Papaya Ground Seed as a Biofumigant against Soil-Borne Pathogens in Hawaii

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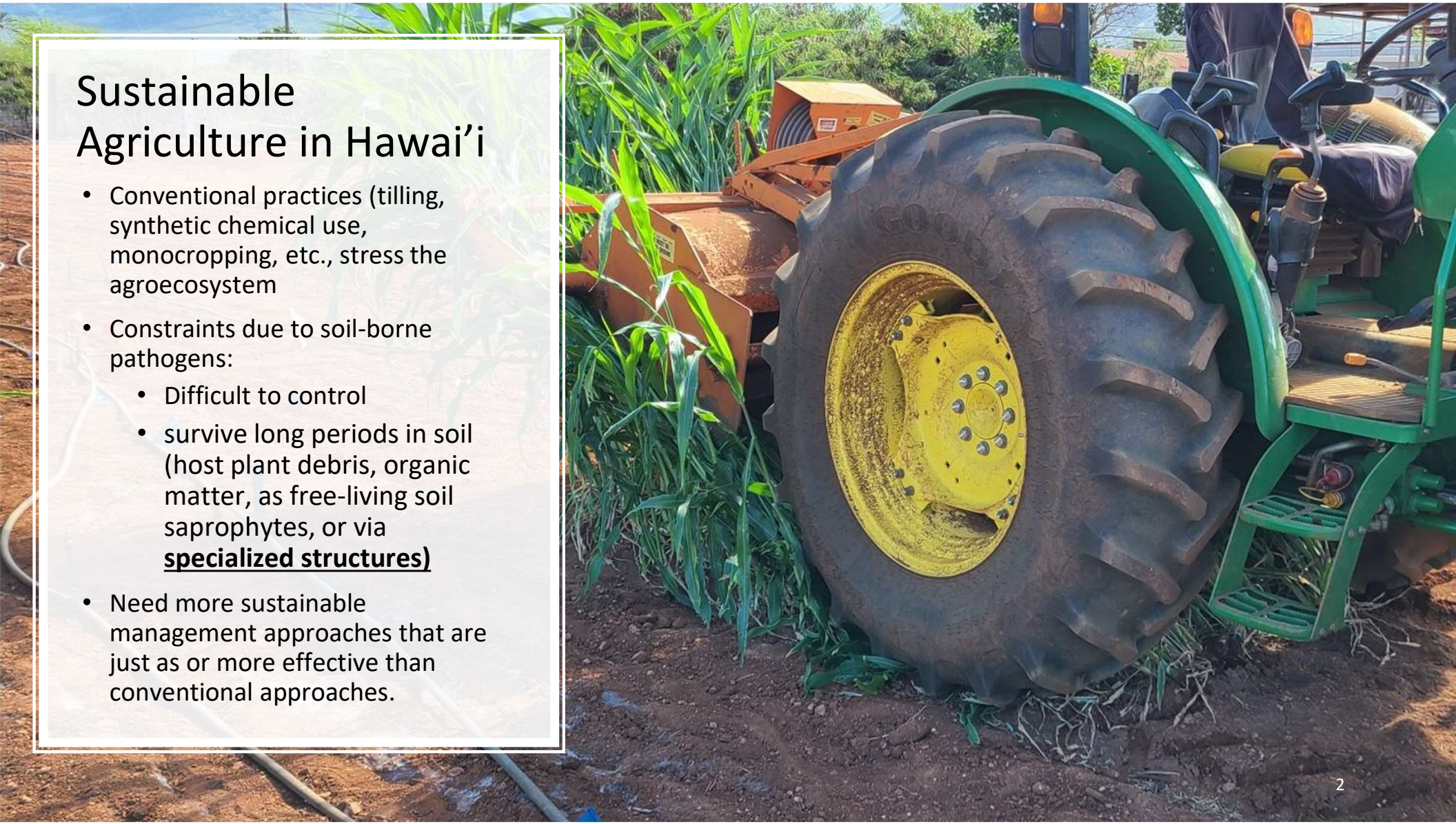
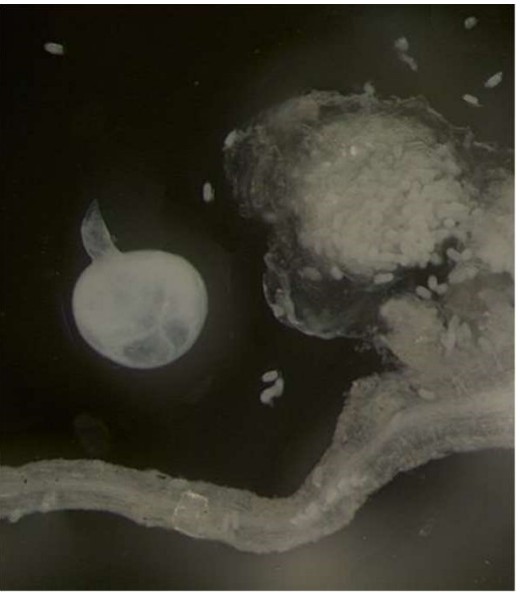
Sustainable Agriculture in Hawai'i

- Conventional practices (tilling, synthetic chemical use, monocropping, etc., stress the agroecosystem
- Constraints due to soil-borne pathogens:
  - Difficult to control
  - survive long periods in soil (host plant debris, organic matter, as free-living soil saprophytes, or via **specialized structures)**
- Need more sustainable management approaches that are just as or more effective than conventional approaches.



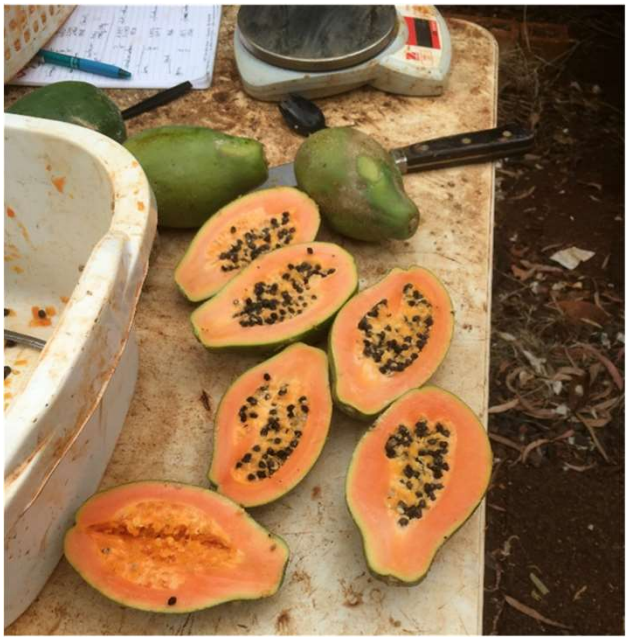


Soil-borne nematodes and fungi pose a serious threat to food security:

- Fusarium wilt
- Root-knot nematodes
- Reniform nematodes

Recycle Ag waste to Protect crops

- $8.2 million
- 570 acres cultivated land (as of 2017)
- **30-50% of papaya produce is culled and/or wasted**
  - **30% of this waste is seeds**

