Integrating vineyard pathogen control with sustainable nutrient and energy management

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Topics

- Application of BSM in pathogen control
  - Direct toxicity
  - Induction of systemic resistance

- Sustainable practices
  - Compost application
  - Anaerobic digestion
  - Channelized aquatic scrubbers

Apple Replant Disease

Virgin

Replant

2nd leaf

Rootstocks vary in susceptibility to pathogens

+Rs -Rs

+Rs -Rs

Pathogens commonly responsible for apple replant disease:

- Fungi
  - *Rhizoctonia solani*

- Oomycetes
  - *Pythium* spp.

- Nematodes
  - *Pratylenchus penetrans*

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

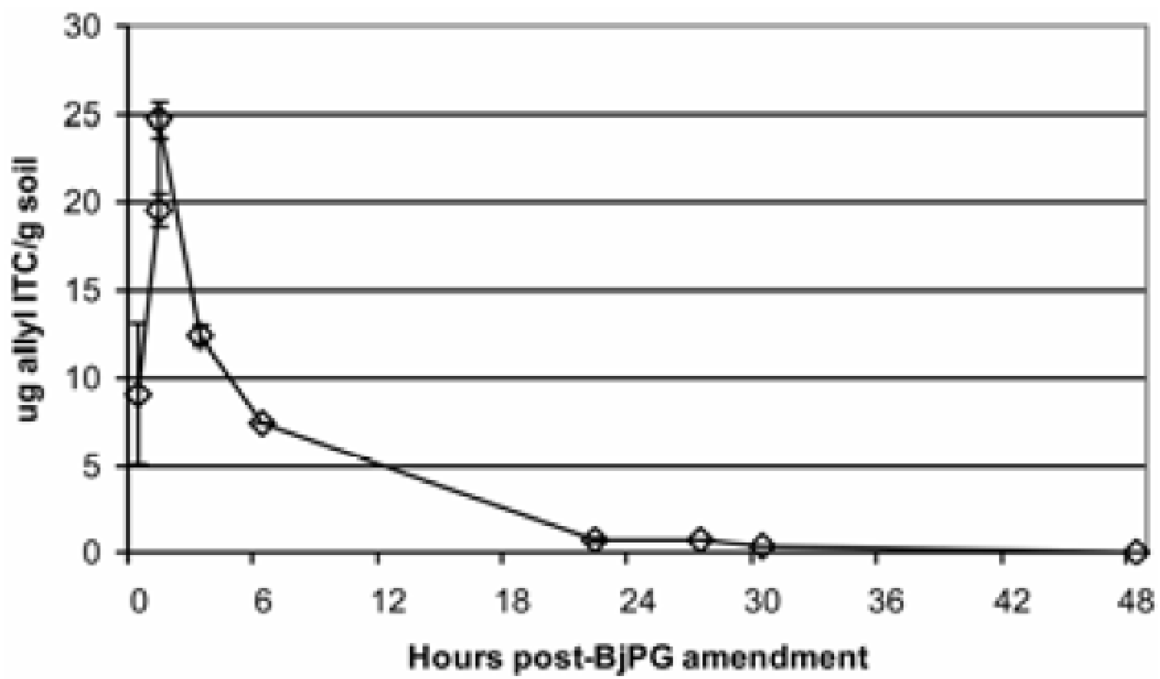
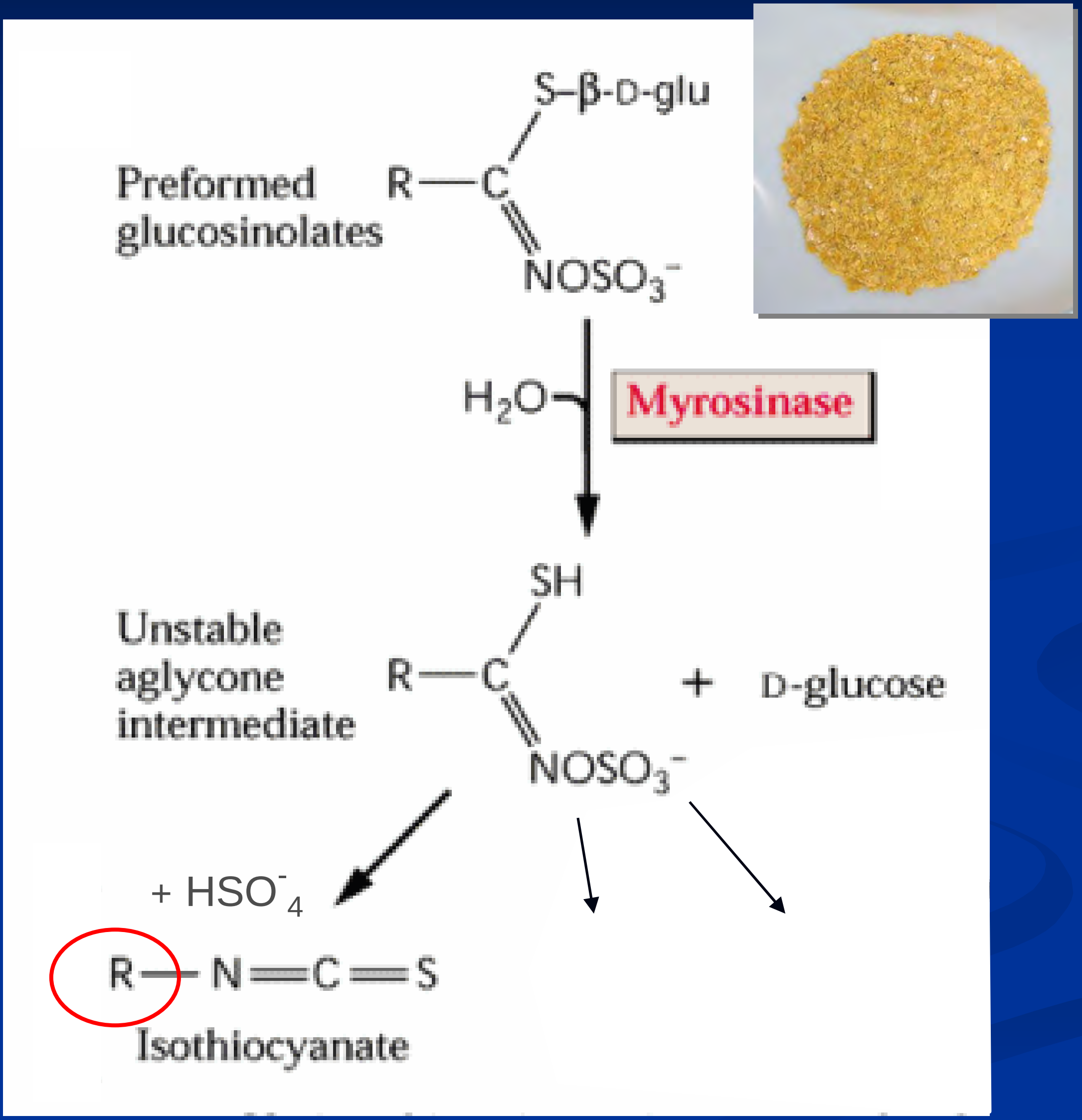


Fig. 1. Temporal pattern of allyl-isothiocyanate emission from Columbia View orchard soil amended with *Brassica juncea* cv. Pacific Gold seed meal (BjPG) as determined by monitoring concentration in the headspace of a chamber by gas chromatography. Seed meal was added to soil at a concentration of 0.5%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

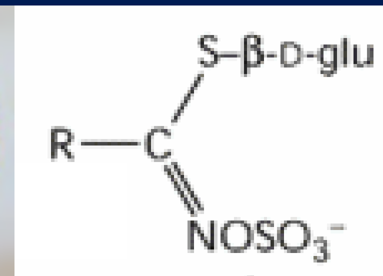
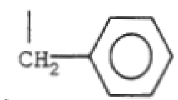
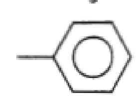
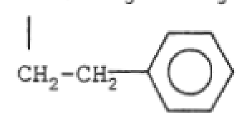


TABLE 1. Isothiocyanate, origin, structure, molecular weight, and common name of parent glucosinolate tested[a]

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	$CH2\ (CH)_3-S-CH_3$	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.

