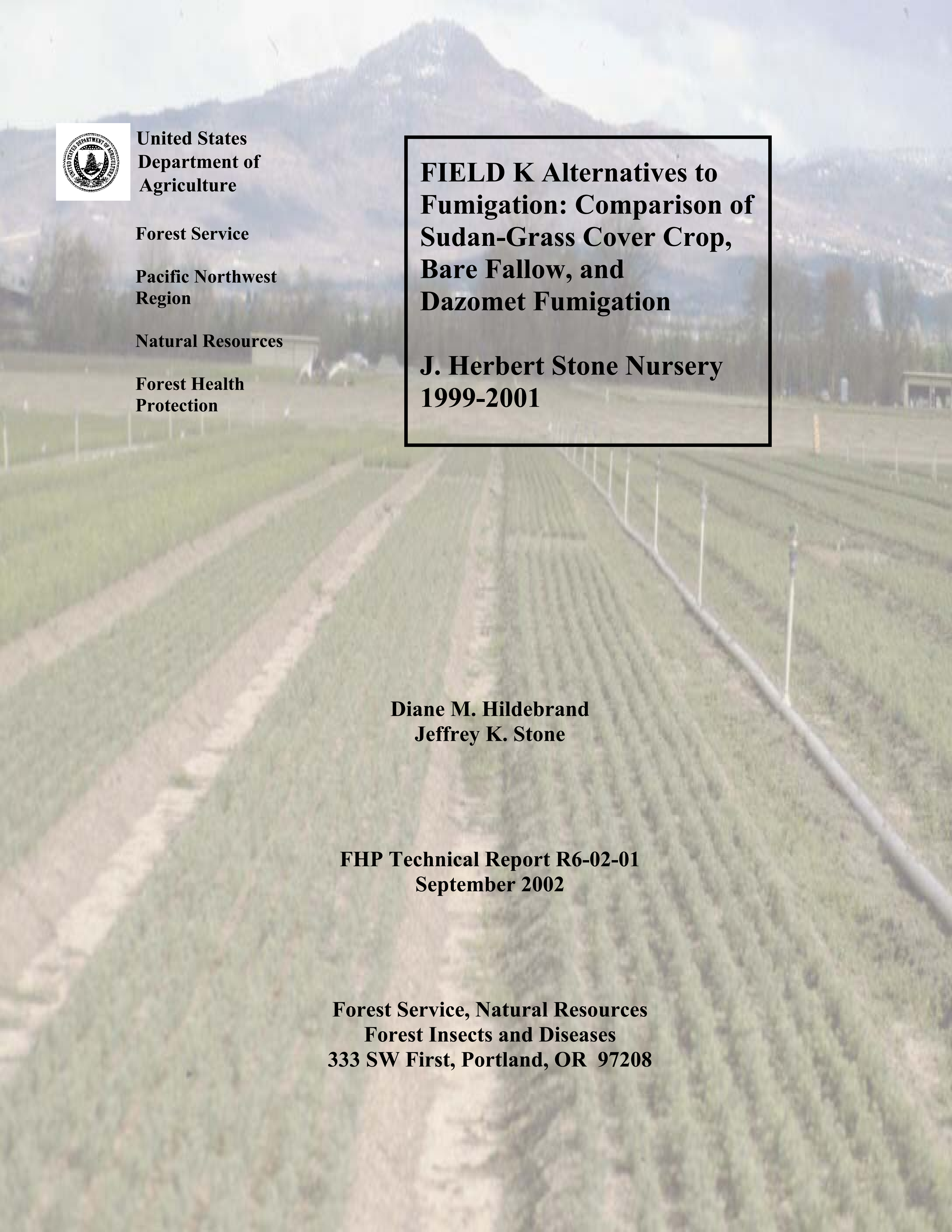

United States
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Pacific Northwest
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Natural Resources

Forest Health
Protection

FIELD K Alternatives to Fumigation: Comparison of Sudan-Grass Cover Crop, Bare Fallow, and Dazomet Fumigation

J. Herbert Stone Nursery 1999-2001

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FHP Technical Report R6-02-01
September 2002

Forest Service, Natural Resources
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Final Report

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Abstract

This trial compared pre-plant treatments of sudan cover crop with and without dazomet fumigation and bare fallow with and without dazomet fumigation on density and size of ponderosa pine, Douglas-fir, western white pine, and noble fir. Treatments were replicated six times. Treatments did not result in significant differences in seedling density or diameter. Height differences due to treatments were inconsistent among species. Trends in the data were also inconsistent between species. Overall, trends indicated that dazomet fumigation might afford a slight improvement in seedling density, diameter, and height. All treatments resulted in seedlings meeting shipping specifications for 2+0 stock.