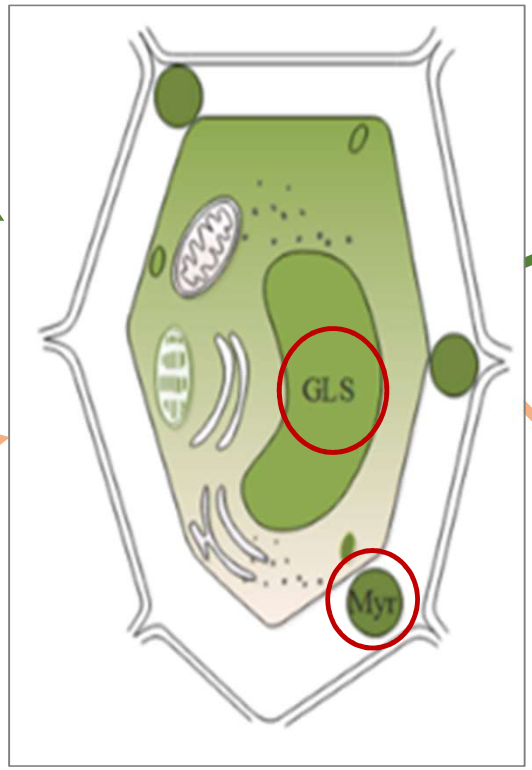


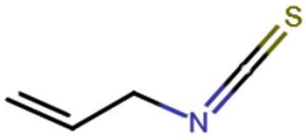
Biofumigation

Suppression of soil-borne pests and pathogens through allelopathic compounds released by *Brassica* species when soil incorporated

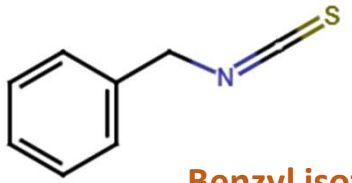
Brown mustard

Papaya fruit



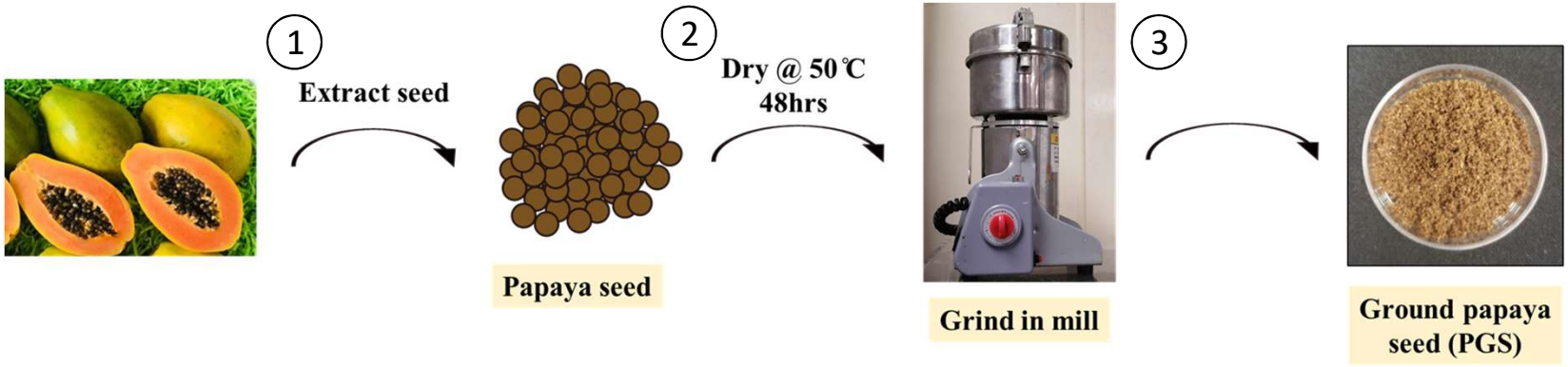


Allyl isothiocyanate (AITC)



Benzyl isothiocyanate (BITC)

How to turn Papaya Ground Seeds (PGS) into Biofumigant?

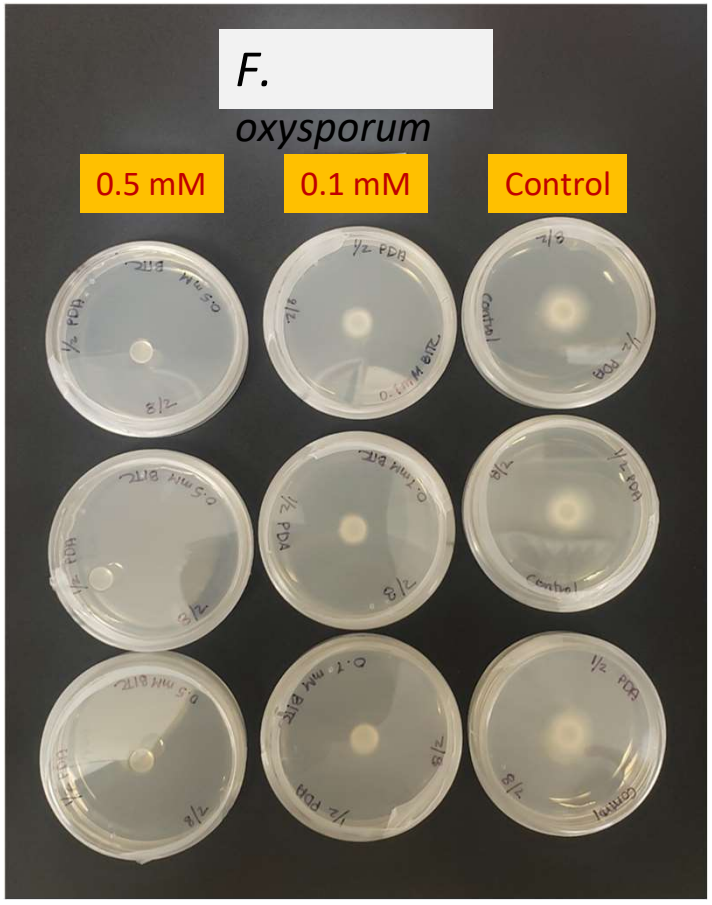


Goal: To develop an effective biofumigant against a broad spectrum of soil-borne pathogens in Hawaii without sacrificing soil

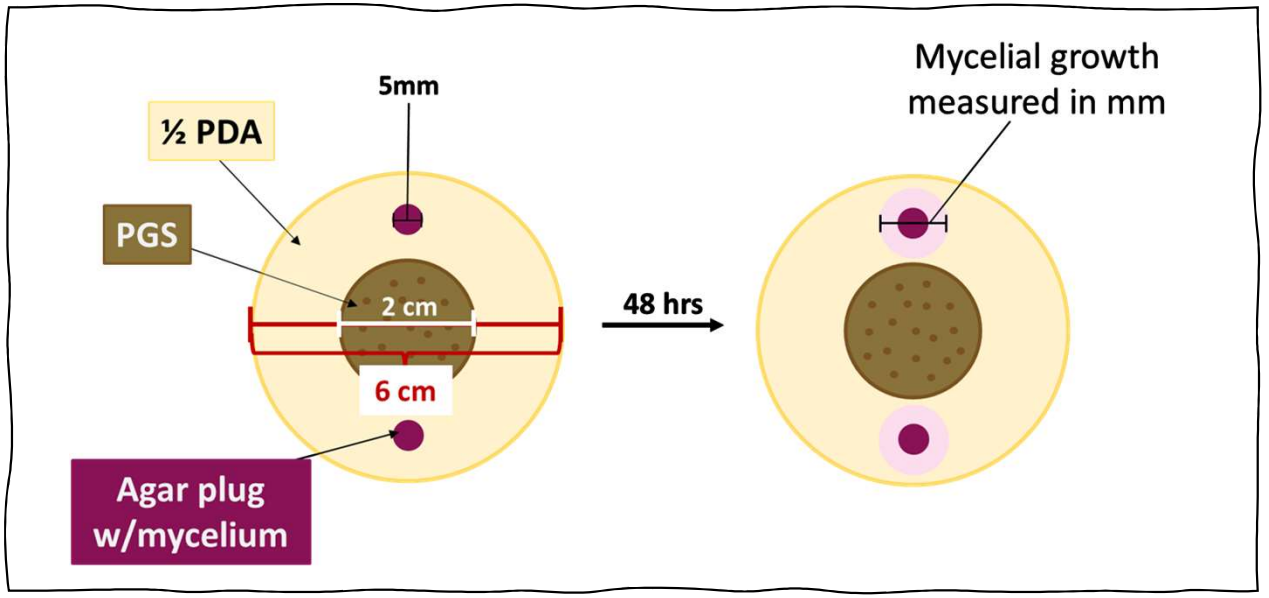
1. Testing the effectiveness of BITC and PGS in suppressing *Fusarium oxysporum* growth *in vitro*
2. Testing PGS suppression of *Fusarium* spp., root-knot nematodes, and reniform nematodes in the greenhouse using various locally and culturally significant crops
3. Testing PGS application methods in a commercial, kai choi field for suppression of Fusarium wilt disease
4. Conducting nematode community data analysis to compare soil health conditions in conventional treatment methods versus PGS treatment