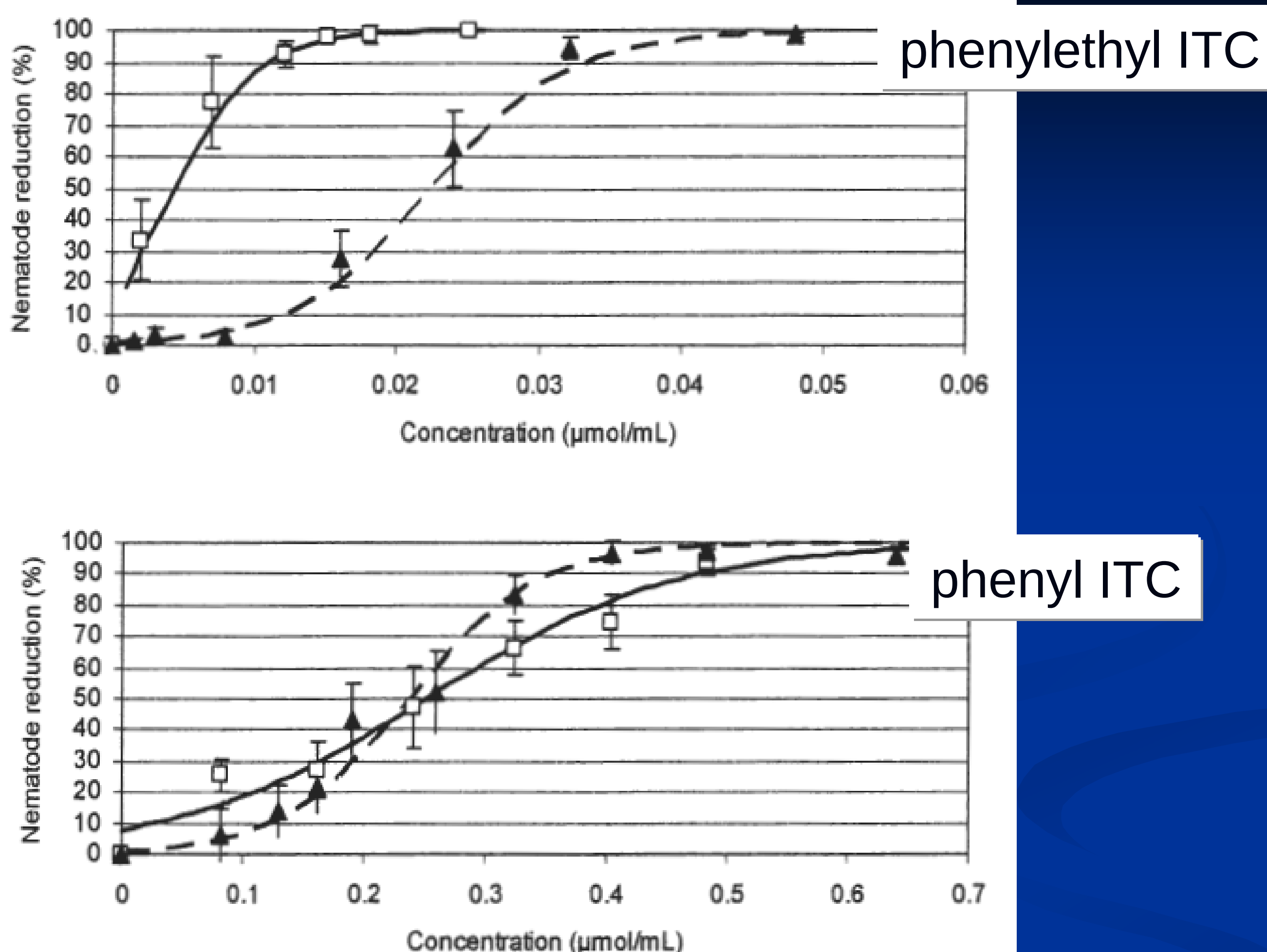
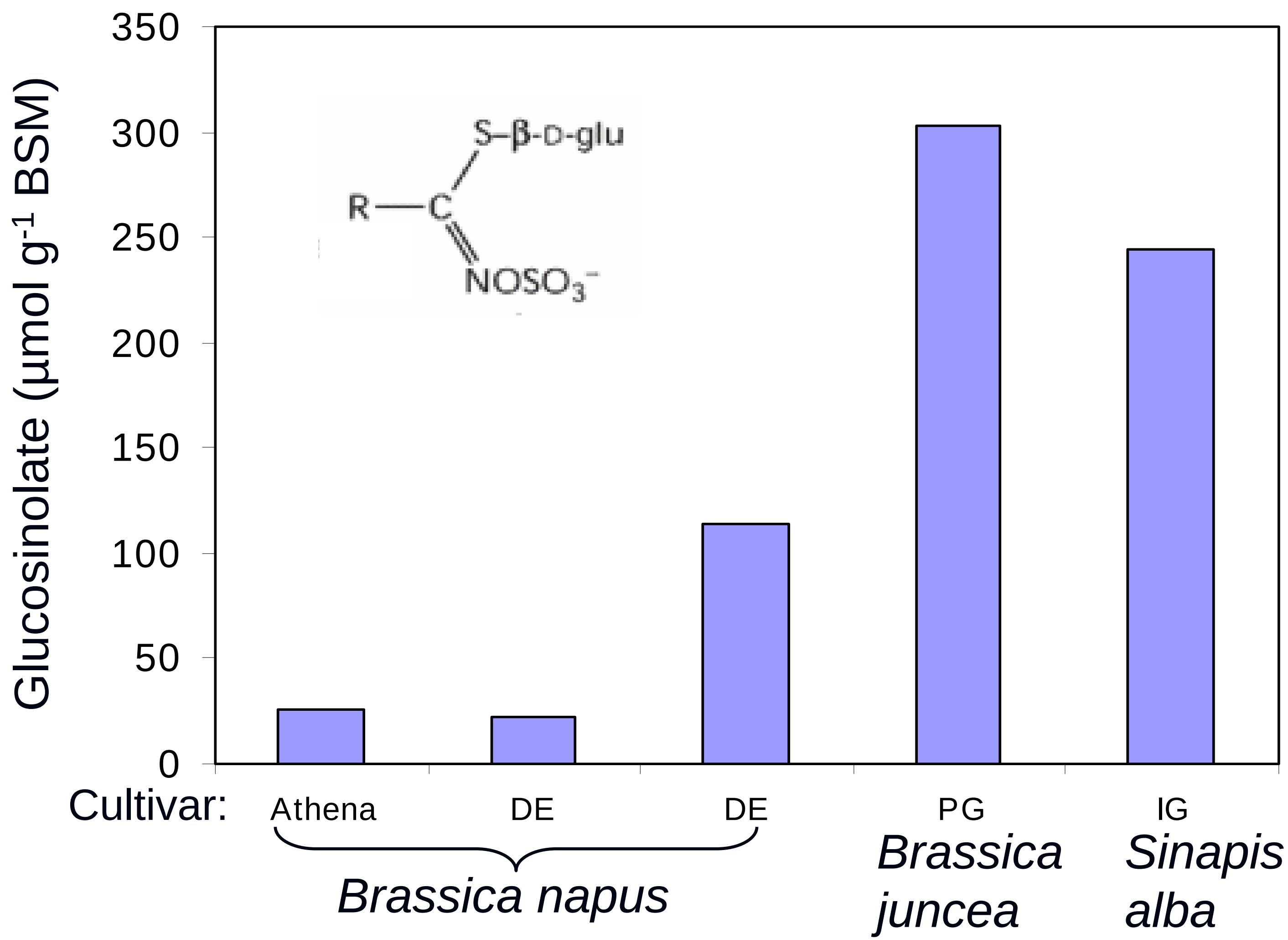


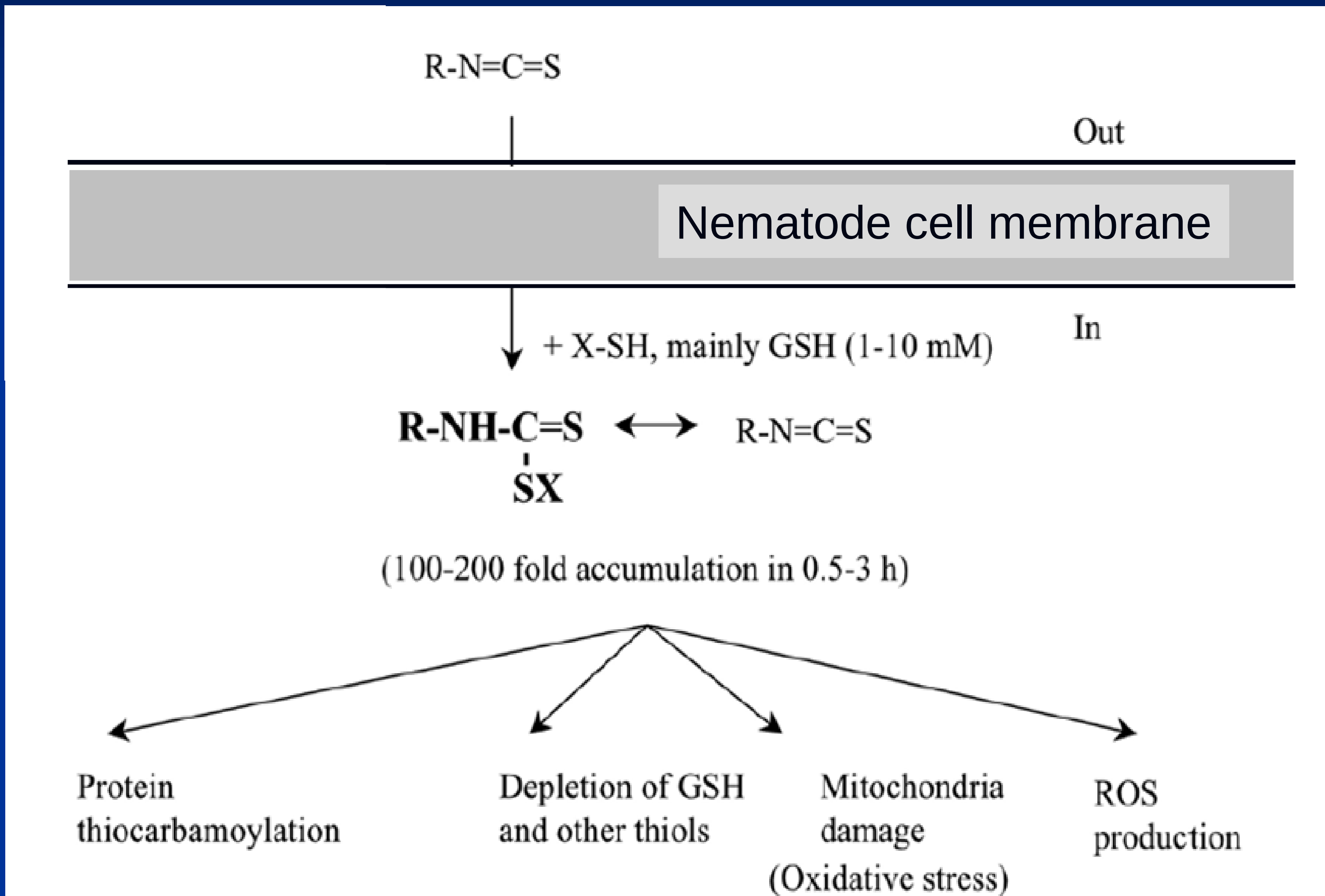
Fig. 2. Response curves for percent reduction of *Meloidogyne javanica* (▲) and *Tylenchulus semipenetrans* (□) exposed to concentration ranges of **A,** 2-phenylethyl and **B,** phenyl isothiocyanates. Vertical bars represent the 95% confidence interval for each mean.

