The Chemistry of Biofumigation & Brassicaceae Seed Meals

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Topics

- Brassicaceae seed meals (BSM) as soil amendments
- Isothiocyanate (ITC) release from glucosinolates
- Toxicity of ITCs
- Application of BSM in nematode control
  - Case study: apple replant disease

Soil amendment with Brassicaceae seed meals (BSM)

Disease control following BSM application

- **Biofumigation by isothiocyanates**
  - Important in control of nematodes and oomycetes
- **Enhancement of plant disease resistance**
  - BSM-induced shift in the soil microbial community

Release of ITC from BSM amended soil

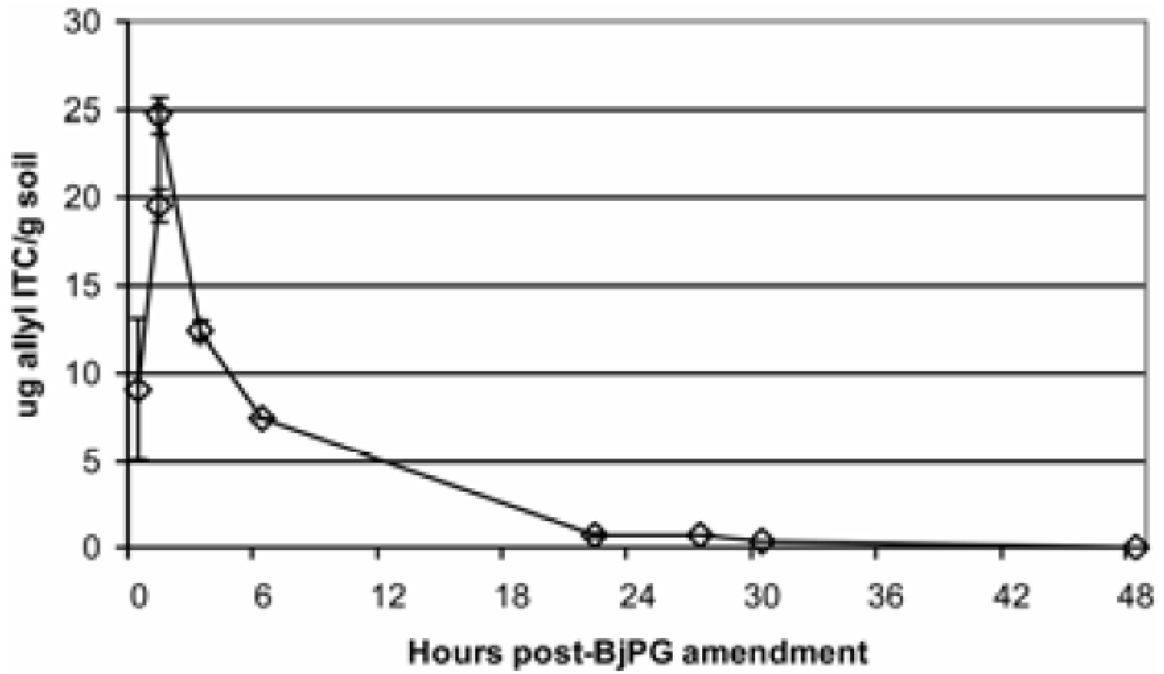
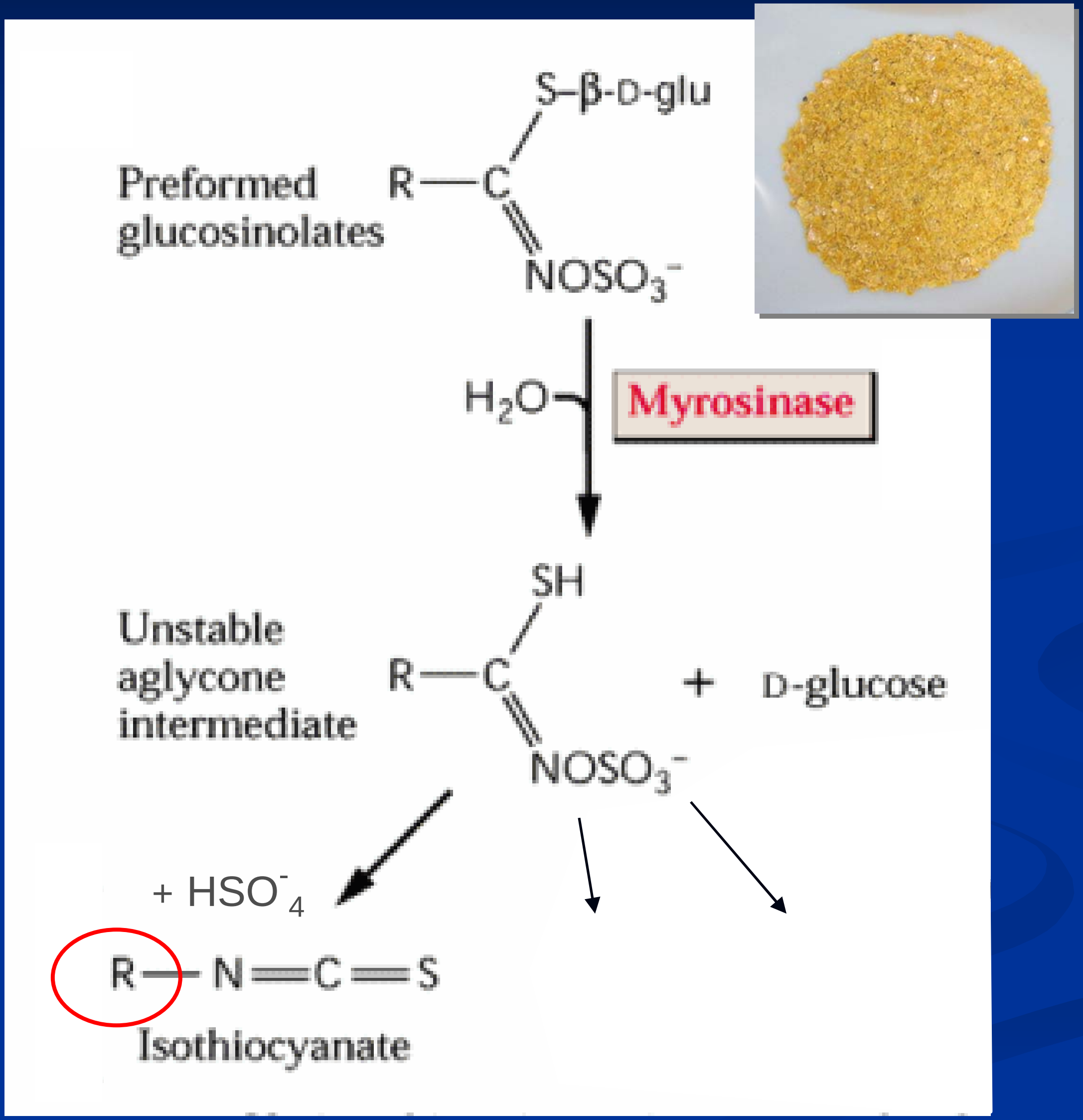