In vitro active stage assays with *Fusarium oxysporum*

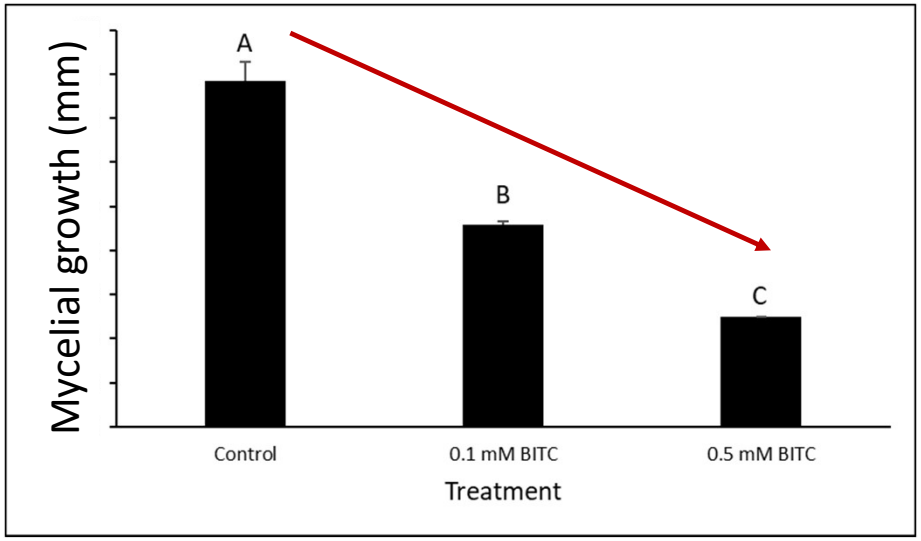
1) Pure BITC



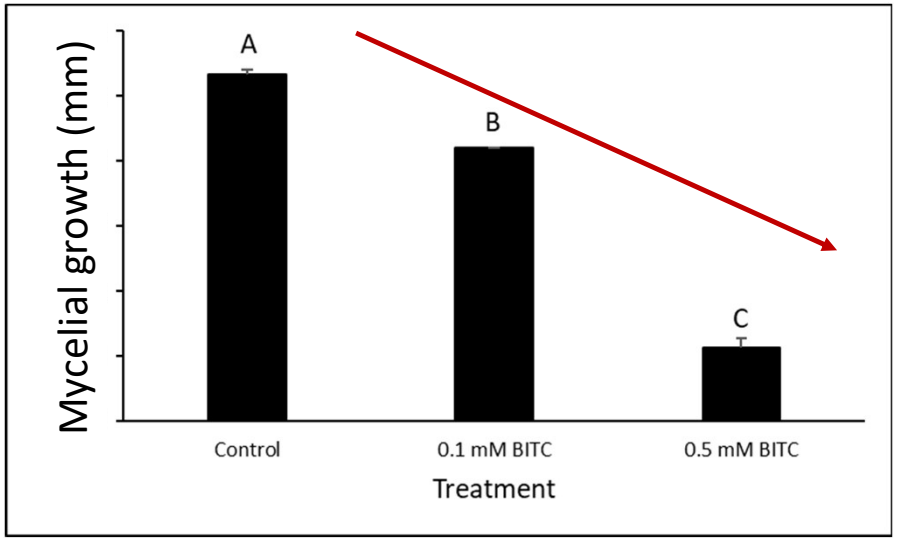
2) PGS biofumigation



Pure BITC *in vitro F. oxysporum* suppression



Trial 1

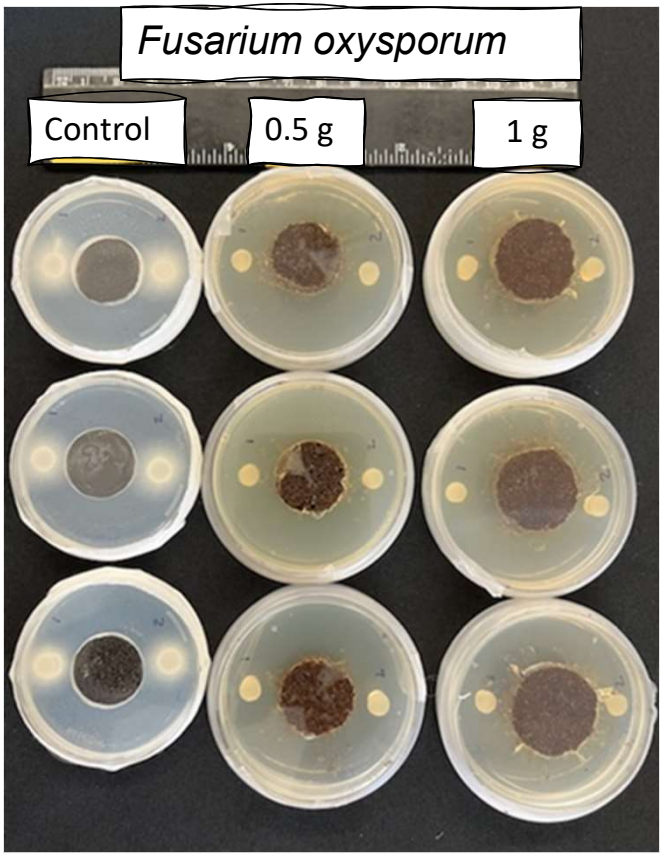


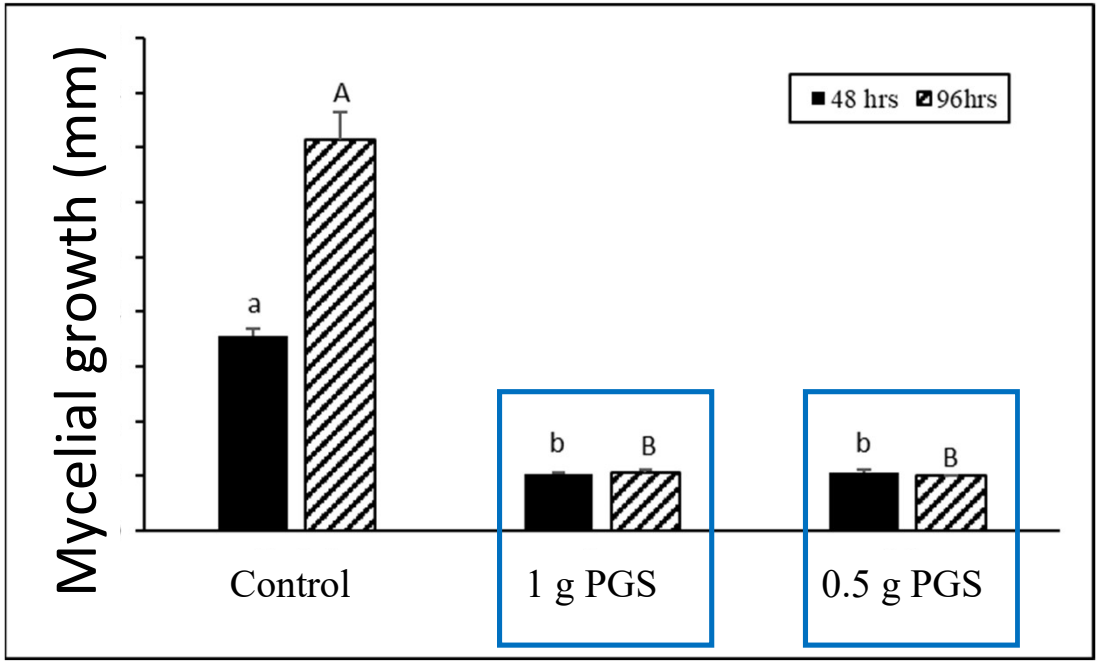
Trial 2

BITC increasingly suppresses *F. oxysporum* growth the higher the concentration used

Biofumigation with Papaya Ground Seeds

Treatments
1 g PGS + 1 ml H_2O
0.5 g PGS + 0.5 ml H_2O
No PGS (control)