Introduction

J. Herbert Stone Nursery routinely uses dazomet (Basamid ® granular) as a soil fumigant in the early fall prior to sowing. Occasionally, the nursery fumigates in the spring with methyl bromide/chloropicrin (67 % methyl bromide with 33% chloropicrin), as needed for some crops. Fumigation is used primarily to control soil-borne fungal pathogens, weeds, and some insects.

Soil fumigation with chemical biocides is not only expensive, but potentially hazardous to human health and to the environment. Methyl bromide has a high potential to deplete stratospheric ozone, and will not be available for soil fumigation in the United States after 2005 (USDA 2000a). The amount of methyl bromide available for soil fumigation as of January 1, 2001, was 50 percent of the 1991 production level (USDA 2000b). Furthermore, fumigation severely disrupts the soil microbiota, eliminating both beneficial and detrimental organisms (Munnecke and Van Gundy, 1979). Opportunistic pathogens, including *Fusarium*, may be among the first microorganisms to re-colonize fumigated soil, either from residual inoculum in roots and debris, from blowing dust, or from soil fragments on equipment (Vaartaja 1967). Populations of some beneficial microorganisms, including those antagonistic to pathogens, develop slowly, while the populations of many opportunistic pathogenic fungi can increase rapidly under favorable conditions (Hansen et al., 1990)

J. Herbert Stone nursery has cooperated in many studies aimed at reducing or eliminating the need for chemical fumigants and other pesticides. Previous alternatives to fumigation trials have shown benefits from bare fallowing, sawdust soil amendment without additional nitrogen, early sowing, and covering seed with non-soil mulch (Stone, et al., 1997; Stone, et al., in preparation; Hildebrand and Stone 2001). Here we report the results of a trial in Field K at J. Herbert Stone Nursery, comparing the effects on seedling density and size from pre-plant treatments: sudan cover crop and bare fallow with and without dazomet fumigation.

Acknowledgement

The Special Technology Development Project (Alternatives to Fumigation II, R2-98-01) provided funding for sample collection, pathogen assay, seedling measurements, and 1+0 data analyses for this trial in Field K at J. Herbert Stone Nursery.

Materials and Methods

This alternatives to fumigation trial was implemented in Field K at J. Herbert Stone Nursery, in a randomized block design, with 6 Blocks, 4 treatments, and 4 conifer species. Treatments included sudan-grass cover crop (CC) with and without dazomet fumigation and bare fallow with and without dazomet fumigation. Because the soil texture is somewhat heavy, field K was expected to have some disease pressure, based on past experience with conifers in this field. With 6 replications, the expectation was that this field trial might provide useful data on the relationship of fungal pathogen population levels and disease in conifer seedlings at J. Herbert Stone Nursery.

Figure 1. Block and treatment layout, Field K, J. Herbert Stone Nursery. BFD is bare fallow with dazomet; CCD is cover crop with dazomet; BF is bare fallow without fumigation; and CC is cover crop without fumigation.

Unit	Block	Treatment	Treatment	Block	Treatment	Treatment
14	1	CC	CCD	2	CCD	CC
15	1	BF	BFD	2	BFD	BF
16	3	CC	CCD	4	CCD	CC
17	3	BF	BFD	4	BFD	BF
29	5	BF	BFD	6	BFD	BF
30	5	CC	CCD	6	CCD	CC

1999

Each of the 6 experimental Blocks had one unit of sudan grass cover crop. The grass cover crop was sown in spring 1999, and tilled under in late summer 1999. Cover crops were sown in Units 14, 16, and 30.

