Cover Crops for Disease Suppression

Alex Stone, Oregon State University

March 20, 2012

http://www.extension.org/organic_production

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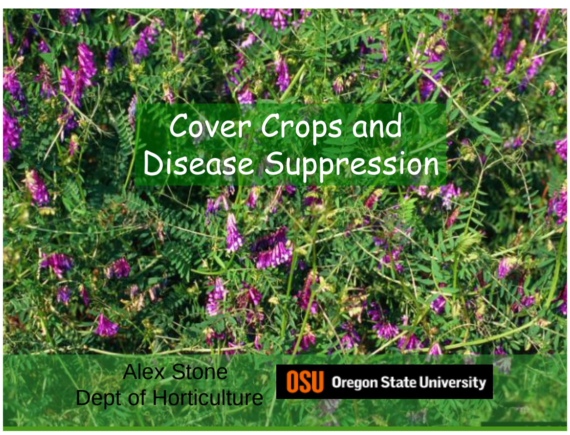
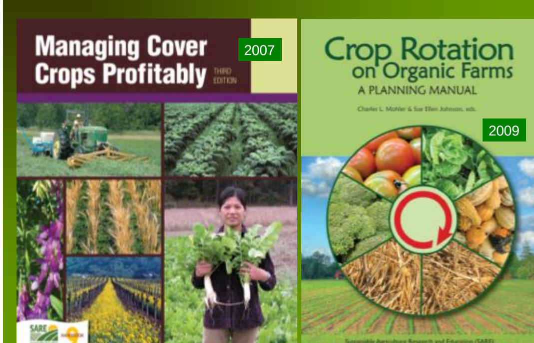
Alex Stone, Oregon State University



Outline

1. Well understood examples of cover crop-mediated soilborne disease suppression
2. Poorly understood examples of cover crop-mediated soilborne disease suppression
3. Designing a suppressive rotational system utilizing cover crops

Resources



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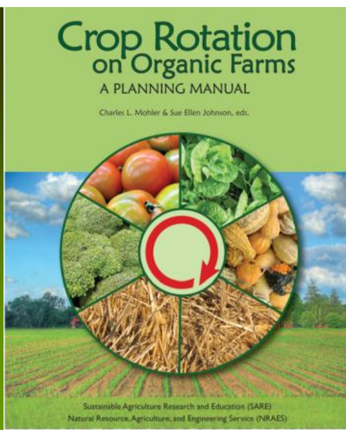
Well understood examples of cover crop-mediated soilborne disease suppression:

using cover crops

- to extend rotation length
- to improve soil physical properties
- as a physical barrier to soilborne pathogens

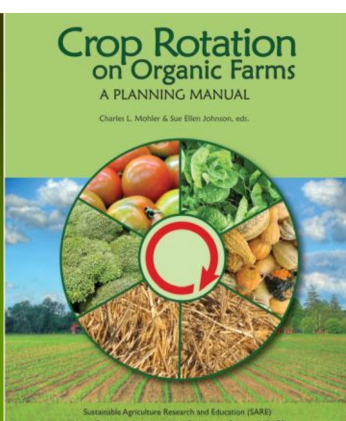
Cover Crops Extend Your Rotation

- Soilborne pathogen propagules have a lifetime. Most die within 4 years, although some, like those that cause club root and Fusarium wilt, live longer.
- Lengthening the number of years between crops susceptible to the same disease is one of the most reliable disease management practices.



Disease Appendix from Crop Rotation on Organic Farms
Cucurbit Diseases: Meg McGrath, Cornell

Fusarium crown and root rot	*Fusarium solani* f. sp. *cucurbitae*	Y (5)
Fusarium wilt (cucumber)	*Fusarium oxysporum* f. sp. *cucumerinum*	Y (5-7)
Fusarium wilt (melon)	*Fusarium oxysporum* f. sp. *melonis*	Y (5-7)
Fusarium wilt (watermelon)	*Fusarium oxysporum* f. sp. *niveum*	Y (5-7)
Gummy stem blight (aka black rot)	*Didymella bryoniae*	Y (2)
Papaya ring spot virus (PRSV)	Papaya ring spot virus (PRSV)	NA
Phytophthora blight	*Phytophthora capsici*	Y (>3)
Powdery mildew	*Podosphaera xanthii*	N