PGS biofumigation *in vitro* suppressed *F. oxysporum* growth, but there no difference between concentrations seen

PGS suppression of Fusarium wilt and root-knot nematode in leafy greens in a greenhouse setting

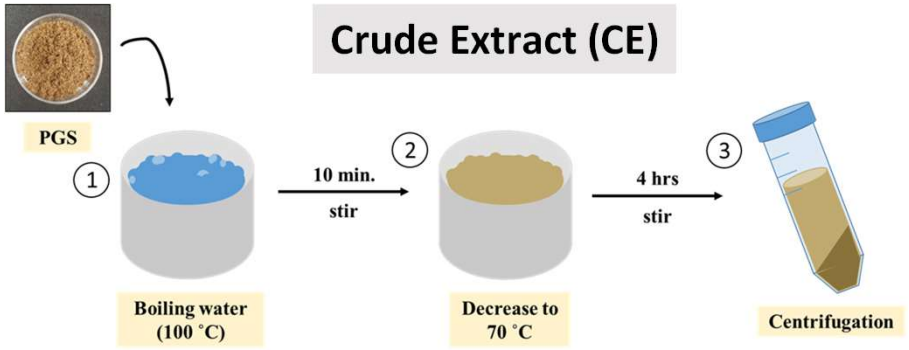
'Manoa' Lettuce

'Hirayama' Kai Choi

Transplant **'Hirayama' kai choi** seedlings **1 week after** soil amendment Experiment was **terminated 1 month after** nematode inoculation

Field soil infested with *Fusarium spp.* from a leafy green farm

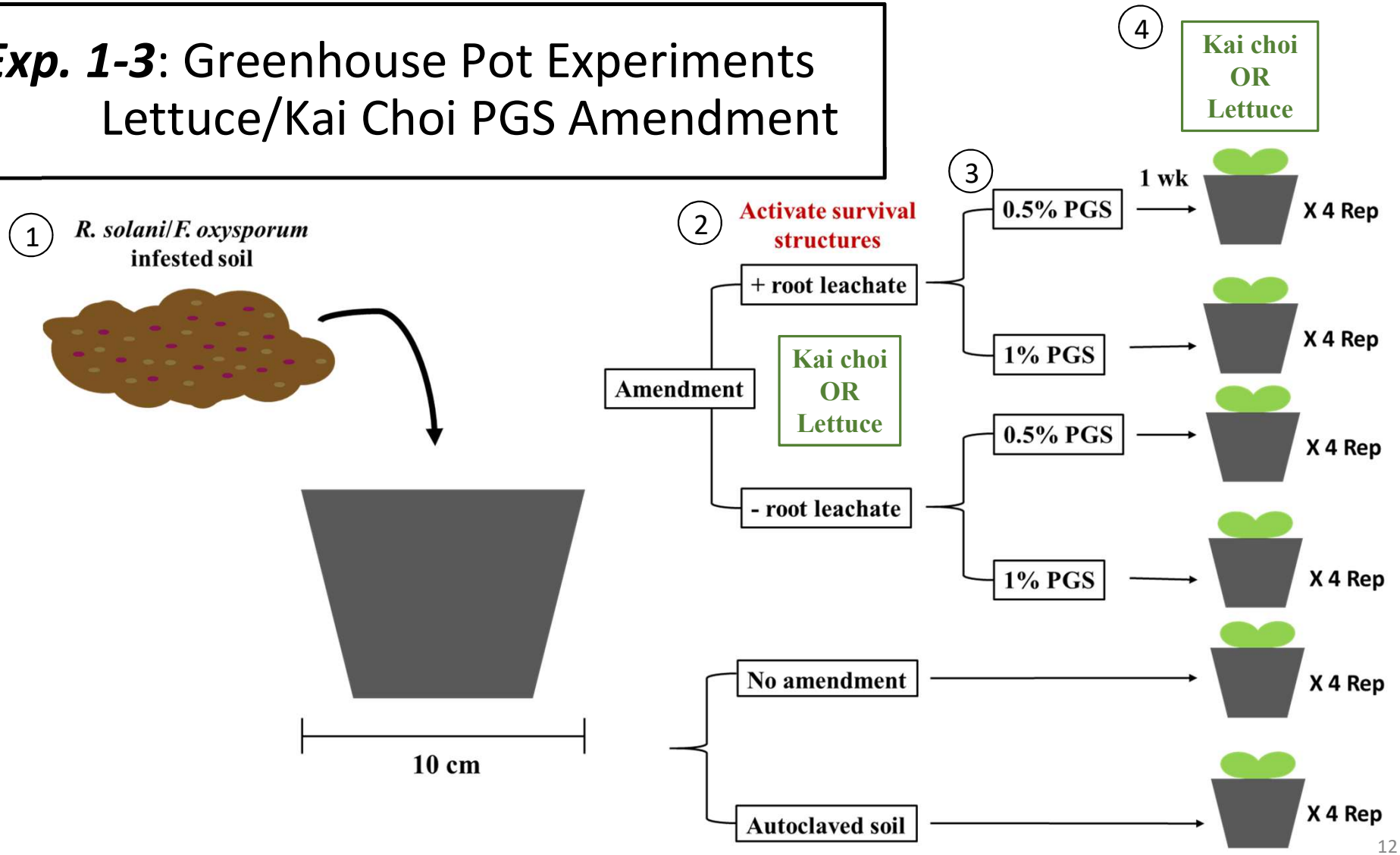
Treatments 1-5 inoculated with **100 *M. incognita* juveniles**



Treatments (x4 reps)

