1. Overview of soil health and role of soil fumigation in California agriculture

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Overworked Soils

1. Coastal Growing Areas
   - Multiple Crops per year
   - Susceptible cultivars
   - Mobile cultivation and harvest equipment

2. Soil born diseases
   - Strawberries
   - Lettuce
   - Ornamentals
   - Tomatoes

3. Remediation
   - Soil fumigation
   - Organic amendments
   - Crop rotation
Complex of soil diseases

- Lettuce
- Tomato
- Ornamentals
- Strawberry
- Grape
Corky Root (*Rhizomonas suberifaciens*)
Sclerotinia sclerotiorum and minor
Weed control requirements
Organic culture
Schematic of healthy soil and root system
Alternatives used for diseases and weeds

- GMO
  - Blabla
  - Blabla
- Resistant varieties
  - Blabla
- Cover crops
  - Blabla
New Strawberry Varieties
Alternative Planting Material - Plug Plants
Strawberry Breeding for disease tolerance
Covercrop
Phase out of Methyl Bromide
Chemical and Non-Chemical Alternatives
Chemical test substances

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<tr>
<th>Telone II</th>
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<td>Telone C-35</td>
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<td>Iodomethane (Midas)</td>
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<td>Iodomethane/CP (Midas)</td>
<td>Chloropicrin</td>
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Bio Control Studies

Gliocadium (soil guard)
Glomus (mycorrhizae)
Biocontrol fungi

Bacillus subtilus
B. licheniformis
B. laterosporus
Schematic of movement varying with soil type
2. Fumigant alternatives in practice and development

Characteristics of an ideal fumigant
Objective in soil fumigation is to establish a lethal concentration and maintain the concentration for a sufficient period of time to kill the organism.
Dose:
Concentration $\times$ Time = Kill

Soil borne organisms are dependant on fumigant diffused in water, insects are killed by fumigant portion in air.
Highly volatile Substances

- Dissolve in the soil water
- Vapors move through air spaces in soil
- Establish a dynamic equilibrium between soil air and water
- Move back and forth between mediums as it moves through the soil particles
Properties of an ideal soil fumigant

- Low molecular weight
- Low vapor pressure (gas at room temperature)
3. Integrated management of soil health

Overview of non chemical soil management practices
# Projects 1995-1998

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## Projects 1999-2003

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1.a. Weeding requirements in strawberries
1.b. Strawberry Yield Alternative Fumigants

The diagram shows the total marketable yield in Kg for different treatments. The treatments include UTC, Midas (50:50), Midas + Inline, Iodo 100% (4x), Iodo 100%, Inline, and Midas + Vapam. The yields are visually represented in the graph, with the highest yield observed in the "Midas + Vapam" treatment compared to others.
### Alternative Plant and Fumigant Programs

<table>
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<th>Soil management program</th>
<th>Total fruit production</th>
<th>Total Fruit wt</th>
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<td>11480 b</td>
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<td>Organic Plug Plant</td>
<td>8075 a</td>
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<td>MeBr/CP Plug Plant</td>
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Strawberry Plug Production
Runner Tip
Short-day and day-neutral selections
Plug Program Status

- Disease free tips
- Additional cultivars
- National reorganization
- Increased utilization in non-fumigated soil
- Expanded use of bio-control agents
2. Lettuce Root Disease Control

- Sclerotinia spp.
- Corky Root
- Miscellaneous bottom rot organisms
- Fusarium
Lettuce Production
Sclerotinia Incidence By Fumigant

The bar chart shows the percentage incidence of Sclerotinia for different fumigants and treatment strategies. The fumigants include UTC, IODO 98:2, IODO 98:2 Shank, INLINE, TELON C35 Shank, MB/PIC 57:43 Shank, CP, and CP Shank*. The incidence ranges from 0% to 45%, with UTC showing the highest incidence and CP Shank* showing the lowest.
Corky Root Severity By Fumigant

- UTC
- IODO 98:2
- IODO 98:2 Shank
- INLINE TELON C35 Shank
- TELON 57:43 Shank
- MB/PIC Shank
- CP Shank
- CP Shank

Corky Root Severity

0 0.5 1 1.5 2 2.5

UTC IODO 98:2 IODO 98:2 Shank INLINE TELON C35 Shank TELON 57:43 Shank MB/PIC Shank CP Shank CP Shank

Corky Root Severity
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<th>24's</th>
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<td>458.3</td>
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<td>INLINE</td>
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<td>TELON C35 Shank</td>
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<tr>
<td>MB/PIC 57:43 Shank</td>
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<td>763.8</td>
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3. Turf and Ornamentals

- Turf
- Calla Lily
- Larkspur
- Freesia
3.1. Turf
Seedling vigor on turf

![Bar graph showing seedling vigor on turf]

- MeI+Chloro
- MeI+Chloro+MeB
- MeI+MeB
- Vapam HLTelone C-35
- Untreated 1
- Untreated 2

Vigor 0-5
Plant stand on turf
Seedling height on turf
Weeds in turf fumigation study
3.2. Calla Lily
Yield of Calla bulbs

- Untreated Check
- Mel 100%
- Mel 60% - Chlorpic
- MeB 67% - Chlopic
- MeB 99% - Chlopic
- Telone 40% - Chlorpic

Calla Bulbs in kg/plot

- Large
- Small
- Diseased
Weed control in Calla

Number of weeds per plot

- Untreated
- Check
- Mel 100%
- Mel 60% Chlorpic
- MeB 67% Chlorpic
- MeB 99% Chlorpic
- Telone 40% Chlorpic
3.3. Larkspur
Stand loss caused by soil borne *Fusarium oxysporum*
Larkspur Production By Fumigant

![Bar chart showing flower production by fumigant treatments.](image-url)

- **Midas 150lb**: High flower production with a peak of 9 flowers/plant.
- **Midas 75lb**: Moderate flower production with a peak of 7 flowers/plant.
- **MB/CP**: Moderate flower production with a peak of 6 flowers/plant.
- **K-Pam/Telone**: Low flower production with a peak of 4 flowers/plant.
- **UTC**: Lowest flower production with a peak of 2 flowers/plant.

Legend:
- Red: # in bloom
- Blue: flowers/plant
Freesia Greenhouse Study
Fumigant Standard
Midas
Sclerotinia in tomatoes
Production and Increase of Microsclerotia
Girdling and Plant Death
Remediation

- Soil fumigation
- Organic amendments
- Crop rotation
Conclusions

- Strawberries and Ornamentals are severely impacted by soil-borne diseases in absence of fumigation
- Midas and Telone products are highly effective fumigant alternatives
- More work is needed on non-chemical alternatives commercially