The remaining units not in native grass production, were bare fallowed. The bare fallow areas were tilled and sawdust incorporated in late spring 1999. No additional N was added until after the conifer crops had emerged. Bare fallow areas were kept weed free by irrigation (to germinate weed seed) and tilling as needed throughout summer and fall 1999. Units in bare fallow sown as part of this trial were Units 15, 17, and 29.

In an east-west direction across field K, perpendicular to the beds, a line split the field in half, with 3 blocks to the north and 3 to the south. Two 90' wide strips ran north-to-south across the Blocks, perpendicular to the beds. No fumigation occurred within these two 90' wide strips. All remaining conifer bed space, both where the cover crop was tilled under and in the bare fallow, was fumigated with dazomet in early Fall 1999.

2000

Field K was kept reasonably weed free until sowing on April 28, 2000. In each of the 6 blocks, four species were sown: 1) western white pine, *Pinus monticola* Dougl. ex D. Don., 2) Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, 3) ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., and 4) noble fir, *Abies procera* Rehd.; with at least 40' of the seedlot in each of 4 treatments. The rest of field K was sown operationally.

<u>Soil Pathogens</u>

Soil samples were taken for soil-borne fungal assay shortly after sowing in spring 2000. Soil samples were collected in polyethylene bags, transported to the laboratory in cooler boxes, stored at 4^{o} C, and processed within 48 hours of collection. Soil samples were passed through a 0.6 cm screen and 10 g (fresh wt) added to flasks containing 90 mL of 0.1 % water agar. These samples were mixed and serially diluted (1:10, 1:100) in 0.1% water agar for plating. A portion of each soil sample was weighed in tared aluminum dishes and oven dried for determination of water content and conversion of propagule counts to a soil dry weight basis.

Four plates of each sample, 0.5 mL diluted soil on each plate, were prepared on two selective media. Komada's medium (Komada 1975), modified with the amendment of 1 g/L of LiCl for suppression of *Trichoderma* spp. (Wildman 1991) was used for enumeration of *Fusarium* species, primarily *F. oxysporum*. Dilution plates of Komada's medium were incubated under fluorescent light and read after six days. For determination of *Pythium* spp., a modified V-8 medium was used, containing 200 mL clarified V-8 juice, 10 mg rifampicin, 20 mg rose bengal, 250 mg ampicillin, 10 mg pimaricin, 20 g agar per liter. Plates were inoculated with soil dilutions as above, incubated in dark at room temperature, and read after two days. The average number of colonies on four plates multiplied by the dilution factor and corrected for water content yielded colony forming units per gram of oven-dried soil (CFU).

Statistical Analyses

Statistical analyses were carried out using SYSTAT 8.0 (Systat 1998) or SAS software (SAS 1992). Analysis of variance (ANOVA) with Tukey's multiple comparison procedures were used for comparisons of seedling quality factors among treatments at each nursery. Seedling density and mortality data were logit transformed as recommended for proportional data containing zeros (Sabin and Stafford, 1990) and analyzed using ANOVA. Mean CFU for each replicate plot were analyzed using the Kruskal-Wallis procedure and the Mann-Whitney U statistic for comparisons between treatments.

Density and Morphology

After the 1+0 growing season, September 2000, density and seedling morphology were recorded *in situ* for four subplots in each treatment. Density was derived from the number of seedlings per counting frame (0.5 ft by bed width or 2 square ft) randomly placed at three positions within each treatment. Height was measured in cm above ground, and diameter in mm at ground level, for 10 seedlings in the middle 6 rows within the counting frame (omitting the two outer rows).

In the Fall of the 2+0 growing season, 2001, nursery personnel measured density, diameter, and heights *in situ*, for each of the 4 seedlots for each of the 4 treatments for each of the 8 replicates.

Results

At the time of sowing in spring 2000, more weeds were apparent in the non-fumigated treatments.

Soil Pathogens

ANOVA indicated significant differences in population levels of *Pythium* spp. between treatments. Population levels of *Pythium* spp.were very high in all treatments, with that in the sudan cover crop without fumigation greater than in the bare fallow without fumigation greater than in the sudan cover crop with dazomet fumigation (Table 1).