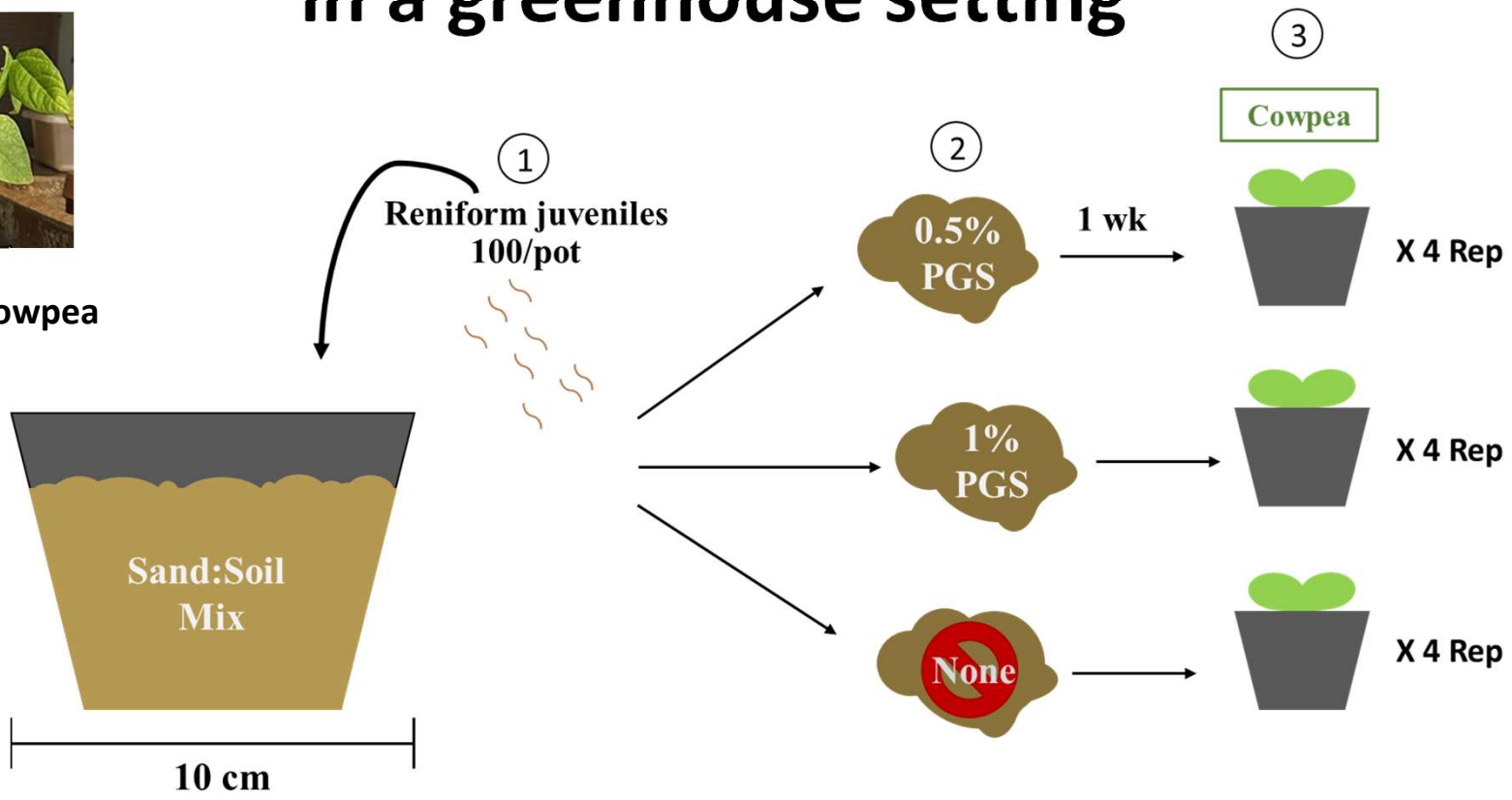
1) **PGS 0.5%** = papaya ground seeds at 0.5% (dw equivalent)
2) **PGS+CE** = PGS 0.5%+0.5% of crude extract
3) **PGS 1%** = papaya ground seeds at 1%
4) **BM** = brown mustard at 1%
5) **NA** = not amended
6) **Auto** = not amended and autoclaved

Exp. 1-3: Greenhouse Pot Experiments
Lettuce/Kai Choi PGS Amendment



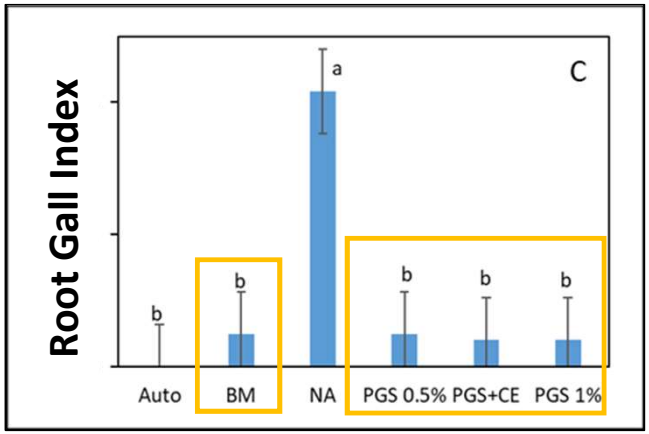
PGS suppression of reniform nematodes in cowpea in a greenhouse setting

'Black Eye' Cowpea



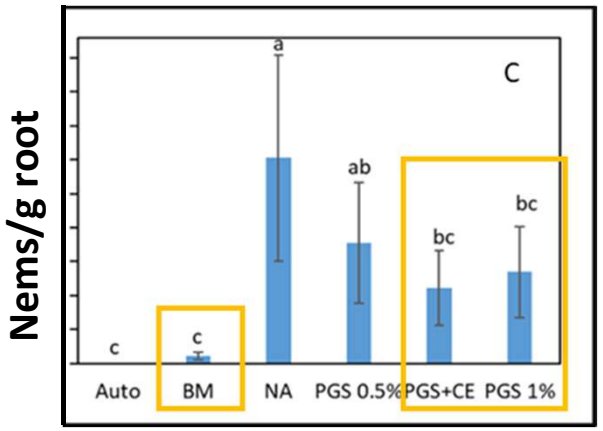
Effects of PGS as a biofumigant against root-knot and reniform nematodes

Lettuce



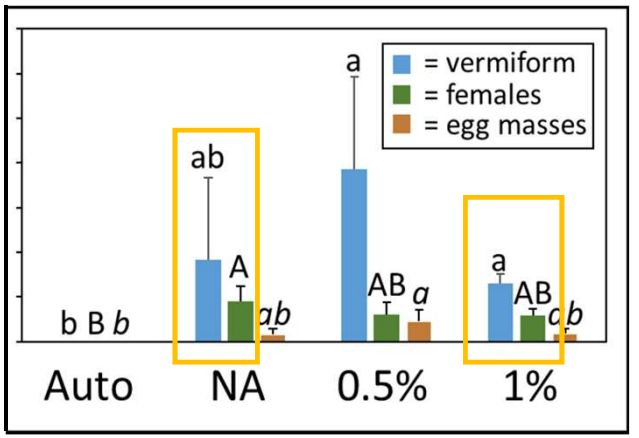
Root galling effectively reduced in all treatments except the control