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

BSM glucosinolate levels vary



Cellular effects of ITCs



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

BSM application in nematode control: Apple replant disease

Two mechanisms of initial BSM-induced nematode suppression

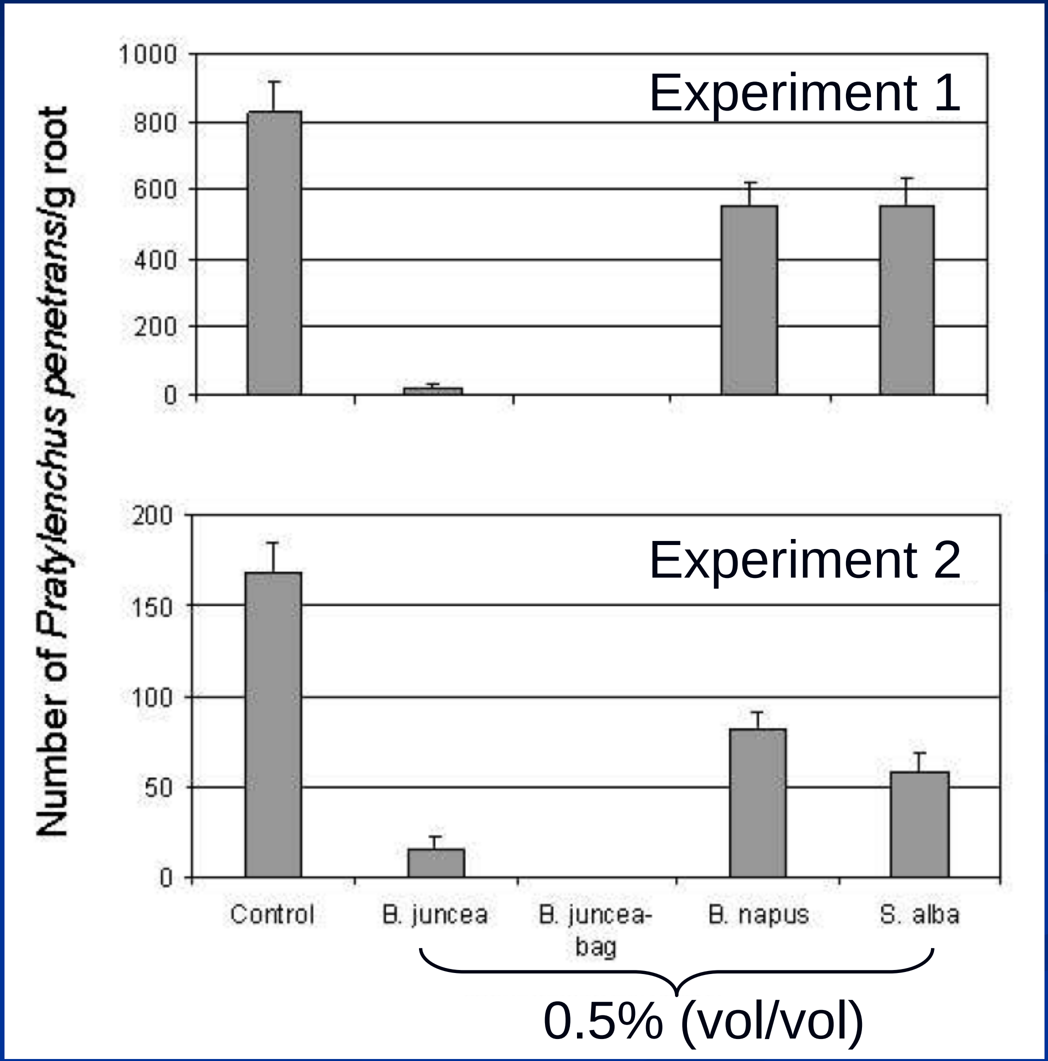
glucosinolate → ITC

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

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%

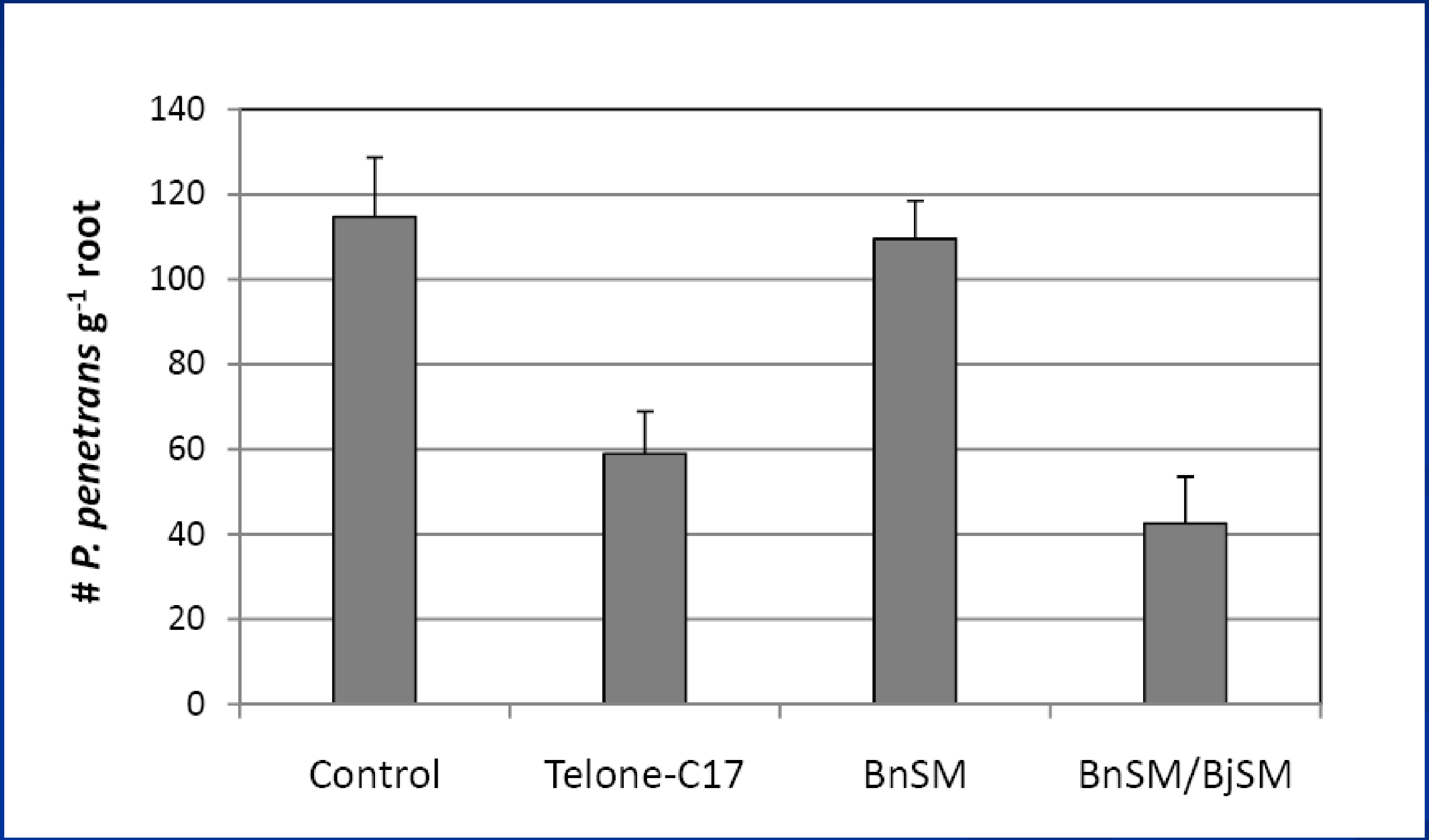
Superior protection conferred by *Brassica juncea* seed meal