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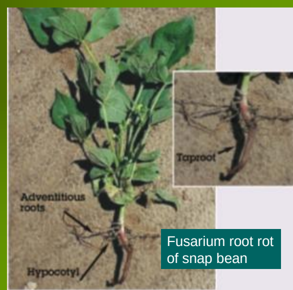
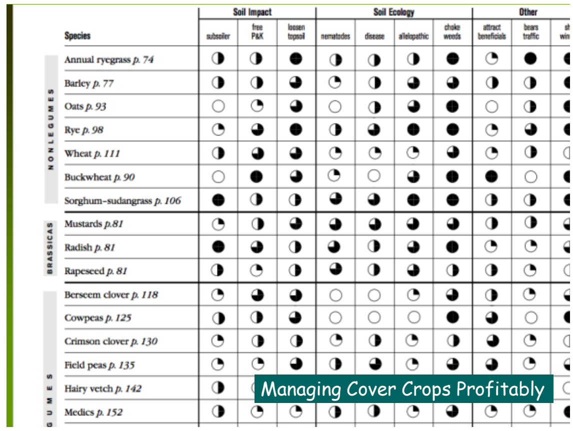
Cover Crops Improve Soil Properties

- Root rots are often exacerbated by compaction.
- Cover crops that improve soil physical properties and break through compacted layers can reduce root rot severity.



Fusarium root rot of snap bean

Roman-Aviles et al, 2003. MSU Bulletin **E2876**



	Species	Soil Impact: subsoiler	Soil Impact: free P&K	Soil Impact: loosen topsoil	Soil Ecology: nematodes	Soil Ecology: disease	Soil Ecology: allelopathic	Soil Ecology: choke weeds	Other: attract beneficials	Other: bears traffic
NONLEGUMES	Annual ryegrass *p. 74*	◑	◑	●	◑	◑	◑	●	◔	●
	Barley *p. 77*	◑	◑	◕	◔	◑	◕	◕	◑	◑
	Oats *p. 93*	○	◔	◕	○	◑	◕	●	○	◑
	Rye *p. 98*	◔	◕	●	◑	◕	●	●	◔	◕
	Wheat *p. 111*	◑	◕	◕	◔	◔	◔	◕	◔	◑
	Buckwheat *p. 90*	○	●	◕	◔	○	◕	●	●	○
	Sorghum-sudangrass *p. 106*	●	◑	◑	◕	◕	●	●	◑	◑
BRASSICAS	Mustards *p.81*	◔	◑	◕	◕	◕	◕	◕	◑	◑
	Radish *p. 81*	●	◕	◑	◕	◑	◕	●	◔	◔
	Rapeseed *p. 81*	◑	◔	◑	◕	◑	◕	◑	◑	◔
LEGUMES	Berseem clover *p. 118*	◔	◕	◕	○	○	◔	◕	◑	◔
	Cowpeas *p. 125*	◑	◑	◕	○	○	○	●	◕	○
	Crimson clover *p. 130*	◔	◑	◑	◔	◑	◔	◑	◕	◔
	Field peas *p. 135*	◔	◔	◕	◑	◕	◔	◕	◕	◔
	Hairy vetch *p. 142*	◑	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Medics *p. 152*	◑	◔	◔	◑	◑	◔	◕	◔	◔

Managing Cover Crops Profitably

Management Strategies for Improved Soil Quality with Emphasis on Compaction (SARE project LNE94-044)

- "Rapeseed, crown vetch, wheat and sudangrass were the most effective at reducing root rot and increasing bean growth as compared to no cover crop, hairy vetch or white clover."

Wolfe et al, 1996

http://s457.photobucket.com/albums/qq294/WaltonFarmspics

Outline

Well understood examples of cover crop-mediated soilborne disease suppression:

using cover crops

- to extend rotation length
- to improve soil physical properties
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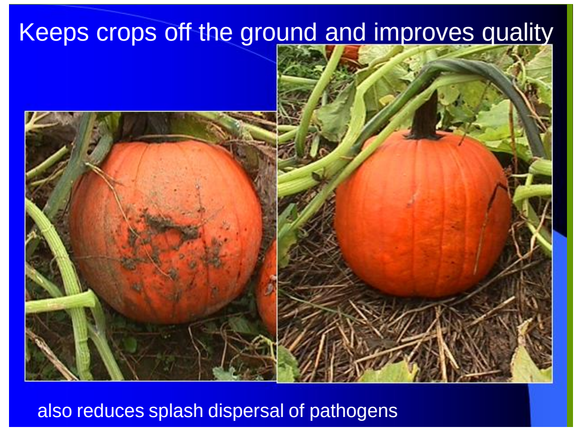
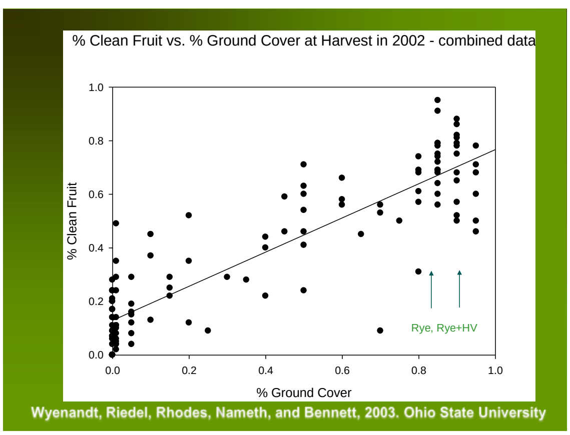
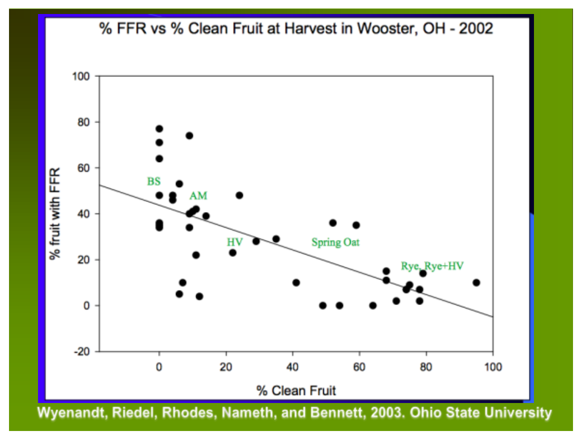
Using cover crops for control of Fusarium fruit rot in commercial pumpkin production.

Christian A. Wyenandt, R. M. Riedel, L. H. Rhodes, S. G. P. Nameth, and M. A. Bennett, Dept of Plant Pathology and Horticulture and Crop Science
The Ohio State University

F. solani f. sp. *cucurbitae*







eOrganic resources

What is Organic No-Till, and is it Practical?
http://www.extension.org/pages/18526/what-is-organic-no-till-and-is-it-practical

•At end, links to Weed 'Em and Reap video series on organic reduced tillage, including Ron Morse (VTech) demonstrating organic no till pumpkin production.

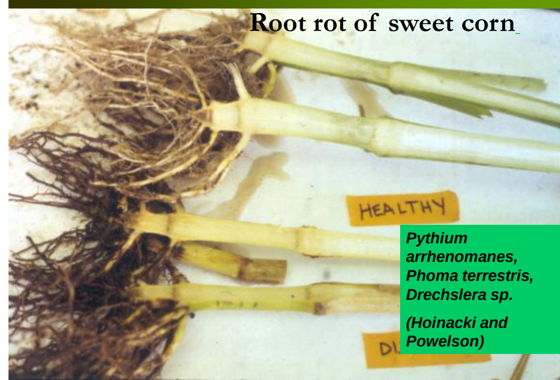
Outline

1. Well understood examples of cover crop-mediated soilborne disease suppression
2. Poorly understood examples of cover crop-mediated soilborne disease suppression
3. Designing a suppressive rotational system utilizing cover crops

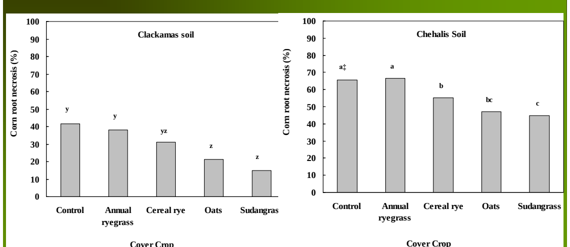
Poorly understood examples of cover crop-mediated soilborne disease suppression

- Incorporating a cover crop to shift soil biological properties
  - Highly variable (even in one location)
  - Not readily transferable to other soils, cropping systems, and climates