Kai choi



Nematode root penetration reduced in brown mustard, PGS 1%, and PGS+CE

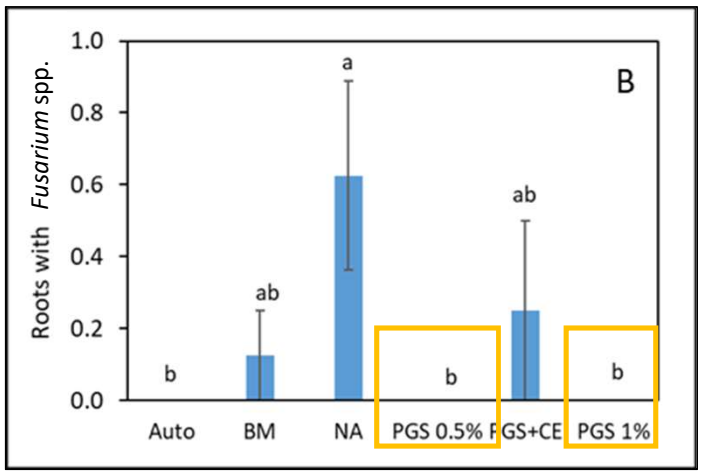
Cowpea



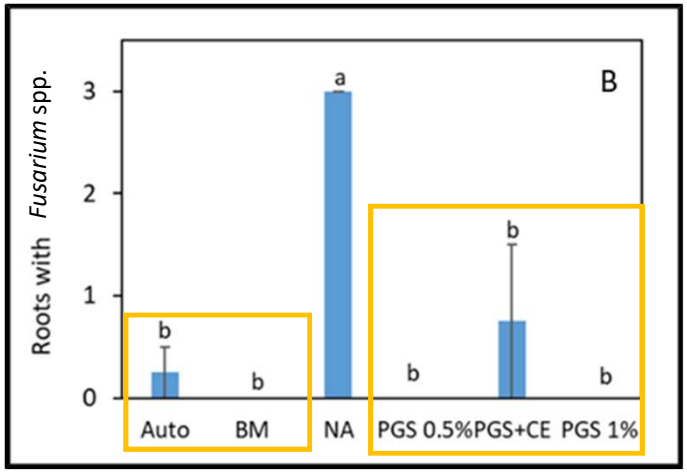
Nematode root parasitism seeing some reduction at 1% PGS, especially females

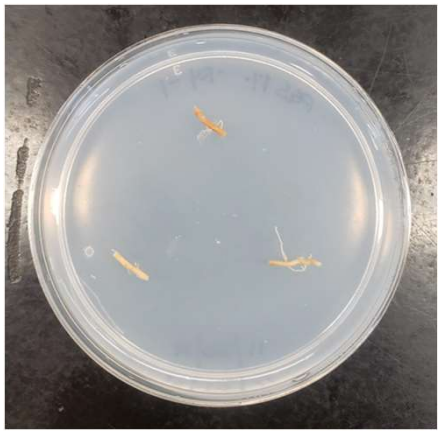
Effects of PGS as a biofumigant against *Fusarium* root colonization

Lettuce



Kai choi



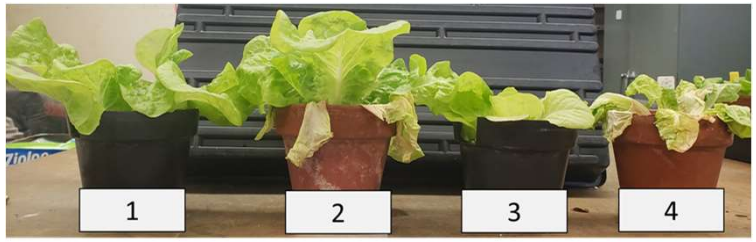


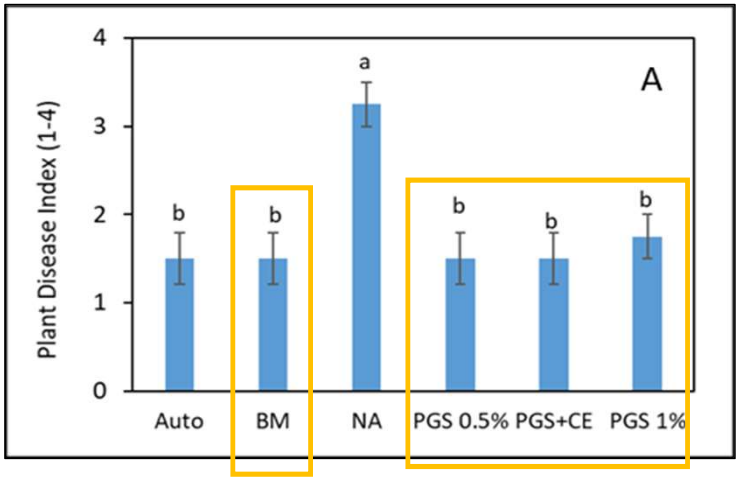
PGS is able to suppress *Fusarium* root colonization in lettuce and kai choi

Effects of PGS as biofumigant against a *Fusarium oxysporum* and root-knot nematodes

Disease Index (1-4)

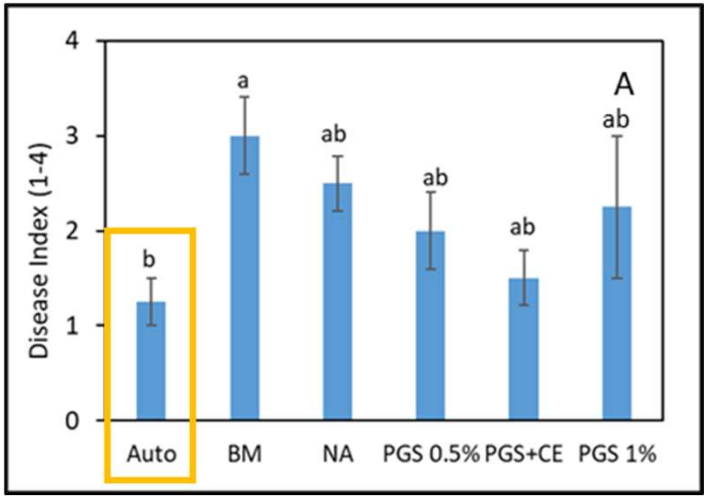
Lettuce





PGS affectively reduces disease caused by *Fusarium* and root-knot nematodes in lettuce

Kai choi



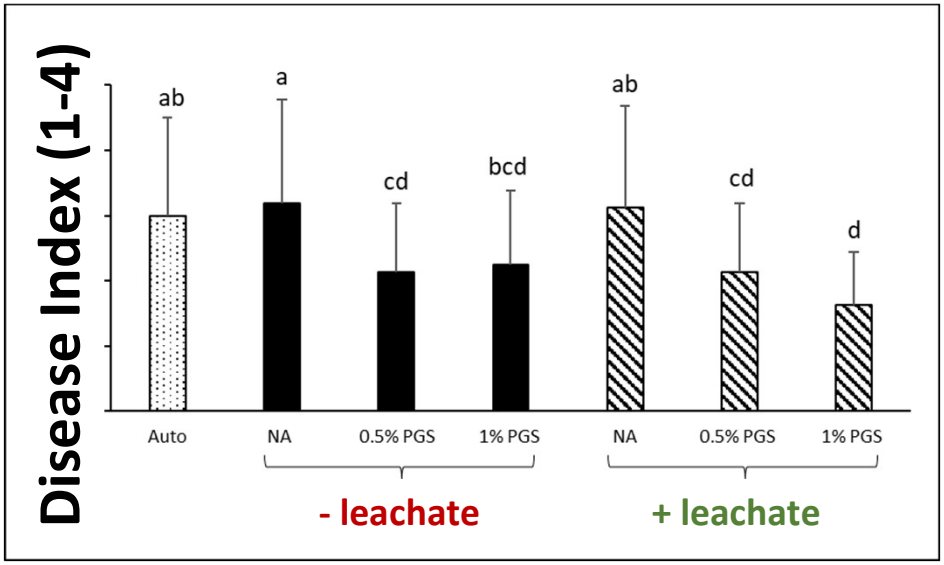
PGS did not significantly reduce disease in kai choi