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

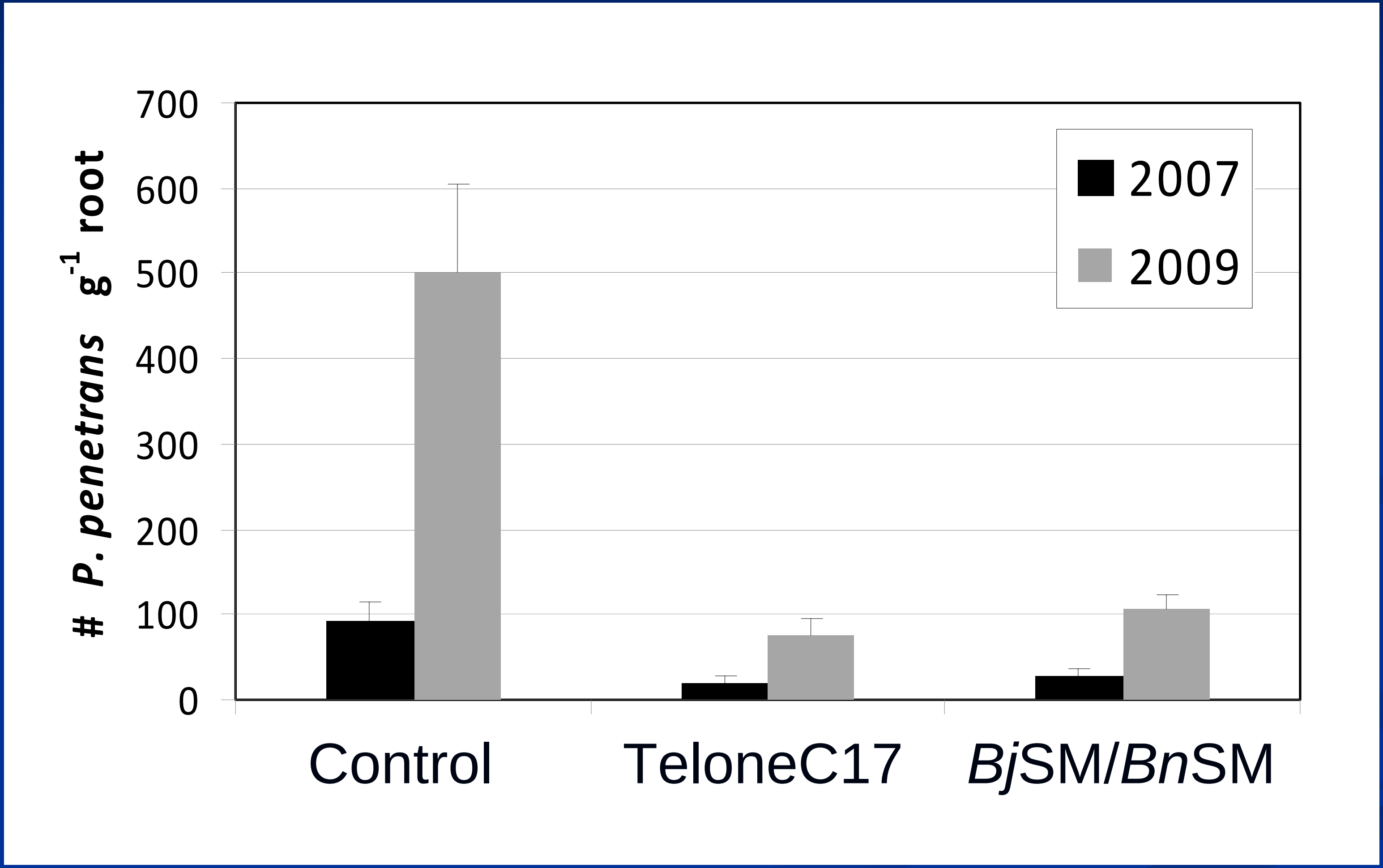


Mazzola & Brown (2009) unpublished

Commercial organic orchard

Planted May 2006 with M26 rootstock; harvested October 2006

Orchard results: Sustained control of lesion nematode



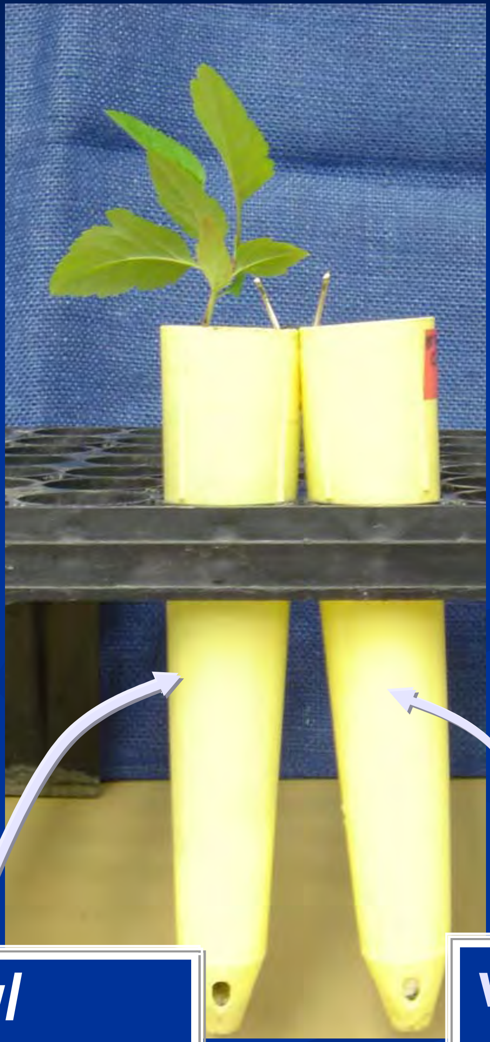
Commercial organic orchard
Planted May 2007 with Gala / M26 rootstock

Mazzola & Brown (2009) unpublished

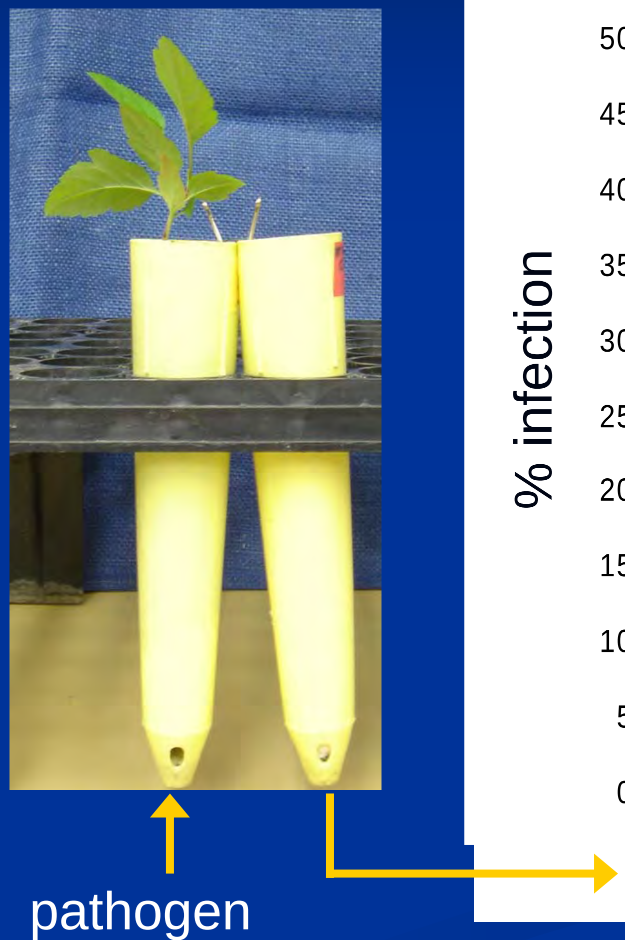
BSM induction of systemic plant disease resistance

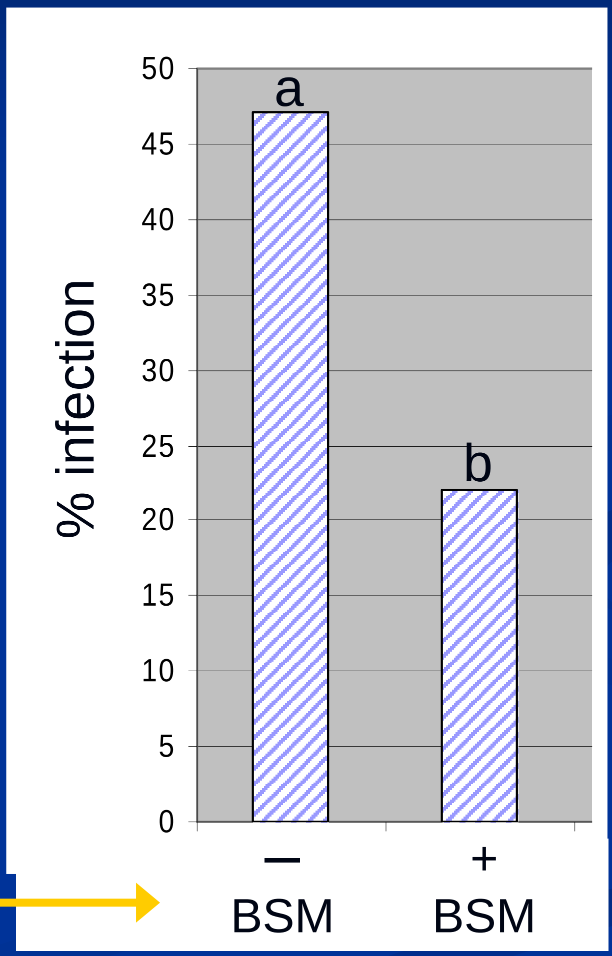
Split-root assays to assess systemic resistance