Root rot of sweet corn

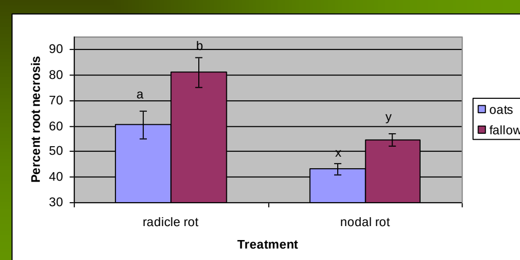


Early cover crop work: containers (Darby, 2002)



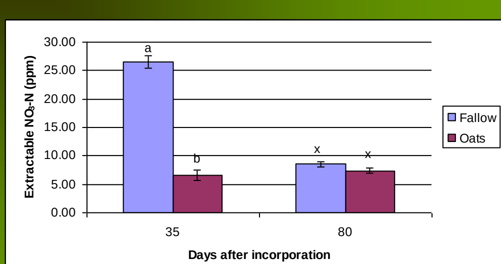
Oat and sudangrass cover crops suppress root rot of corn

Root rot severity, field-grown corn

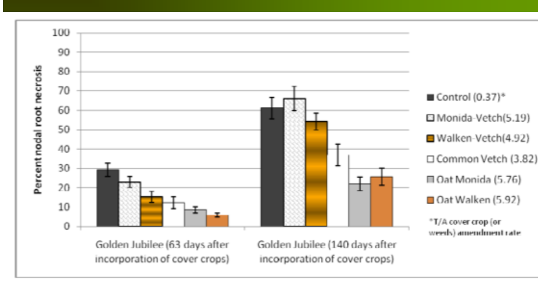


Miyazoe and Stone, OPVC Report, 2006

N Immobilization



Miyazoe and Stone, OPVC Report, 2006



Stone and Miyazoe, OPVC report, 2011

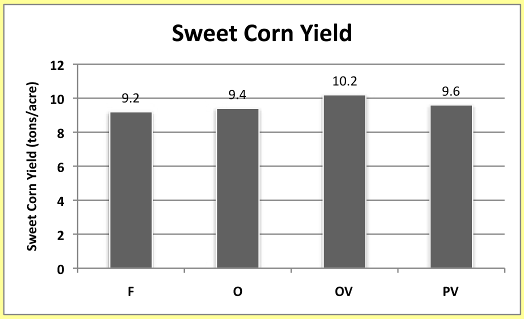


Fig. 5. Effect of cover crops on graded yield of sweet corn in strip-till systems (n=6).

John Luna OPVC report, 2009

Hairy vetch improves tomato production in Delaware, US

Hairy vetch is the most widely used winter annual legume because of its winter hardiness, its high productivity, and its high N content.

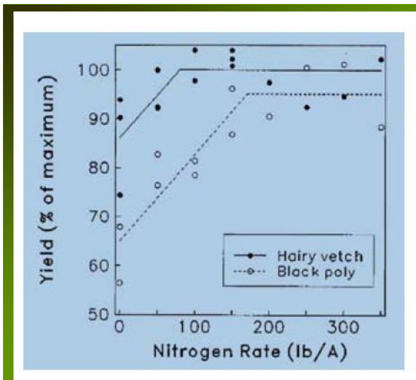
Teasdale and Abdul-Baki 2007

Teasdale and Abdul-Baki 2007

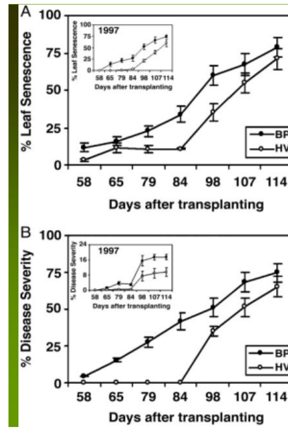
Figure 2. A high-speed flail mower converts the cover crop to a mulch without disturbing the soil.

Figure 3. Transplanting tomatoes into hairy vetch mulch using no-till transplanters.