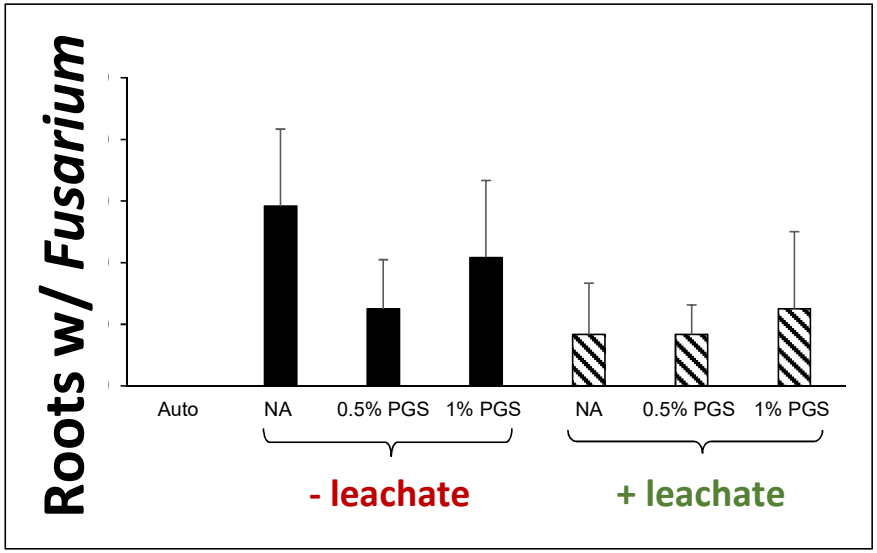
Effects of root leachate + PGS as biofumigant against a *Fusarium oxysporum* in kai choi

Additional factor: treat w/ or w/o kai choi root leachate

Treatments:

1) **PGS 0.5%** = papaya ground seeds at 0.5% (dw equivalent)
2) **PGS 1%** = papaya ground seeds at 1%
3) **NA** = not amended
4) **Auto** = not amended and autoclaved

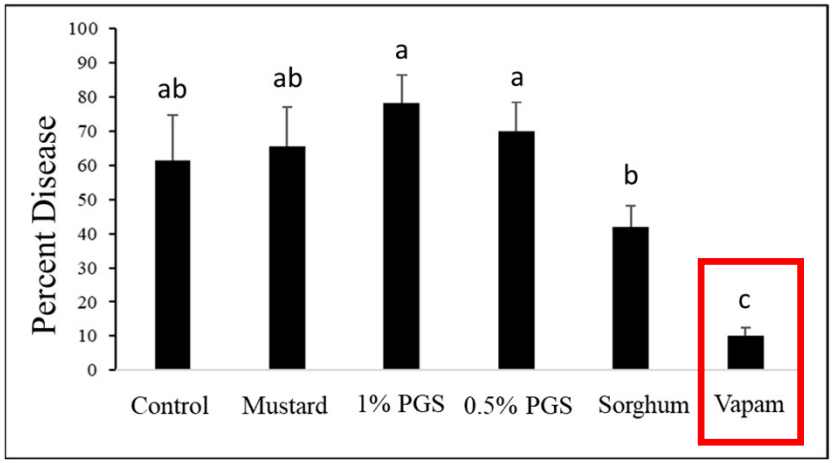


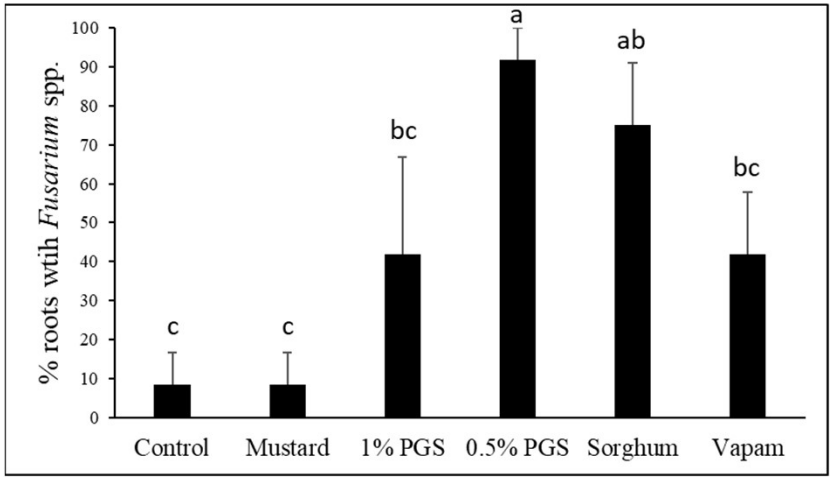


Effects of PGS as biofumigant against *Fusarium* wilt in a commercial kai choi field (Trial 1)

Treatments:

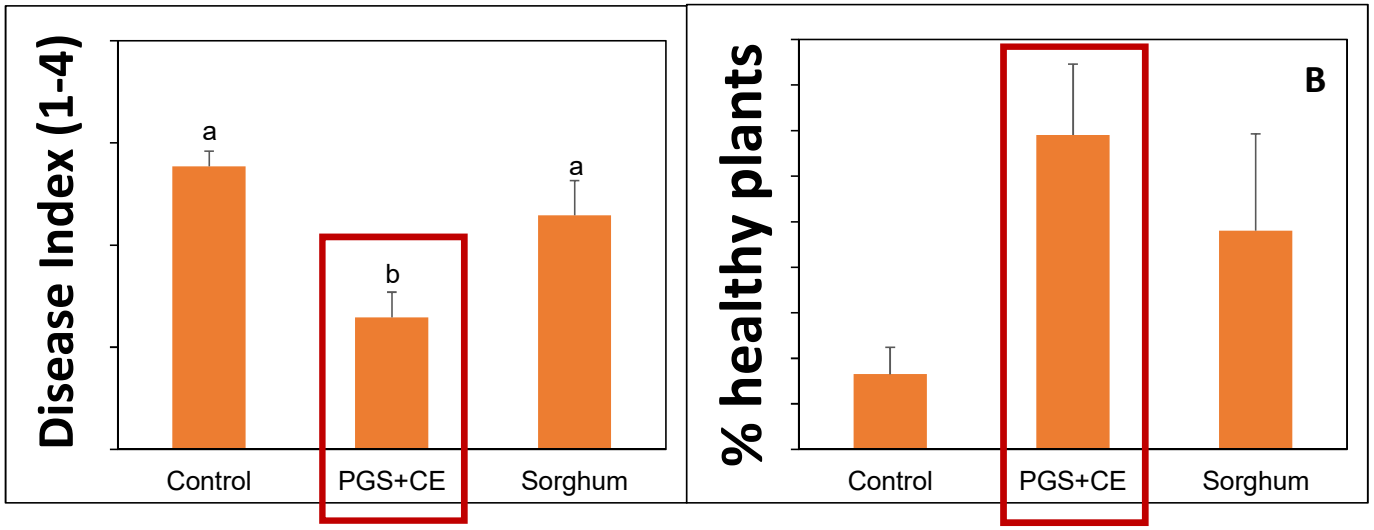
1. Control = no amendment
2. Mustard = mustard at 1%
3. 1% PGS
4. 0.5% PGS
5. Sorghum
6. Vapam = conventional fumigation