10-week old Gala seedling



BSM induces systemic resistance against *Rhizoctonia solani* infection

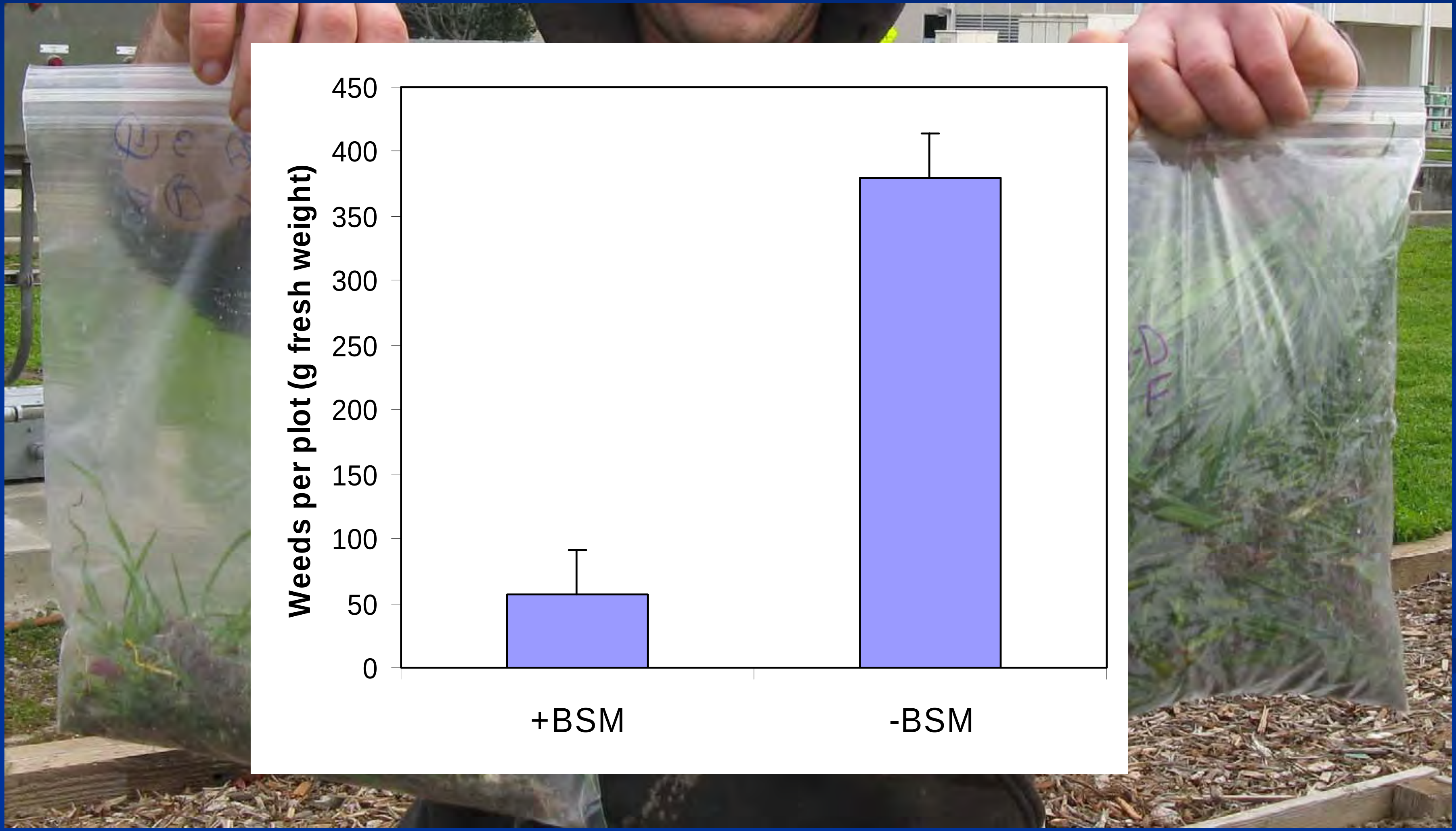




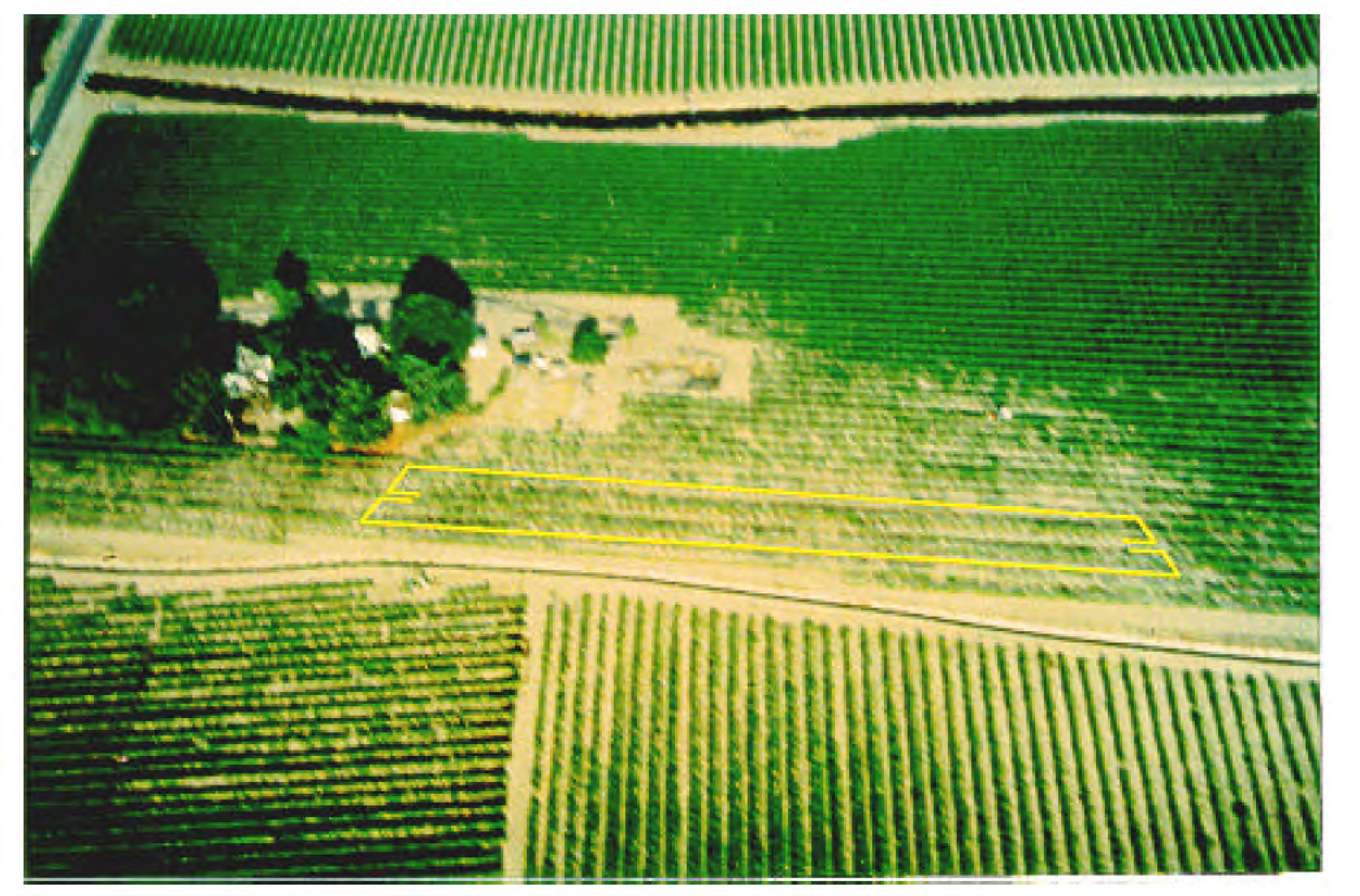
Conclusion

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

Immediate post-application phytotoxicity of BSM controls weeds



BSM for control of vine replant disease?