Fig. 1. Temporal pattern of allyl-isothiocyanate emission from Columbia View orchard soil amended with *Brassica juncea* cv. Pacific Gold seed meal (BjPG) as determined by monitoring concentration in the headspace of a chamber by gas chromatography. Seed meal was added to soil at a concentration of 0.5% (vol/vol). Bars = standard deviation of the mean.

Mazzola et al. (2007) Phytopathology 97:454-460

ITC release from glucosinolate hydrolysis



ITC toxicity

- Type of ITC
- Concentration of ITC
- Nematode species

BSM glucosinolate composition varies

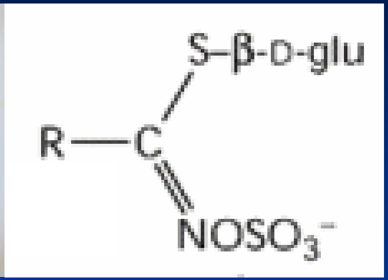
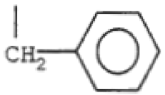
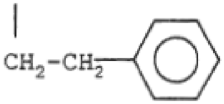


TABLE 1. Isothiocyanate, origin, structure, molecular weight, and common name of parent glucosinolate tested[a]

Isothiocyanate	Plant species	Plant part	Structure of side chain R	Molecular weight	Glucosinolate common name
Allyl	*Armoracia lapathifolia, Brassica juncea, B. napus, B. oleraceae*	Seed, leaf, root, stem	$CH2(CH)_2CH_3$	99.2	Sinigrin
Benzyl	*Carica papaya, B. hirta, Lepidium sativum*	Seed, leaf, root, stem		149.2	Glucotropeolin
Butyl	*A. lapathifolia, Capparis flexuosa*	Seed, leaf, root, stem	$CH2(CH)_2CH_3$	115.2	
Ethyl	*Lepidium menziesi*	Seed	CH_2CH_3	87.1	Glucolepdiin
Methyl	*Capparis* spp.	Seed	CH_3	73.1	Glucocapparin
Phenyl	*A. lapathifolia*			135.2	
4-Methylsulfinyl(butyl)	*B. oleraeae*	Seed, leaf, root, stem	$CH2(CH)_3\text{-}S\text{-}CH_3$	177.3	Glucoraphanin
2-Phenylethyl	*A. lapathifolia, B. juncea, B. napus, B. hirta*	Seed, leaf, root, stem		163.2	Gluconasturtiin

[a] Data from Fahey et al. (11) and Brown and Morra (5).

Zasada, I. A., and Ferris, H. 2003. Sensitivity of *Meloidogyne javanica* and *Tylenchulus semipenetrans* to isothiocyanates in laboratory assays. Phytopathology 93:747-750.