ANOVA indicated significant differences in population levels of *Fusarium* spp. between treatments. Population levels of *Fusarium* spp. were high to very high in all treatments, with that in the sudan cover crop greater than all others (Table 1).

Table 1. Effect of soil treatments on population levels of *Pythium* and *Fusarium* species at J. Herbert Stone Nursery, Field K, spring 2000.

Treatment	Pythium spp.[a]	Fusarium spp.[a]
Sudan CC	502.8 a[b]	9211.1 a
Sudan CC, Dazomet	177.8 c	3025.0 b
Bare Fallow	300.0 b	4427.8 b
Bare Fallow, Dazomet	138.9 cd	1813.9 b

[a] Colony-forming-units per gram of dry soil. [b] Letters indicate different at P< 0.03.

In situ Measurements

Biologically meaningful differences are important to consider along with statistical differences. Where variability results in no statistical differences, trends in the data can provide useful information. Especially for discussing trends in the data, conventions for the threshold of credibility are proposed as follows: A meaningful difference for density might be two seedlings per square ft; for height, a difference of 2 cm; and for diameter, a difference of 0.5 mm.

For ponderosa pine (**PIPO**), after the 1+0 growing season, there were significant treatment effects on diameter and height, but not on density (as determined by ANOVA). After the 2+0 growing season, multiple comparisons indicated no significant differences in density, diameter or height. Trends in the data indicate that density in the sudan cover crop without fumigation averaged 2.5 seedlings/sq ft fewer than that in the bare fallow with dazomet (Table 2). Trends in the data indicate that height in the bare fallow with or without dazomet averaged at least 2.3 cm less than in the sudan cover crop with dazomet. Trends indicate the best treatment for PIPO was sudan cover crop with dazomet (second highest density, largest caliper, tallest).

Table 2. Effect of soil treatments on **PIPO** density, diameter, and height at J. Herbert Stone Nursery, Field K, 1999-2001.

Treatment	Density[a]	Diameter (mm)	Height (cm)
2+0, 2001			
Sudan CC	27.0	6.4	26.1
Sudan CC, Dazomet	28.5	**6.5**	**27.8**
Bare Fallow	27.9	5.9	25.0
Bare Fallow, Dazomet	**29.5**	6.0	25.5
1+0, 2000			
Sudan CC	30.8	3.9	11.7
Sudan CC, Dazomet	32.2	4.0	12.0
Bare Fallow	30.9	3.7	10.6
Bare Fallow, Dazomet	29.0	3.9	11.6

[a] Seedlings per sq ft.

For Douglas-fir (**PSME**), after the 1+0 growing season, treatments resulted in statistically different density, diameter, and height (as determined by ANOVA). After the 2+0 growing season, multiple comparisons indicted no significant treatment effect on density, diameter, or height. Trends in the data indicate both dazomet treatments averaged greater density (2.9 seedlings/sq ft) than the treatments without fumigation (Table 3). Trends indicate the height in the sudan cover crop with dazomet treatment averaged 2.3 cm greater than that in the unfumigated treatments.

Table 3. Effect of soil treatments on **PSME** density, diameter, and height at J. Herbert Stone Nursery, Field K, 1999-2001.

Treatment	Density [a]	Diameter (mm)	Height (cm)
2+0, 2001			
Sudan CC	26.6	5.9	30.7
Sudan CC, Dazomet	**31.1**	6.0	**33.0**
Bare Fallow	28.2	5.8	30.1
Bare Fallow, Dazomet	**33.1**	5.7	31.6
1+0, 2000			
Sudan CC	30.8	2.3	10.9
Sudan CC, Dazomet	37.3	2.6	13.7
Bare Fallow	31.8	2.4	11.4
Bare Fallow, Dazomet	41.2	2.5	13.9

[a] Seedlings per sq ft.