M.V. McKenry, 1999

Use of BjSM on existing vineyards

Table 1. Effects of Indian mustard green manure (GM) and seed meal (SM) application in inter-row and vine row on *Meloidogyne javanica* J_2 population densities in vine row soil in vineyards (cv. Semillon), Denman, Hunter Valley, 1999–2001

Treatment	*M. javanica* J_2/kg soil[A] Initial population density	14 WAT[B]	24 WAT	36 WAT
3-year-old vineyard				
Control	1540 (7.34) a	1107 (7.01) a	1790 (7.49) a	1096 (7.00) a
Inter-row GM	1540 (7.34) a	595 (6.39) a	632 (6.45) b	220 (5.39) b
Vine row GM	1495 (7.31) a	120 (4.79) c	68 (4.22) e	86 (4.46) c
Inter-row SM	1408 (7.25) a	90 (4.50) c	340 (5.83) c	276 (5.62) b
Vine row SM	1425 (7.26) a	121 (4.80) c	185 (5.22) d	76 (4.34) c
LSD ($P < 0.05$)	0.21	0.41	0.37	0.26
15-year-old vineyard				
Control	1670 (7.42) a	2345 (7.76) a	1465 (7.29) a	1366 (7.22) a
Inter-row GM	1152 (7.05) a	268 (5.59) bc	105 (4.65) d	880 (6.78) a
Vine row GM	1248 (7.13) a	169 (5.13) c	317 (5.76) bc	347 (5.85) b
Inter-row SM	1236 (7.12) a	165 (5.11) c	411 (6.02) b	1107 (7.01) a
Vine row SM	1188 (7.08) a	388 (5.96) b	230 (5.44) c	304 (5.72) b
LSD ($P < 0.05$)	0.19	0.68	0.60	0.28

[A] Back transformed means of *M. javanica* J_2 population densities in vine row soil with transformed means ($\log e^x$) in parentheses. Within columns, means with different letters differ at $P < 0.05$ and LSD values are based on $\log e^x$ transformation of nematode population densities.
[B] WAT = weeks after treatment.

Rahman & Somers (2005) Australian J. Plant Path. 34:77-83

Integrating vineyard pathogen control with sustainable nutrient and energy management

Application of composts to improve soil properties

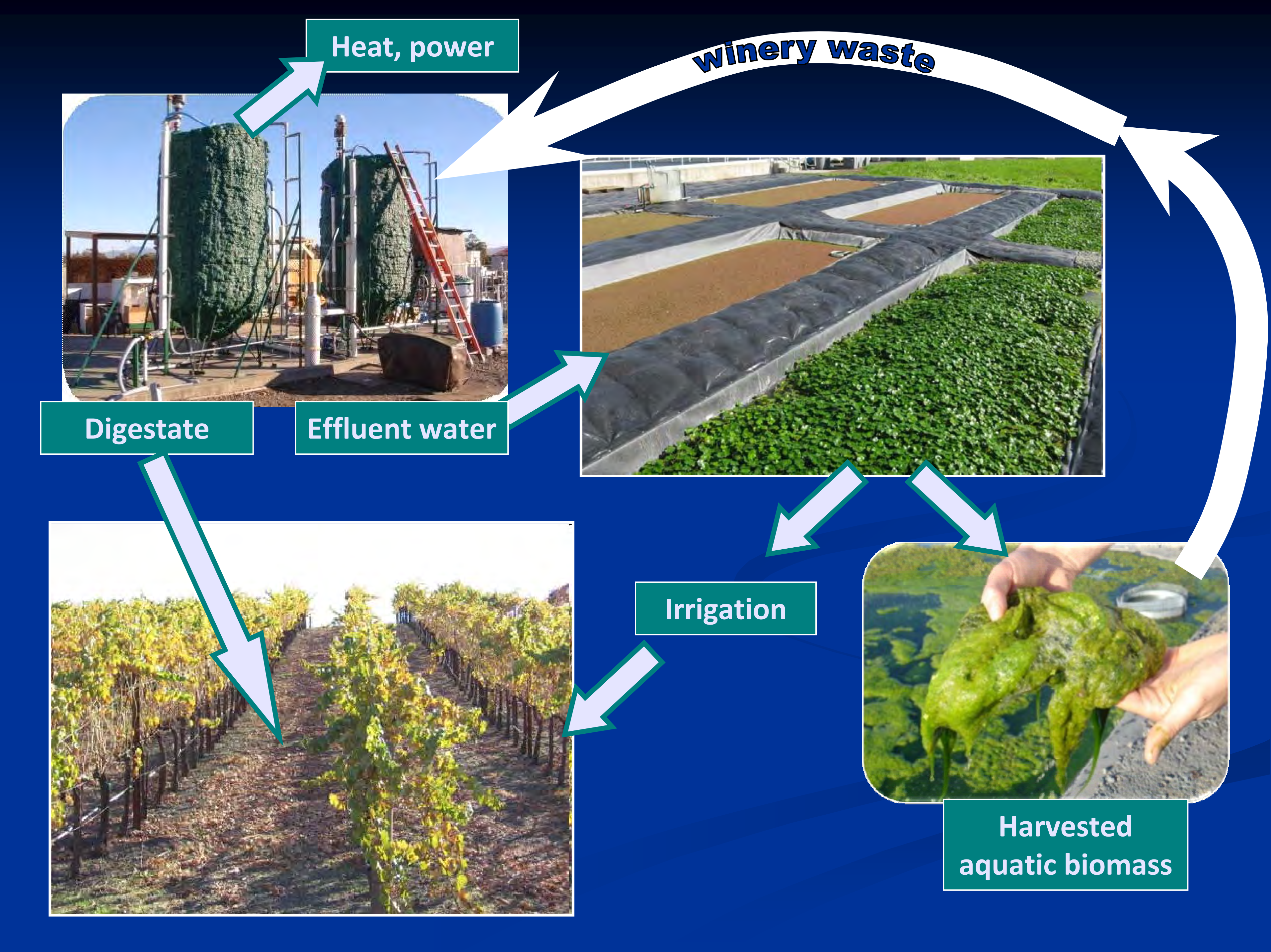
- ⇧ porosity
- ⇧ water holding capacity
- ⇩ bulk density
- improves plant capacity to withstand pathogens

Anaerobic digestion

- provides substrate for composting
- reduces solid waste volume
- provides energy for on-site uses

Clos du Bois

Simi



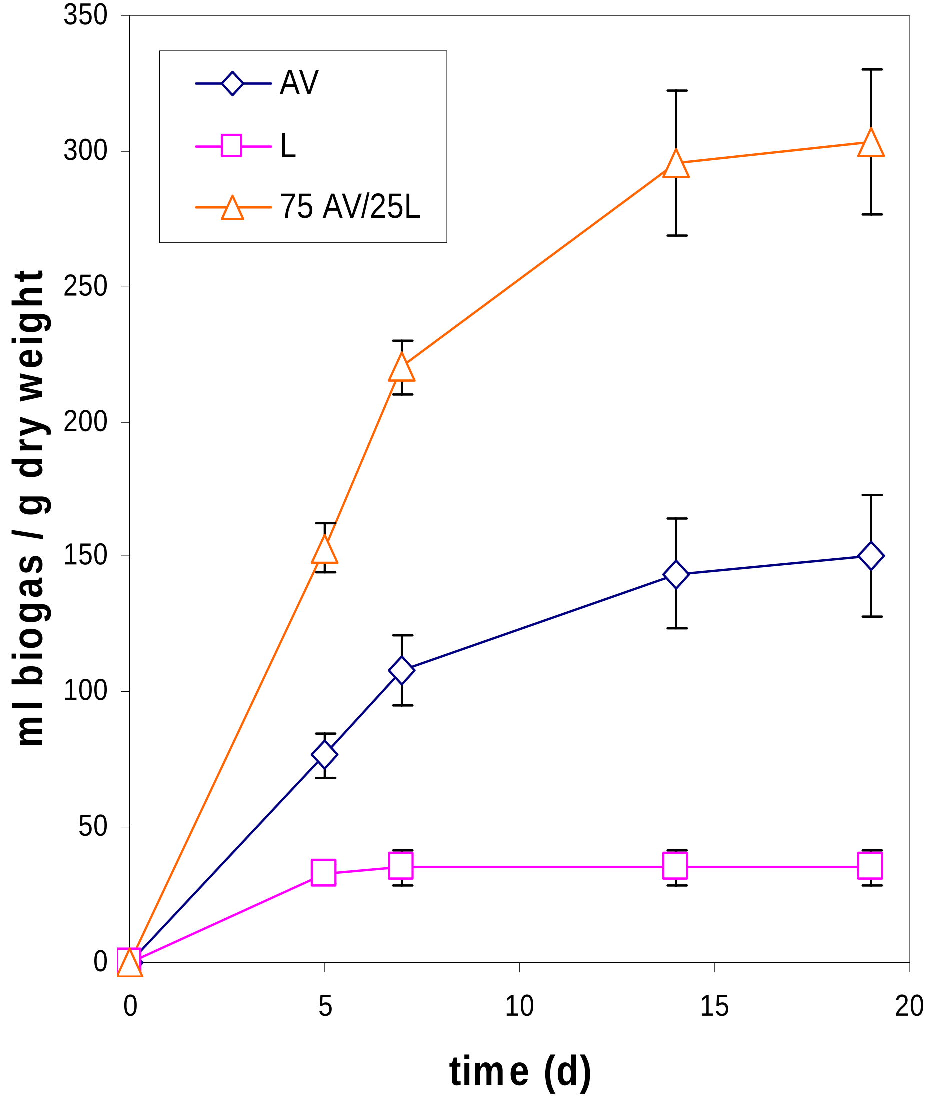
Heat, power
winery waste
Digestate
Effluent water
Irrigation
Harvested aquatic biomass