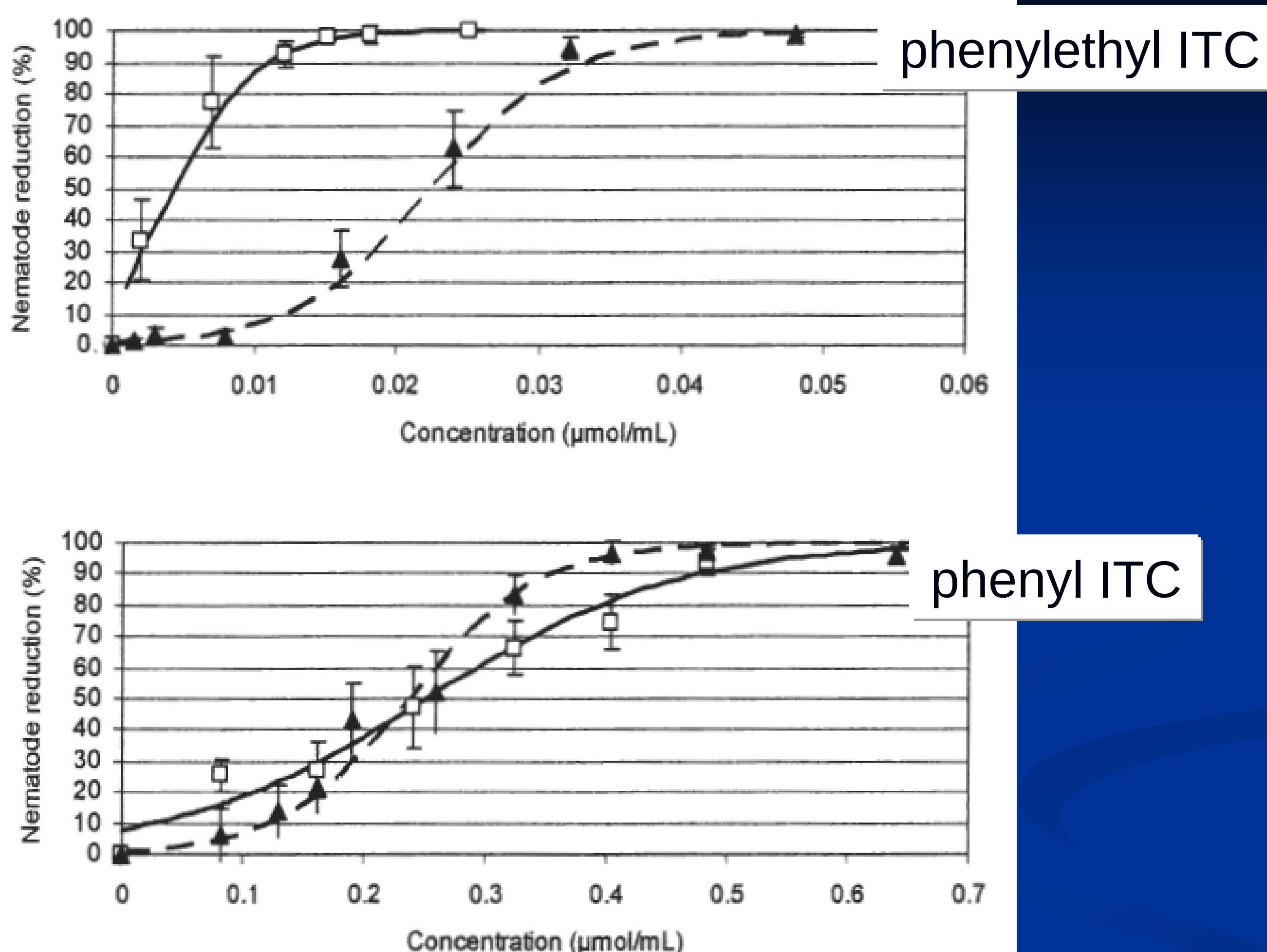


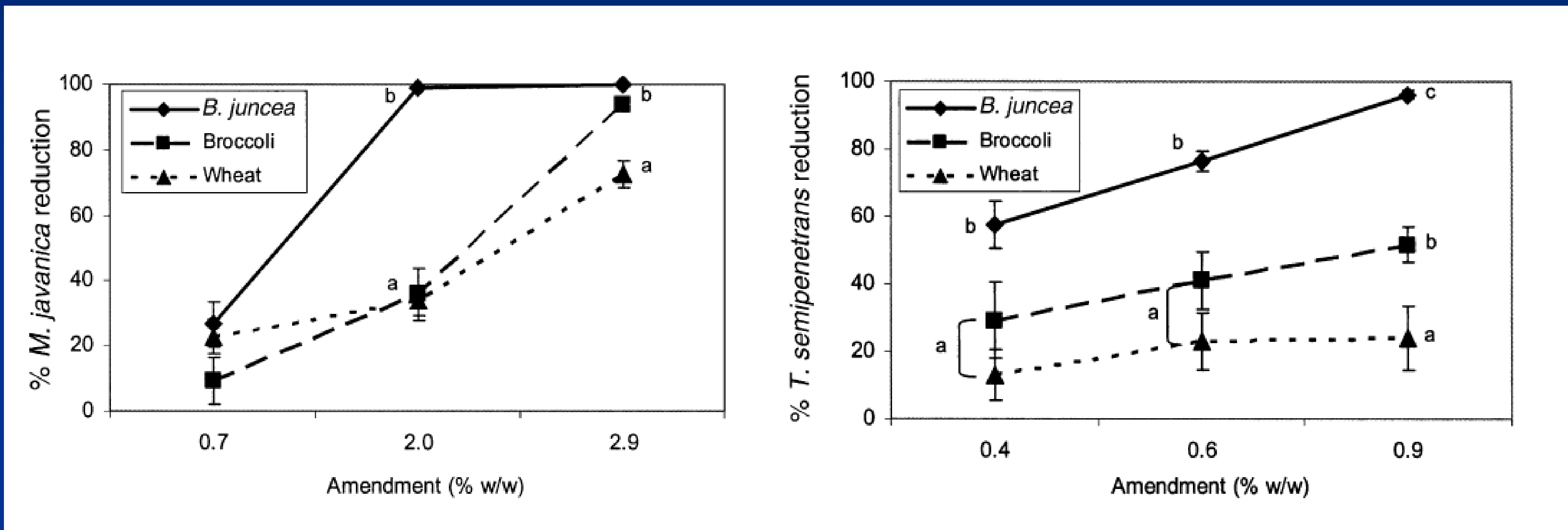
Fig. 2. Response curves for percent reduction of *Meloidogyne javanica* (▲) and *Tylenchulus semipenetrans* (□) exposed to concentration ranges of **A,** 2-phenylethyl and **B,** phenyl isothiocyanates. Vertical bars represent the 95% confidence interval for each mean.