Teasdale and Abdul-Baki 2007



Teasdale and Abdul-Baki 2007

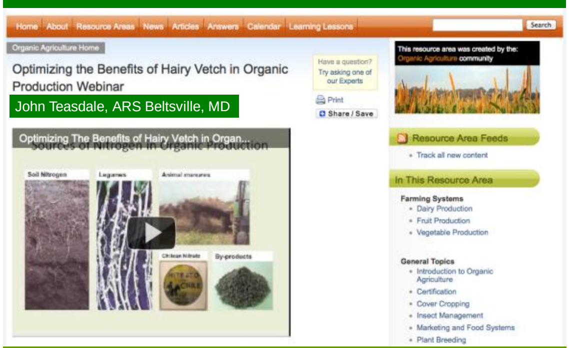


An alternative agriculture system is defined by a distinct expression profile of select gene transcripts and proteins

Kumar et al, 2004
PNAS 101:**10535–10540**

Vetch altered gene expression
- Delayed senescence
- Reduced foliar disease severity

eOrganic Resources



Fusarium wilt of watermelon

Egel and Martyn, APSnet Education Series www.apsnet.org/Education/

Integrated Management of Fusarium Wilt of Watermelon
Additive Effect of Hairy Vetch and Moderately Resistant Variety

Fig. 3. Field plots showing differences in severity of Fusarium wilt and plant growth between watermelon cv. Seedless Sangria (left) and Millionaire (right) grown in green-manured beds.

over two years:
- ✓ hairy vetch green manure reduced wilt by 26%
- ✓ the resistant cultivar reduced wilt by 48%
- ✓ when combined, wilt was reduced by 70%

Zhou, X. G., and Everts, K. L. 2006.

Impact of varietal resistance on hairy vetch suppression of Fusarium wilt of watermelon

- hairy vetch–induced wilt suppression was evaluated in the greenhouse on 12 watermelon cultivars with different levels of wilt resistance
- suppression increased as the level of resistance in cultivars increased.
- Fusarium wilt suppression was
  - 22% in susceptible varieties
  - 53% in moderately resistant varieties
  - 63% in highly resistant varieties

Zhou and Everts, 2007

Suppressiveness is related to reduced stem colonization by *Fusarium o.n.*

Table 6. Colonization (CFU/g of fresh tissue) by *Fusarium oxysporum* f. sp. *niveum* in lower stems of two watermelon cultivars grown in hairy vetch green manured or nonmanured field plots in 2003 and 2004[x].

Cultivar[y]	Manure	2003	2004
Millionaire	None	33,888 a[z]	26,125 a
	Hairy vetch	15,238 a	11,625 b
SS	None	88 b	1,750 c
	Hairy vetch	25 c	625 d

Zhou, X. G., and Everts, K. L. 2006.

Table 4. Effects of hairy vetch green manure, cultivar resistance, and soil fumigation on plant growth and fruit sugar content of watermelon in 2003 and 2004[x].

Main effect	2003 Plant growth: Vine length (cm)	2003 Plant growth: Dry weight (g/shoot)	2003 Sucrose (%)	2004 Plant growth: Vine length (cm)	2004 Plant growth: Dry weight (g/shoot)	2004 Sucrose (%)
Manure						
Fallow	133 a[z]	89 a	10.8 a	117 a	69 a	10.2 a
Vetch	148 b	98 a	11.9 b	133 b	83 a	10.9 b
Cultivar						
Millionaire	132 a	73 a	11.5 a	107 a	45 a	10.9 a
SS	149 b	115 b	11.2 a	143 b	107 b	10.3 b

Zhou, X. G., and Everts, K. L. 2006. Suppression of Fusarium wilt of watermelon enhanced by hairy vetch green manure and partial cultivar resistance. Online. Plant Health Progress doi:10.1094/PHP-2006-0405-01-RS.
SS = Seedless Sangria (moderately resistant)

Keinath et al at Clemson University (South Carolina) evaluated hairy and common vetch for suppression of Fusarium wilt of watermelon (in cooperation with the Everts group) in two locations and neither was effective. The Everts group showed that common vetch was as effective as hairy vetch in Maryland.

Keinath et al, 2009 (abstract)

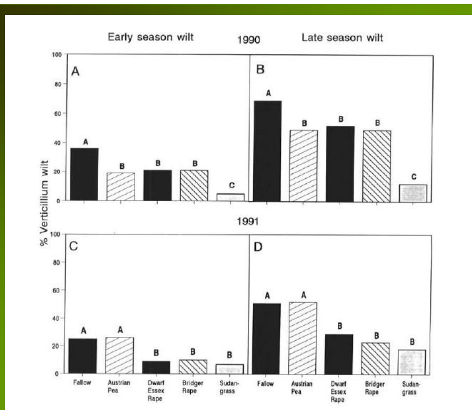
Outline

1. Somewhat predictable mechanisms of cover crop-mediated on soilborne disease suppression
2. Poorly understood examples of cover crop-mediated soilborne disease suppression
3. Designing a suppressive rotational system utilizing cover crops

2 years sudangrass = 1 yr Verticillium wilt suppression
3 years of sudangrass = 2 yrs Verticillium wilt suppression

Fig. 3. Verticillium wilt on potato vines (Russet Burbank) A, on 12 September 1990 after three successive years of fallowing during the growing season and B, on 12 September 1990 after three successive green manure crops of sudangrass.