For western white pine (**PIMO**), after the 1+0 growing season, treatments resulted in significant differences in height, but not density or diameter (as determined by ANOVA). After the 2+0 growing season, multiple comparisons indicated significant treatment effects on height, but not density or diameter. Trends in the data indicate that sudan cover crop with dazomet averaged greater density (by 2.3 seedlings per sq ft) than the other treatments (Table 4). Although height showed significant differences statistically, the greatest difference was only 1.1 cm, with sudan cover crop with dazomet resulting in the greatest height.

Table 4. Effect of soil treatments on **PIMO** density, diameter, and height at J. Herbert Stone Nursery, Field K, 1999-2001.

Treatment	Density [a]	Diameter (mm)	Height (cm)
2+0, 2001			
Sudan CC	18.6	4.4	6.5 ab[b]
Sudan CC, Dazomet	**22.2**	4.5	7.0 a
Bare Fallow	19.4	4.6	5.9 b
Bare Fallow, Dazomet	19.9	4.4	6.2 b
1+0, 2000			
Sudan CC	21.2	1.6	3.5
Sudan CC, Dazomet	24.5	1.7	3.5
Bare Fallow	21.5	1.6	3.5
Bare Fallow, Dazomet	24.6	1.7	3.8

[a] Seedlings per sq ft. [b] Letters indicate different at $P < 0.03$.

For noble fir (**ABPR**), after the 1+0 growing season, treatments resulted in significant differences in height, density and diameter (as determined by ANOVA). After the 2+0 growing season, multiple comparisons indicated no significant treatment effects. Trends in the data indicate sudan cover crop with dazomet resulted in lower density (by 3.4 seedlings/ sq ft) than the other treatments (Table 5).

Table 5. Effect of soil treatments on **ABPR** density, diameter, and height at J. Herbert Stone Nursery, Field K, 1999-2001.

Treatment	Density [a]	Diameter (mm)	Height (cm)
2+0, 2001			
Sudan CC	**28.6**	5.3	16.1
Sudan CC, Dazomet	25.1	5.4	17.6
Bare Fallow	**29.4**	5.0	16.3
Bare Fallow, Dazomet	**28.7**	5.0	18.0
1+0, 2000			
Sudan CC	33.8	1.9	6.9
Sudan CC, Dazomet	27.8	2.0	7.1
Bare Fallow	33.0	1.9	6.9
Bare Fallow, Dazomet	31.2	2.1	8.3

[a] Seedlings per sq ft.

Data for all species combined is shown in Table 6. Treatments did not result in significant differences in density or diameter. Trends in the data indicate that density in the bare fallow with dazomet averaged 2.6 seedlings/sq ft greater than in the sudan cover crop without fumigation. Height showed significant treatment effect. Height in the sudan cover crop with dazomet averaged 2.1 cm greater than that in the bare fallow without fumigation.

Table 6. Effects of treatments on 2+0 density, height, and diameter for all species (PIPO, PSME, PIMO, ABPR) combined, J. Herbert Stone Nursery, Field K, 1999-2001. Significance determined by multiple comparisons.

Treatment	Density [a]	Diameter (mm)	Height (cm)
Sudan CC	25.2	5.5	19.8 ab
Sudan CC, Dazomet	26.7	5.6	**21.4** a
Bare Fallow	26.3	5.3	19.3 b
Bare Fallow, Dazomet	**27.8**	5.3	20.3 ab

[a] Seedlings per sq ft. [b] Letters indicate different at $p < 0.01$

Discussion and Summary

Fungal population levels were extremely high in both fumigated and non-fumigated soil. High population levels may have been an artifact of taking the soil samples shortly after sowing, rather than before sowing. Treatment effects on population levels of soil-borne species of *Pythium* and *Fusarium* did not consistently correlate with seedling densities.

The lack of statistical significance in treatment effects on seedling measurements indicates high variability within the seedbeds. Average measurements can indicate meaningful trends, although even the trends in treatment effects appear to be inconsistent between species. Visual observations indicated that plots without dazomet fumigation had overall shorter and less dense seedlings, although this relationship is not clear from the numerical data.

The results in Field K indicated that use of sudan cover crop without fumigation was not devastating. Use of dazomet fumigation tended to provide a slight improvement in seedling parameters, but may not be necessary.

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