Zasada, I. A., and Ferris, H. 2003. Sensitivity of *Meloidogyne javanica* and *Tylenchulus semipenetrans* to isothiocyanates in laboratory assays. Phytopathology 93:747-750.

Nematode suppression with brassicaceous amendments: application based upon glucosinolate profiles

Soil Biology & Biochemistry 36 (2004) 1017–1024

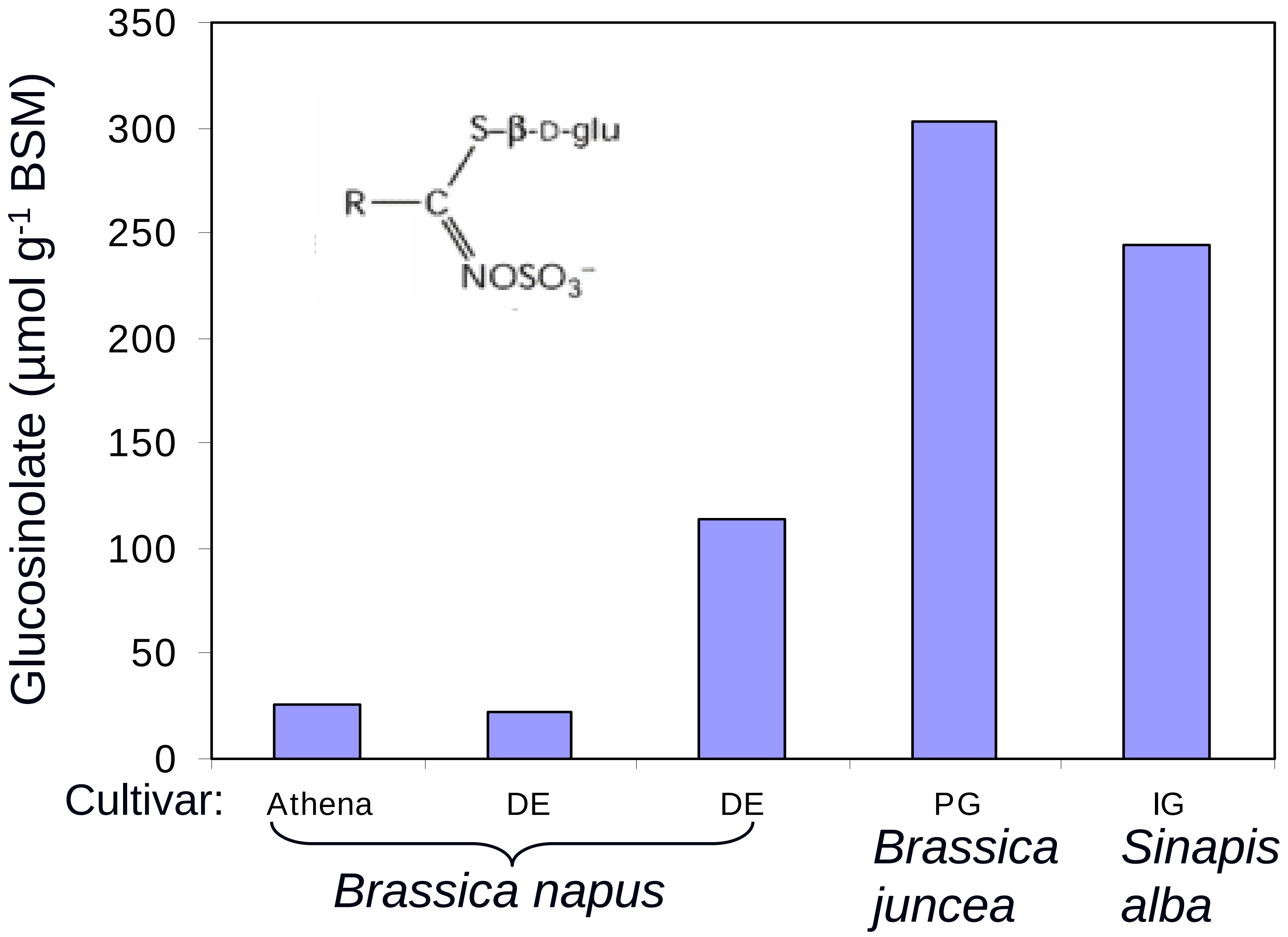
I.A. Zasada*, H. Ferris



Plant	µmol glucosinolate / g DW	major ITC released
B. juncea	110	allyl
Broccoli	2.4	4-methylsulphinylbutyl
Wheat	--	--