Davis et al, 1996

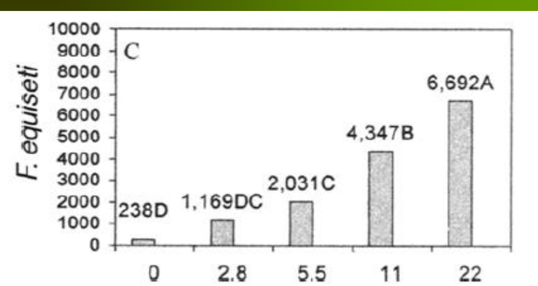


Davis et al, 1996

TABLE 7. The effect of green manure and N treatments on potato yield in 1990

Treatment	Yield (metric tonnes ha^{-1})^{y} Total	U.S. #1	Tubers >280 g
Field study 1			
Cropping treatment			
Fallow	30 B	20 B	6 C
Austrian winter pea	34 B	23 B	11 B
Sudangrass	39 A	27 A	17 A
Dwarf Essex rape	32 B	22 B	8 BC
Bridger rape	32 B	22 B	9 BC

Davis et al, 1996



rate of sudan grass amendment (t/ha)

Davis et al, 2004

- Sweet corn grown for 2 or 3 years in succession increased yield and suppressed Verticillium wilt in subsequent potato crops by 60-70%.
- Soil Verticillium populations were not affected by cover cropping, but infection of potato feeder roots by Verticillium was reduced.
- Corn cover crops increased soil populations of *Ulocladium* spp and *Fusarium equiseti*, which colonize potato roots, and their soil populations were related to wilt suppression.
- Jubilee sweet corn was approximately twice as effective as Supersweet Jubilee, which was related to Jubilee's much larger aboveground biomass; mean DM for Jubilee was 8.12 T/A, while the mean DM of SSJ was 4.2 T/A.

Davis et al, 2010

Idaho (Davis) Suppressive System

- *"Sudangrass is a good forage crop. When grown, a cash green forage cutting can be harvested in mid summer, and the re-growth can then be put down in late fall as a green manure.*
- *Second, a green manure can be part of a double cropping system (e.g. peas followed by sudangrass).*
- *Sweet corn may be grown as a crop, and following harvest, the green stalks may be incorporated into soil.*
- *Green wheat and/or barley provide excellent green manures. These crops may be also grown, harvested early, and the green regrowth incorporated as green manures in the fall….These are all means of using green manures without taking land out of production."*

Davis et al, 2010

Idaho Suppressive System (cont'd)

- *"Even if land is taken out of production, this need not always be a poor option.*
- *Green manures provide excellent rotations and provide other benefits in addition to disease control.*
- *Finally, although a more difficult and long term approach, our agricultural policy could be adjusted to encourage grower utilization of cover crops. Such a policy would help encourage the nurturing of soil for long term sustainability."*

Davis et al, 2010

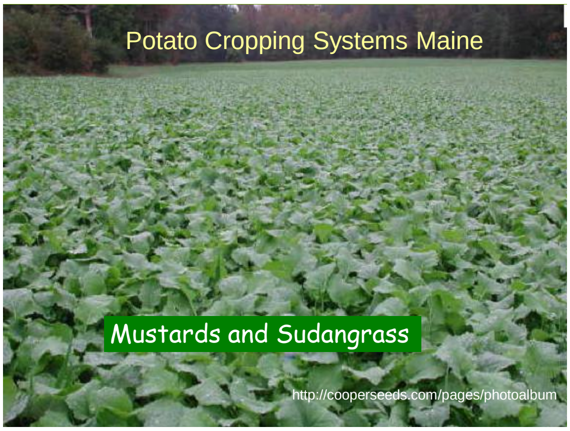


Table 1
Rotation crops evaluated for effects on soilborne potato pathogens and diseases in laboratory, greenhouse, and field trials