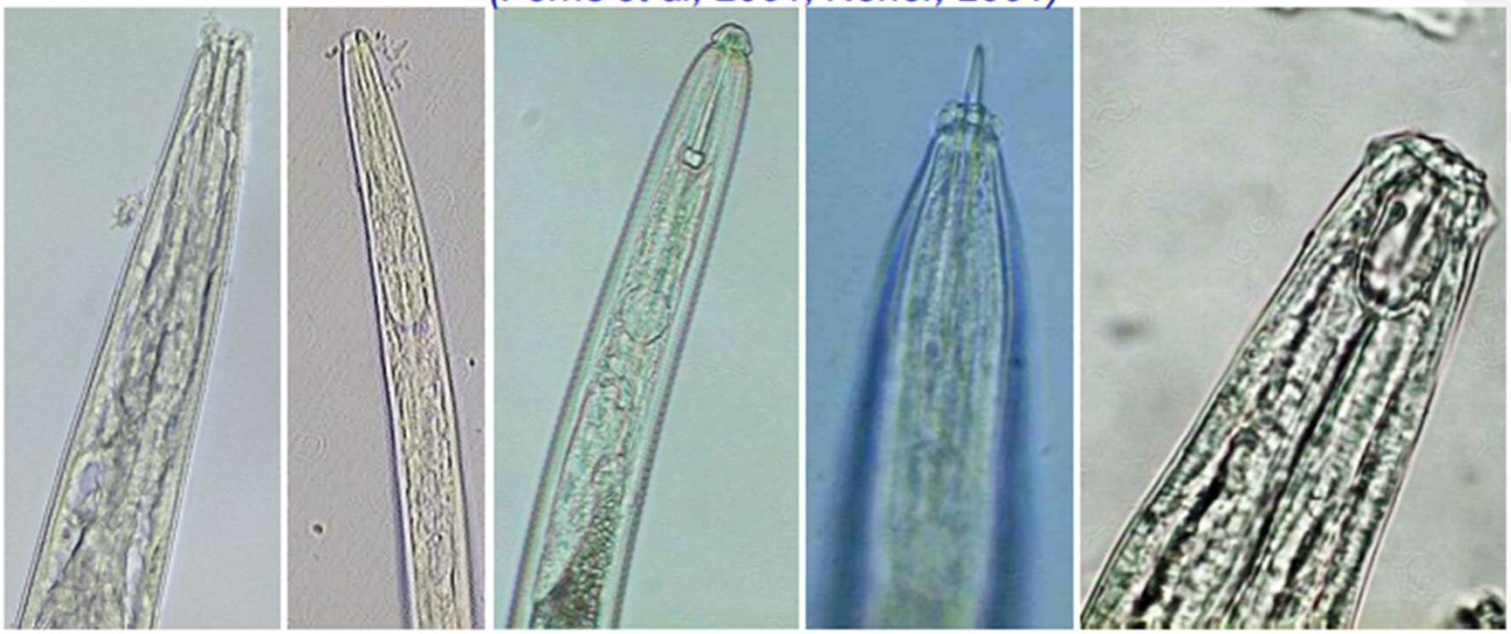
Effects of PGS as biofumigant against a *Fusarium* wilt in a commercial kai choi field (Trial 2)

Treatments:
1. Control = no amendment
2. 1% PGS + CE
3. Sorghum



Using nematodes as soil health indicators

(Ferris et al, 2001; Neher, 2001)



Bacterivore **Fungivore** **Herbivore** **Omnivore** **Predator**

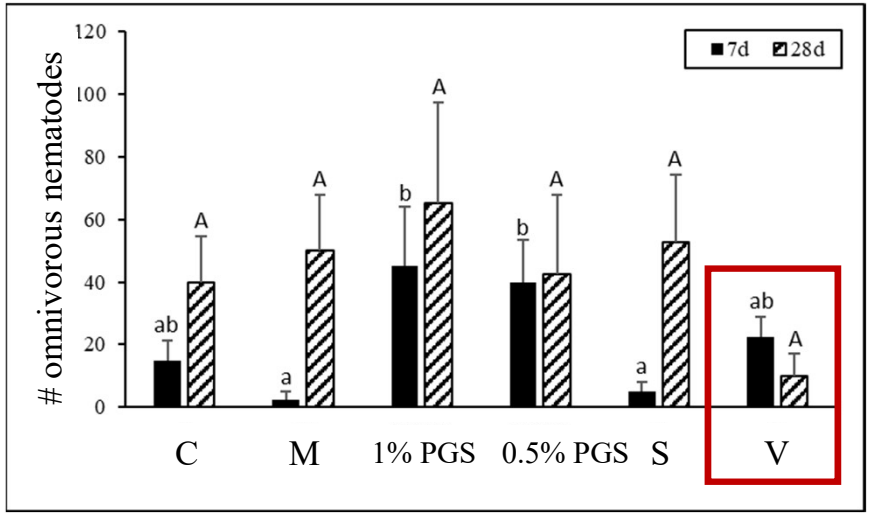
EI=Enrichment index

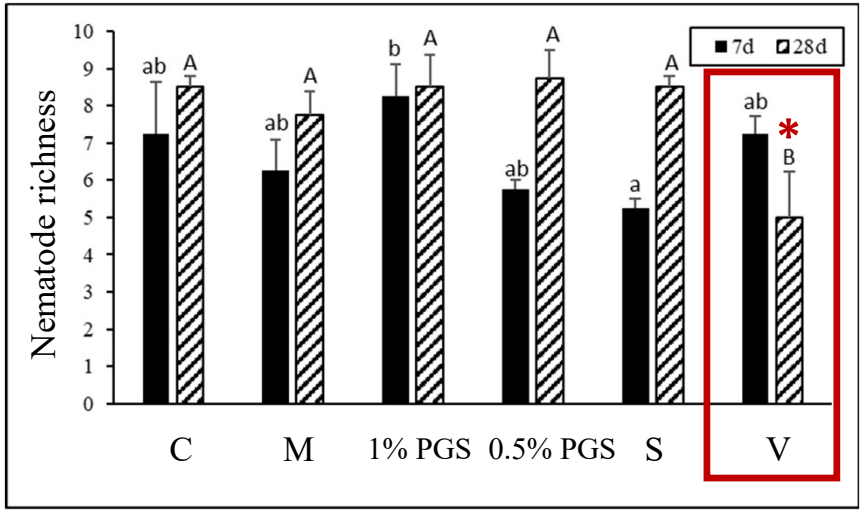
CI=Channel index

SI=Structure index

+ richness, diversity

Effects of biofumigation versus conventional fumigation on soil health





Treatments:

1) **C** = no amendment control
2) **M** = Mustard at 1%
3) **1% PGS** = papaya ground seed at 1% (dw:dw)
4) **0.5% PGS** = papaya ground seed at 0.5% (dw:dw)
5) **S** = Sorghum
6) **V** = Vapam conventional fumigation

Summary

Conclusions

- BITC/PGS is highly effective against *F. oxysporum in vitro*
- *More…*

Future Work

- qPCR quantification of *Fusarium* spp.
- Another trial with nematodes for lettuce, kai choi, and cowpea

Acknowledgements

Committee members

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Kamiya Farms

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