Greenhouse

BSM glucosinolate levels vary



ITC half-life is diminished by organic soil constituents

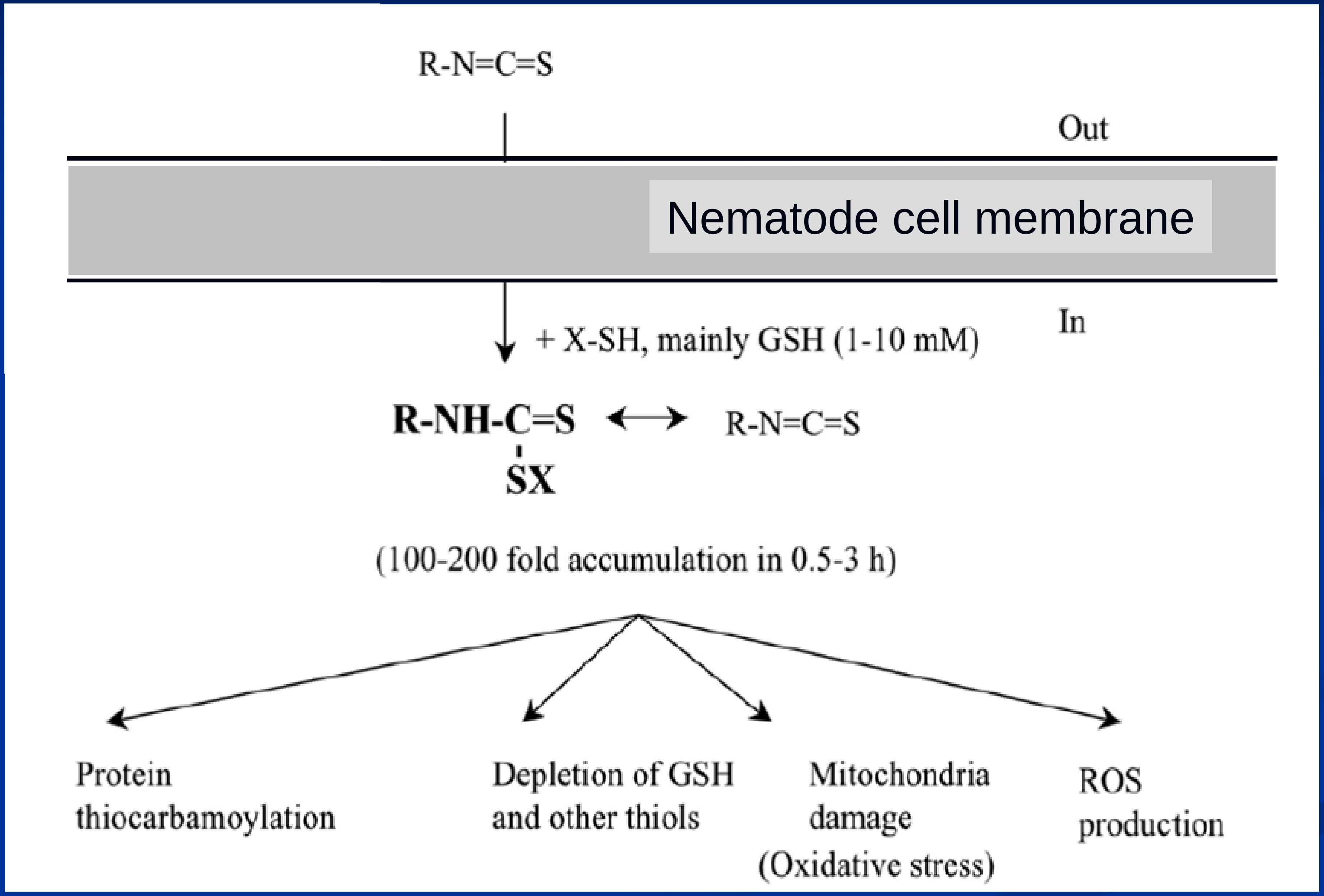
Table 2. Correlation of Soil Characteristics with Transformation Rates of Allyl Isothiocyanate (AI)

compd	pH	organic C	inorganic C	total N	clay	sand
AI	0.2296	−0.6666[a]	0.2129	−0.6292[a]	0.1256	−0.1307

[a] Correlation coefficients that are significant at $P < 0.05$.