Anaerobic digestion

Feedstocks: Dairy waste Aquatic vegetation Winery waste

Laboratory assessment of feedstocks

Advantage of co-digestion



Aquatic vegetation:
drainage channels

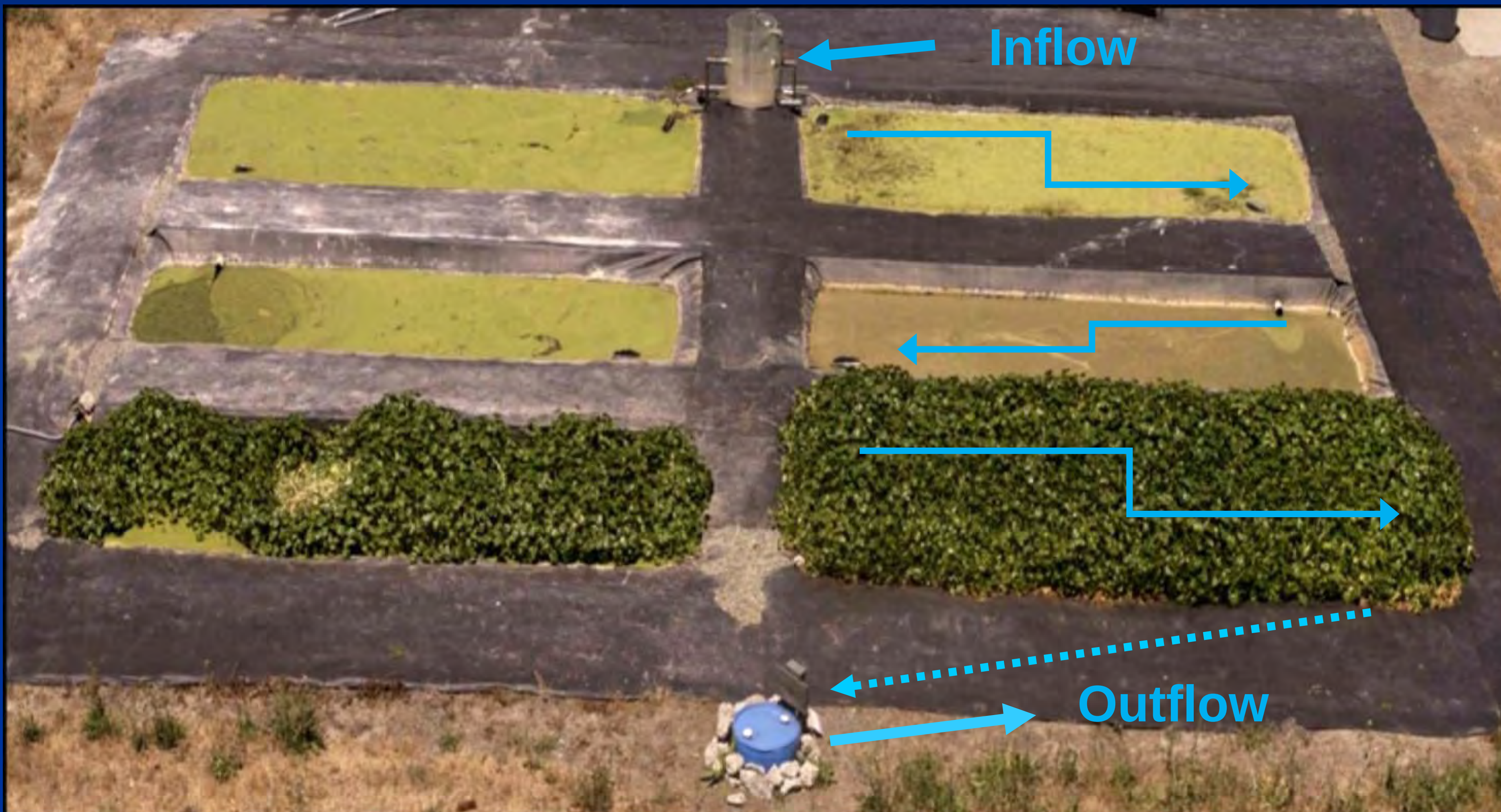
HANNA
WINERY & VINEYARDS

Vineyard constructed wetlands

"This year we saved 4 million gallons of water I was able to use for irrigation instead of buying it or pulling it out of the river"

-- Tim Thornhill, Parducci Winery (The Press Democrat, 1/17/2010)

Channelized Aquatic Scrubbers (CAS) at the Laguna Treatment Plant

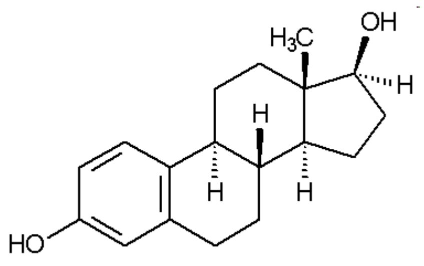


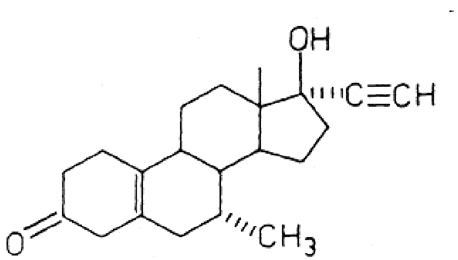
Native vegetation

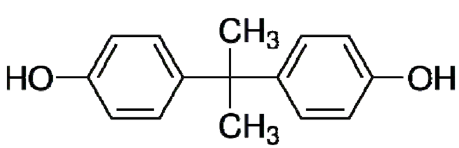
Comparative nitrate removal efficiencies

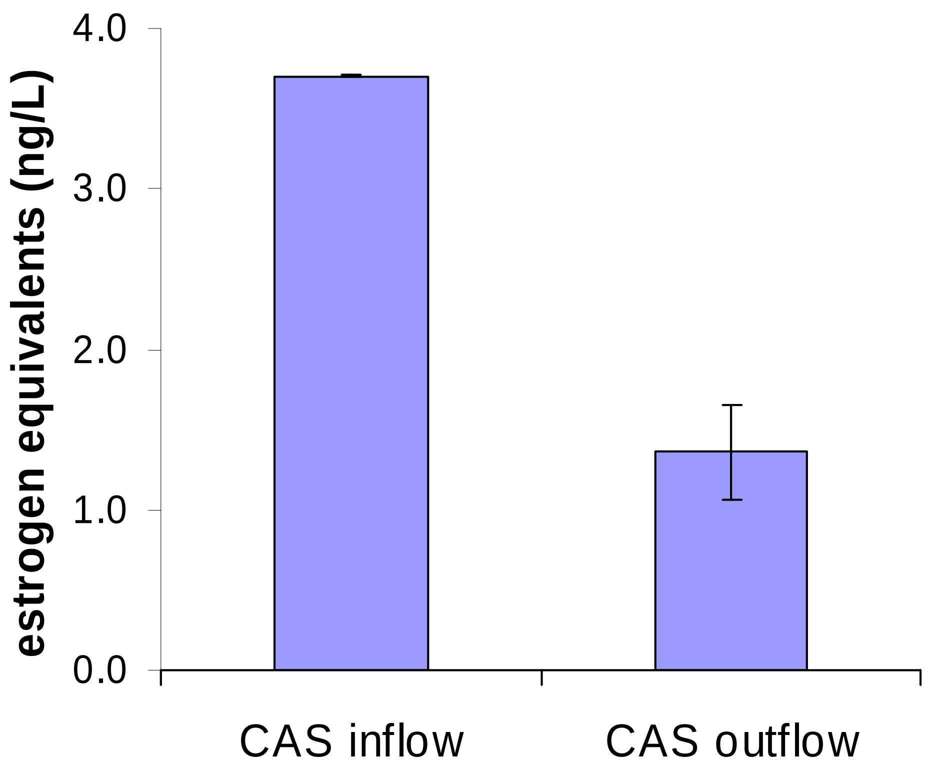
Treatment Systems	Average nitrate removal efficiency (mg N m^{-2} day^{-1})
Arcata Wetlands	800
Kelly Farm Wetlands	625
Prado Wetlands	522
Channelized Aquatic Scrubbers (1 July 2008 – 30 June 2009)	988