J. Agric. Food Chem. **1995,** *43,* 1935–1940

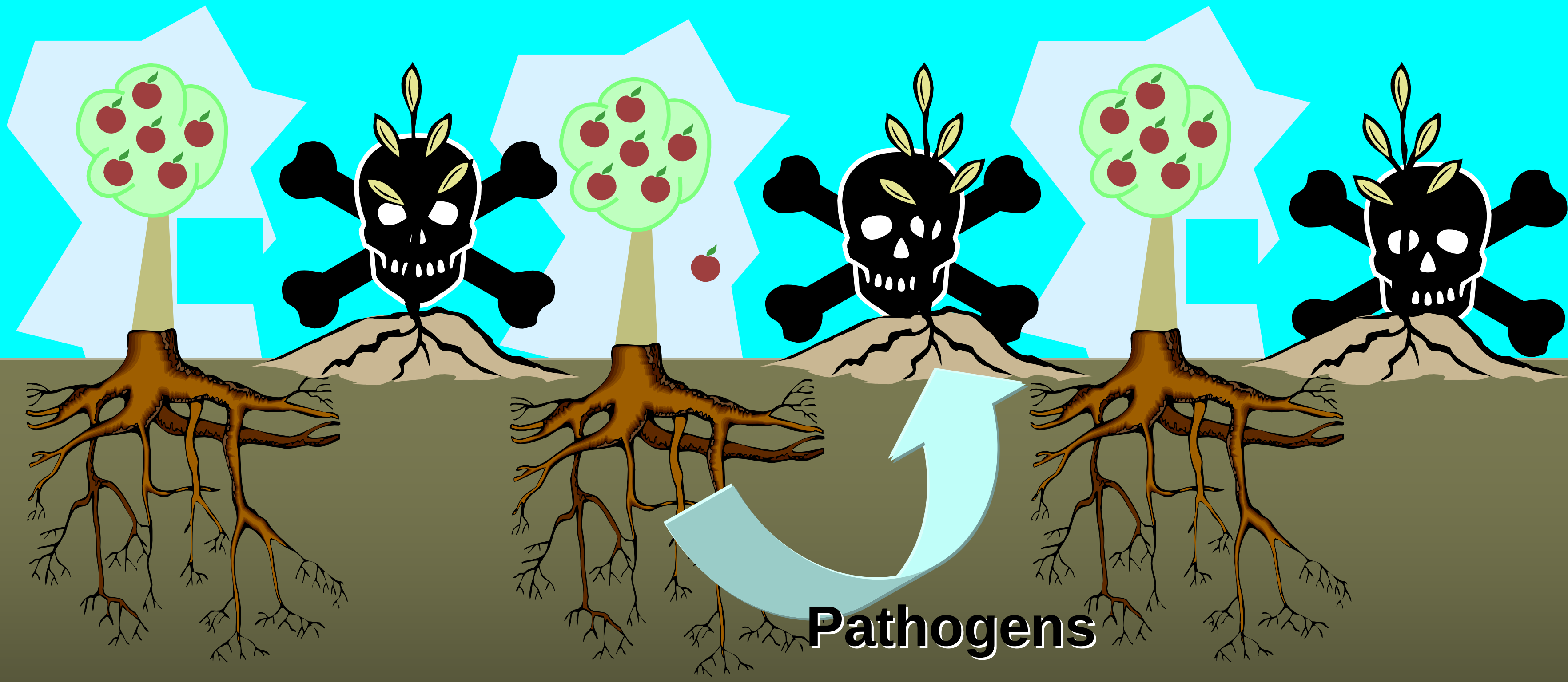
Cellular effects of ITCs



Free Radical Biology & Medicine 38 (2005) 70–77

BSM application in nematode control: Apple replant disease

Replant Disease



Apple Replant Disease: Moxee, Washington

Virgin

Replant

2nd leaf

Apple Replant Disease: Manson, Washington

Virgin

Replant

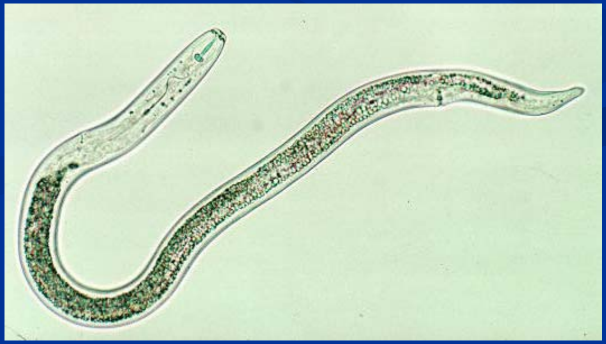
7th leaf

Pathogens commonly responsible for apple replant disease:

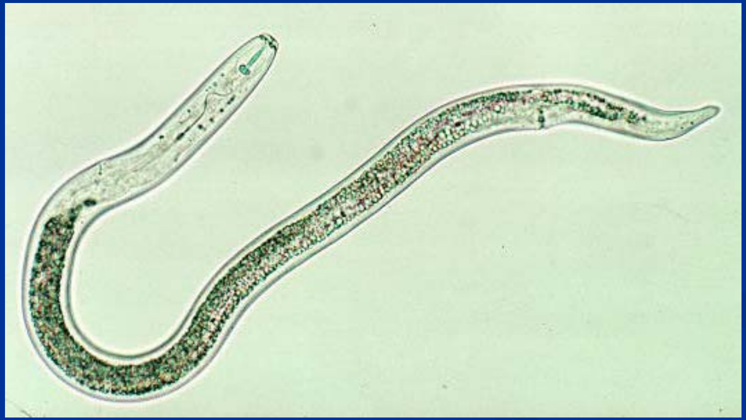
- Fungi
  - *Rhizoctonia solani*

- Oomycetes
  - *Pythium* spp.

- Nematodes
  - *Pratylenchus penetrans*



BSM effect on nematodes



Two mechanisms of initial BSM-induced nematode suppression

glucosinolate → ITC

$R\text{-}NH_2 \rightarrow NH_3$

Seed meal nutrients

Element	Percent composition
Nitrogen	5.6 – 6.8%
Phosphorus	1.2 – 1.4%
Potassium	1.1 – 1.5%
Sulfur	0.9 – 1.6%

Duration of nematode suppression depends on BSM type

TABLE 2. Effect of Brassicaceae seed meal amendment on recovery of *Pratylenchus penetrans* recovered from soil and roots of MM106 rootstock

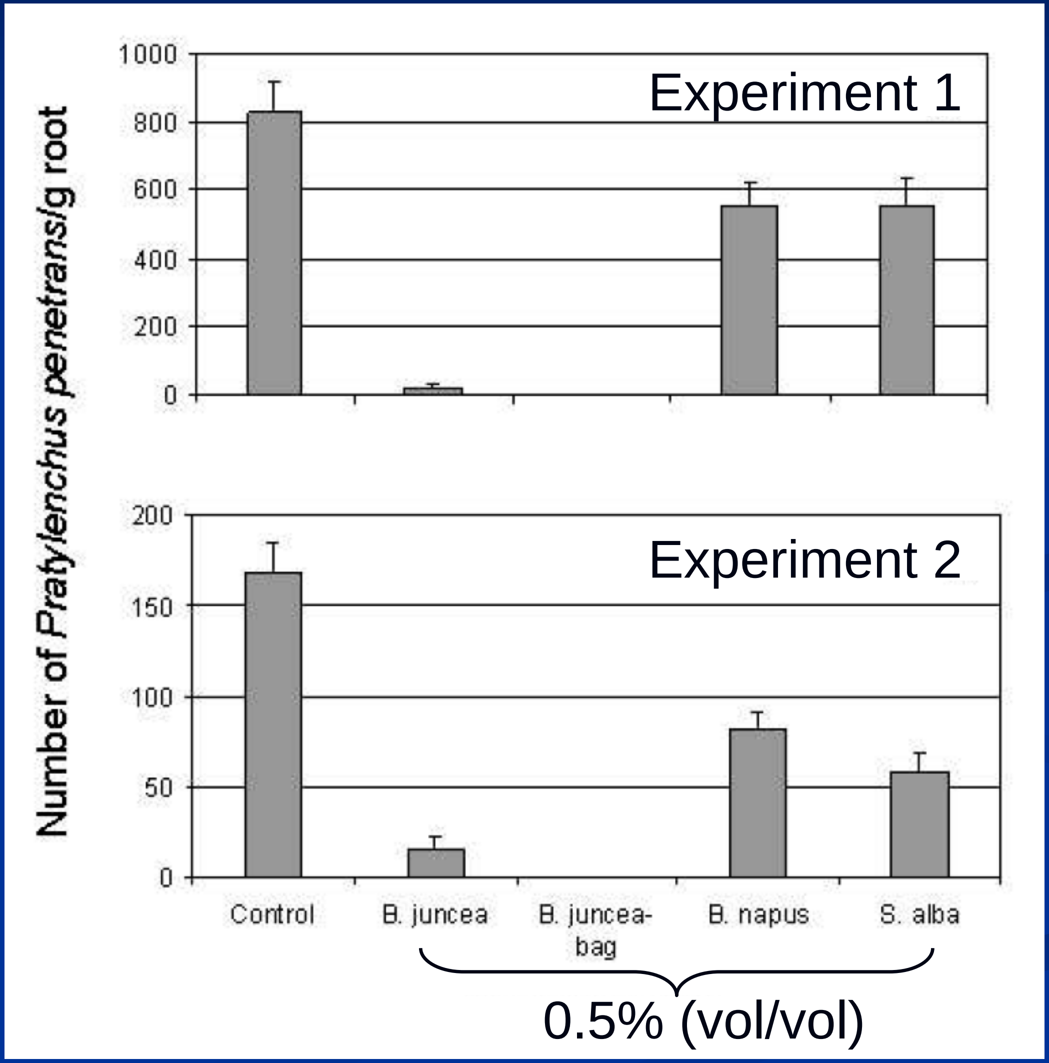
	P. penetrans g^{-1} of soil[z]		
Treatment[y]	Preplant	3 months post plant	6 months post plant
Control	217 b	115 b	643 c
DE *B. napus**	19 a	16 a	281 b
AT *B. napus**	5 a	11 a	177 b
IG *Sinapis alba*	7 a	1 a	246 b
PG *B. juncea*	1 a	4 a	2 a

*Low glucosinolate

Greenhouse

Mazzola et al. (2007) Phytopathology 97:454-460

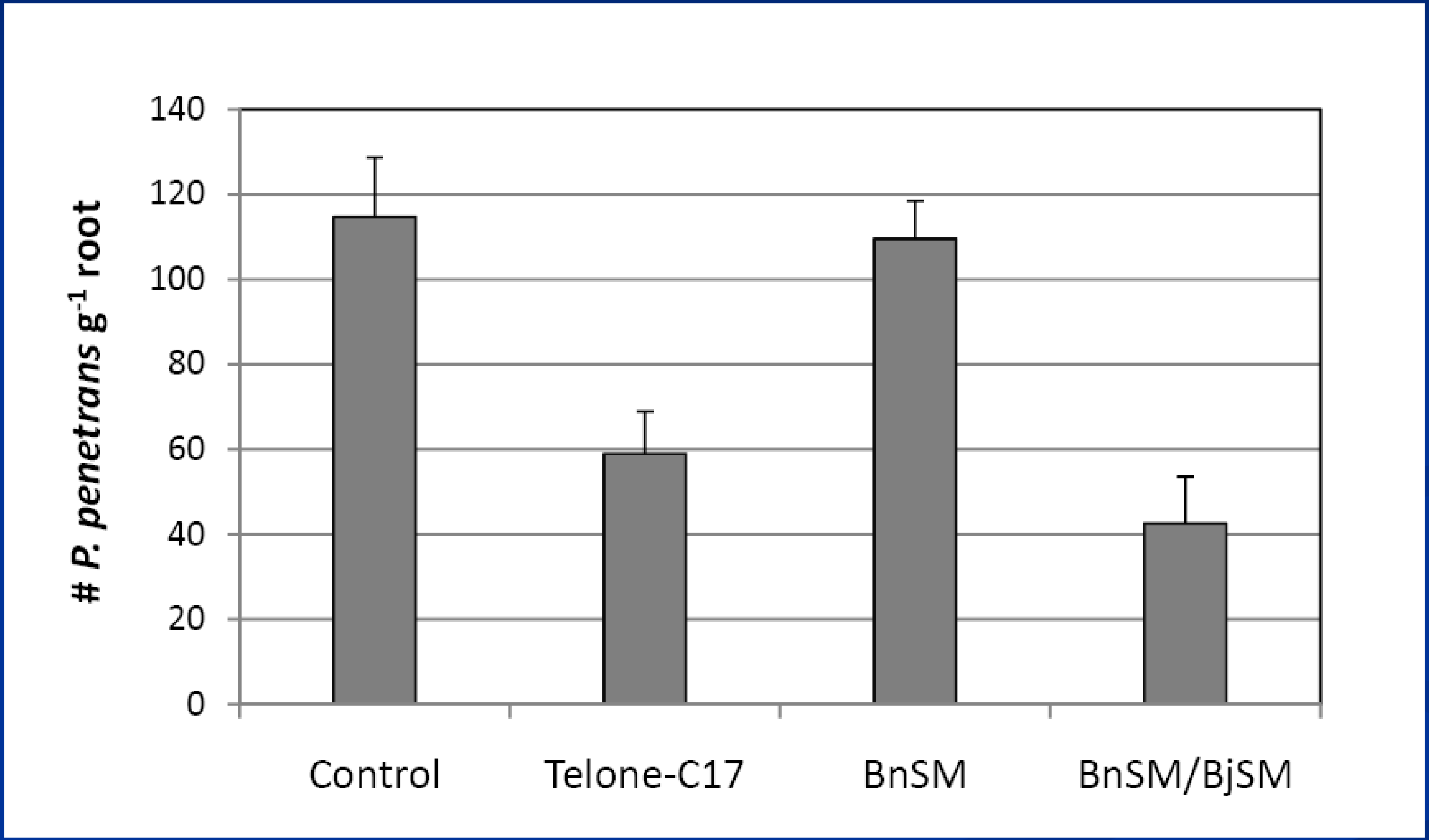
Superior protection conferred by *Brassica juncea* seed meal