Removal of organic contaminants

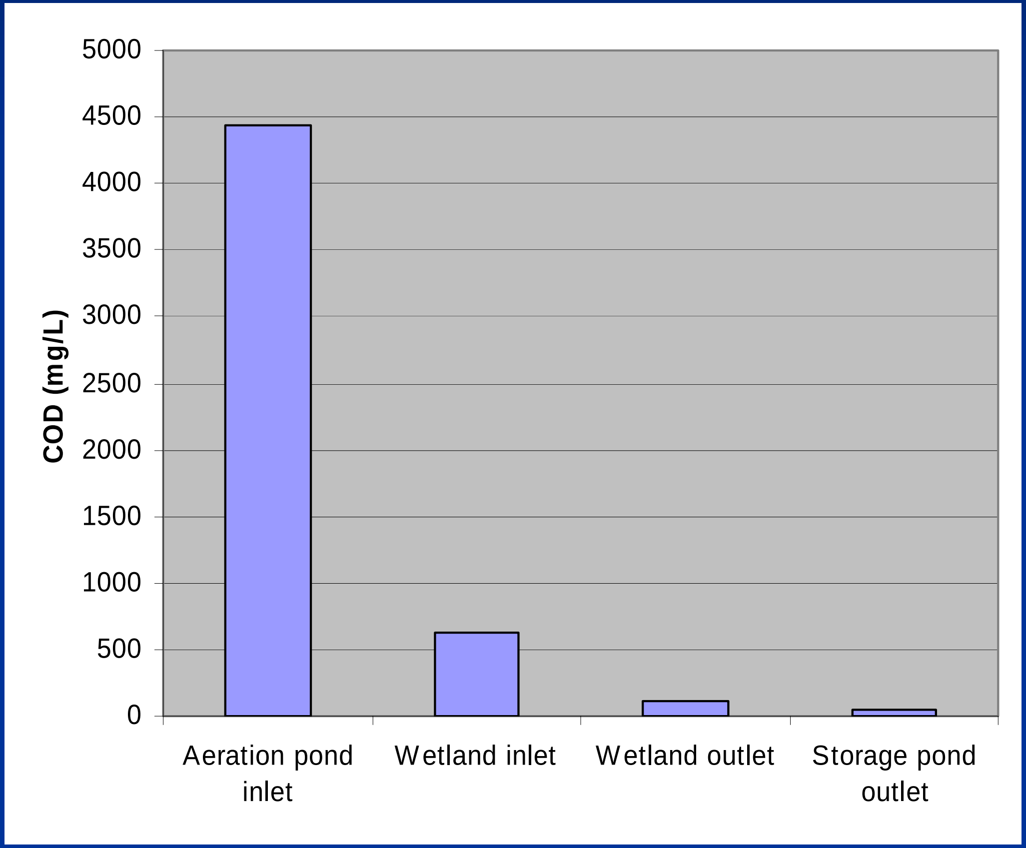








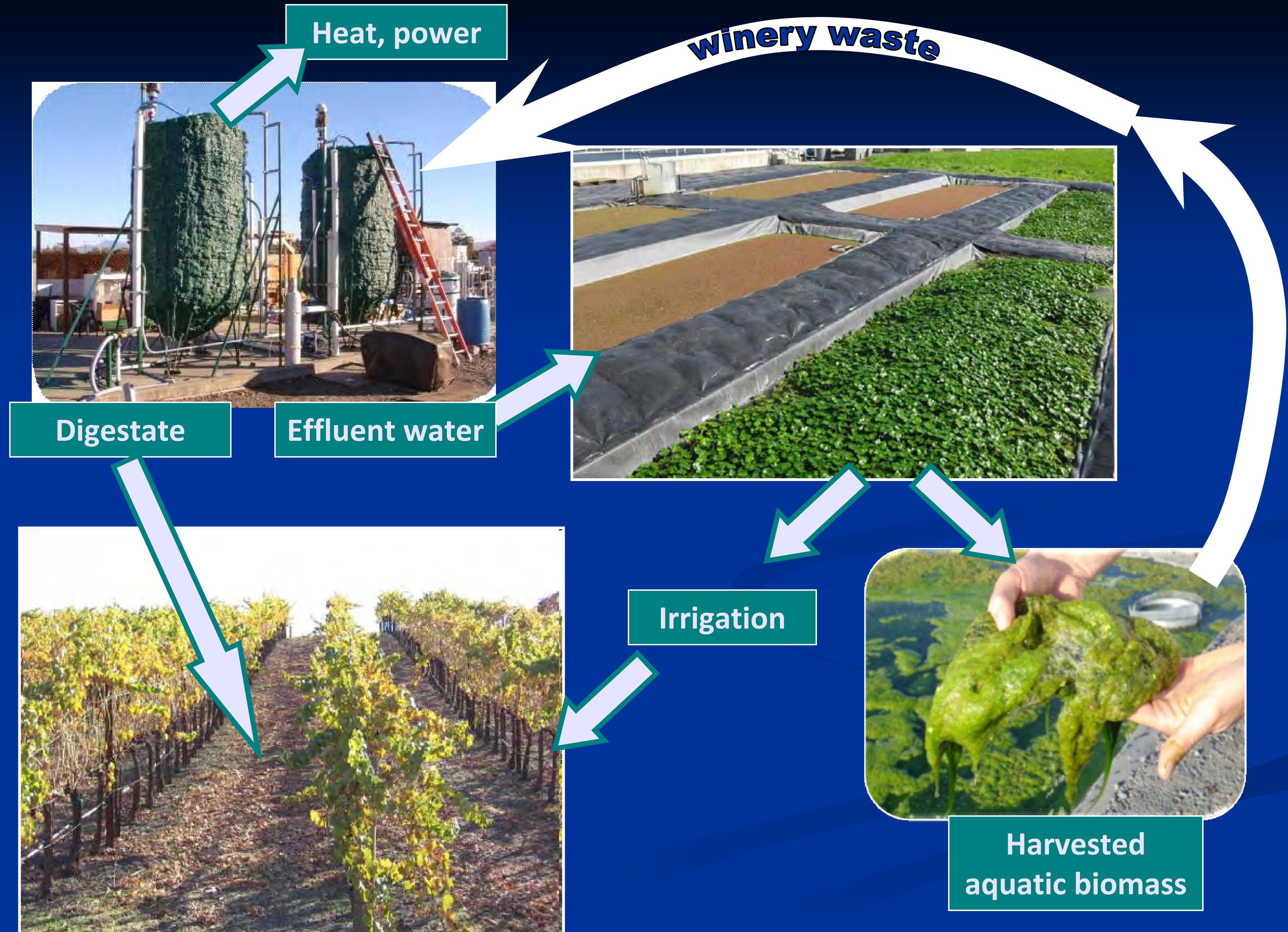
COD reduction by vineyard constructed wetlands



3.3 d

Benzinger, October 2003

Mulidzi (2005) http://www.wynboer.co.za/recentarticles/200505wetlands.php3


Heat, power
winery waste
Digestate
Effluent water
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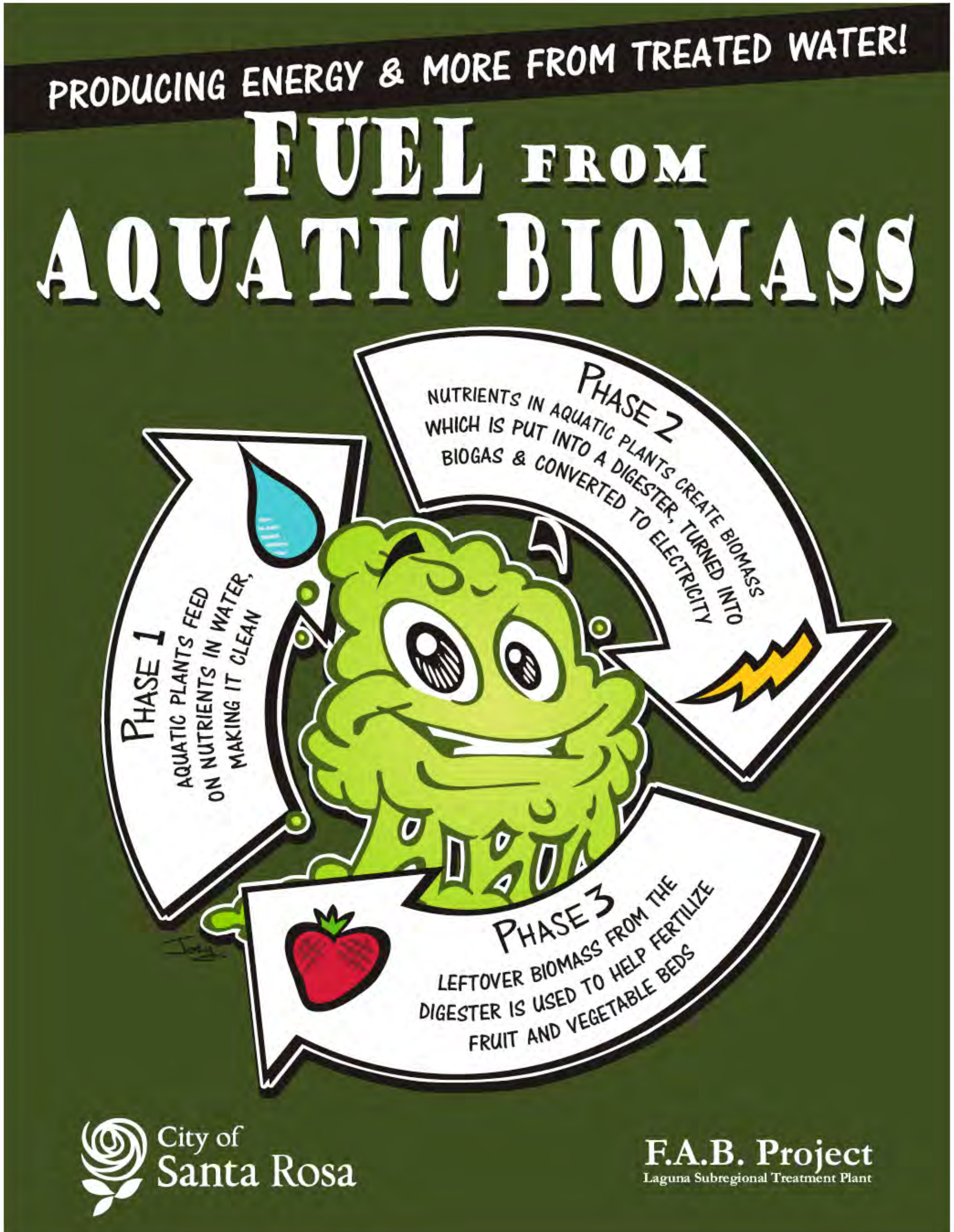
aquatic biomass



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Laguna Treatment Plant

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