Greenhouse
GC orchard soil
Various rootstocks

Mazzola et al. (2009)
Plant Disease 93:51-57

Orchard results: Control of lesion nematode by a BSM mixture

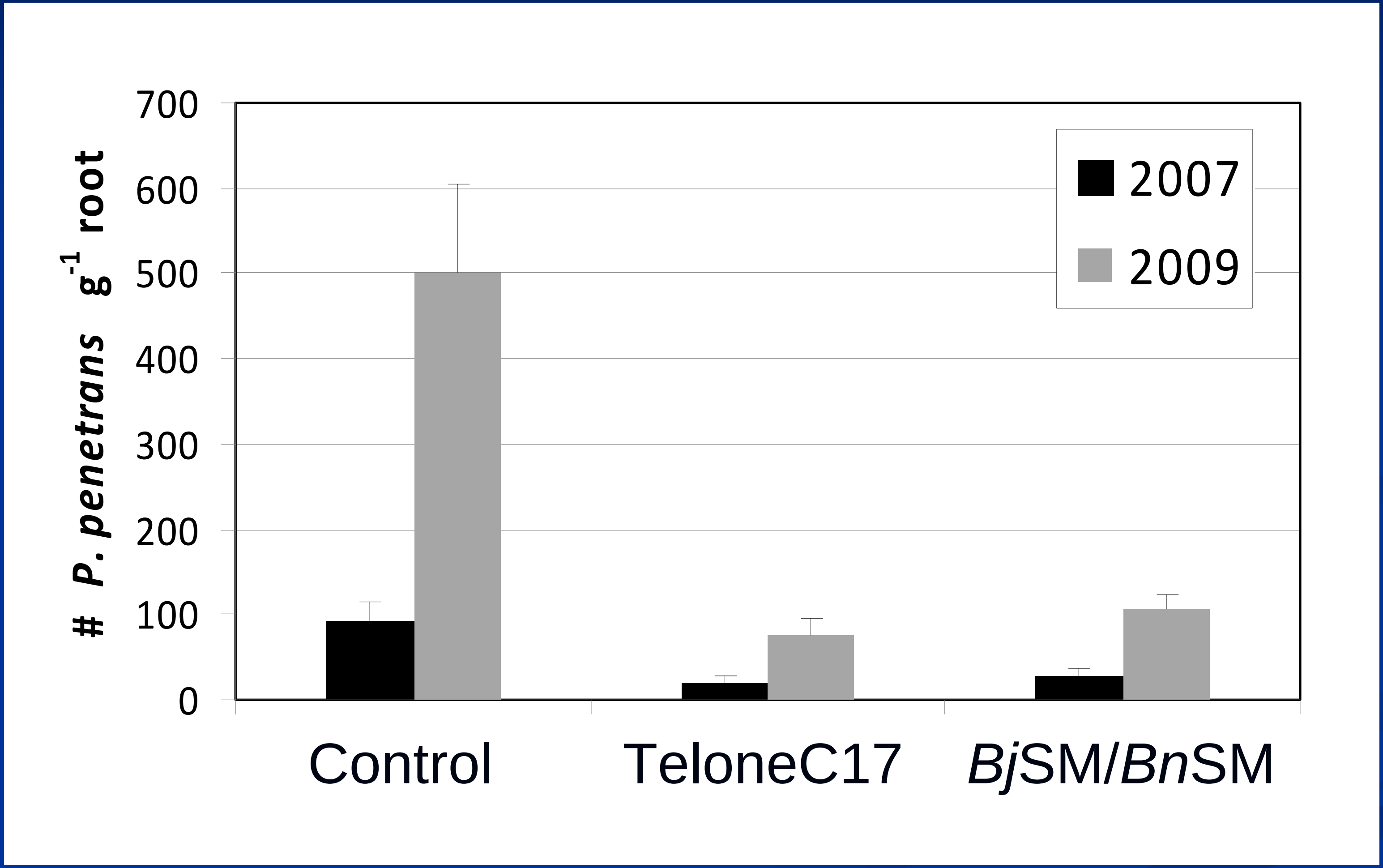


Mazzola & Brown (2009) unpublished

Commercial organic orchard

Planted May 2006 with M26 rootstock; harvested October 2006

Orchard results: Sustained control of lesion nematode



Commercial organic orchard

Planted May 2007 with Gala / M26 rootstock

Mazzola & Brown (2009) unpublished

Conclusion

- BSM mixtures have potential application as pre-plant soil treatments for control of replant diseases.

Acknowledgements

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http://cohenlab.pbworks.com/