Crop name—cultivar	Scientific name	Relative glucosinolate content
Potato—'Shepody' (GH only[a])	*Solanum tuberosum*	None
Oats	*Avena sativa*	None
Ryegrass—'Lemtal'	*Lolium multiflorum*	None
Barley	*Hordeum vulgare*	None
Canola—'Hyola 401'	*Brassica napus*	Low
Rapeseed—'Dwarf Essex'	*Brassica napus*	Moderate
Turnip—'Purple Top'	*Brassica rapa*	Moderate
Radish (oilseed)—unknown	*Raphanus sativa*	Moderate
Yellow mustard—'IdaGold'	*Sinapis alba*	Moderate
Indian mustard—unknown	*Brassica juncea*	High

[a]Potato crop used in place of bare soil (no-crop) control for maintenance of inoculum of *R. solani*. In greenhouse tests only.

Larkin et al, 2007

Farm 1

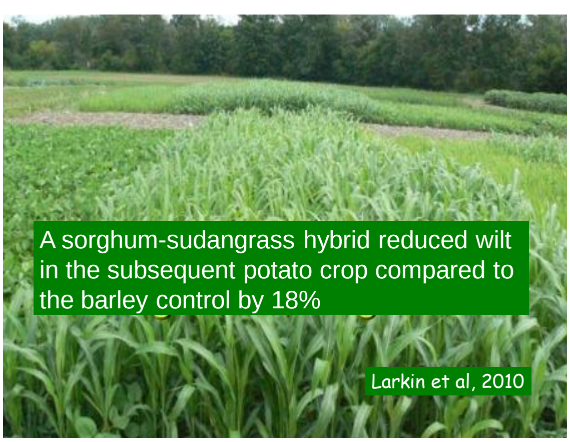
Rotation crop	Powdery scab[a] Incidence	Black scurf[b] Incidence	Common scab[b] Incidence
Oats	58.3 a	30.6 a	2.5
Ryegrass—'Lemtal'	45.8 b	17.5 b	2.5
Yellow Mustard—'Idagold'	56.3 ab	15.8 bc	4.2
Canola	49.1 ab	6.7 c	0.0
Rapeseed—'Dwarf Essex'	47.5 b	8.3 bc	2.5
Indian mustard	34.8 c	33.5 a	5.0
LSD ($P = 0.05$)	10.2	9.7	ns

Larkin and Griffin, 2007

Farm 2

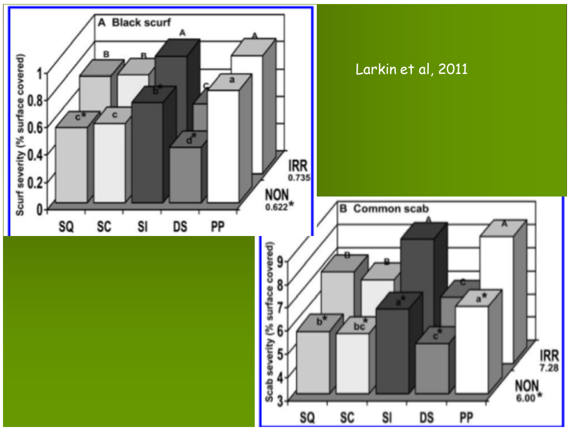
Rotation	Powdery scab[b] Incidence	Black scurf[b] Incidence	Common scab[a] Incidence
Ryegrass—'Barenburg'	1.7	7.5 a	69.2 ab
Ryegrass—'Lemtal'	2.5	0.0 c	80.8 a
Yellow mustard—'Idagold'	3.3	1.7 bc	75.0 a
Rapeseed—'Dwarf Essex'	2.5	1.7 bc	80.0 a
Indian mustard	1.7	5.0 ab	60.8 b
LSD ($P = 0.05$)	ns	3.6	11.7

Larkin and Griffin, 2007



Maine (Larkin) Suppressive System

- The status quo system (SQ) consisted of barley underseeded with red clover followed by potato (2-year).
- The soil-conserving system (SC) featured an additional year of forage grass and reduced tillage (3-year, barley/timothy–timothy–potato).
- The soil-improving system (SI) added yearly compost amendments to the SC rotation,
- The disease-suppressive system (DS) featured diverse crops with known disease-suppressive capability (3-year, mustard/rapeseed–sudangrass/rye–potato).

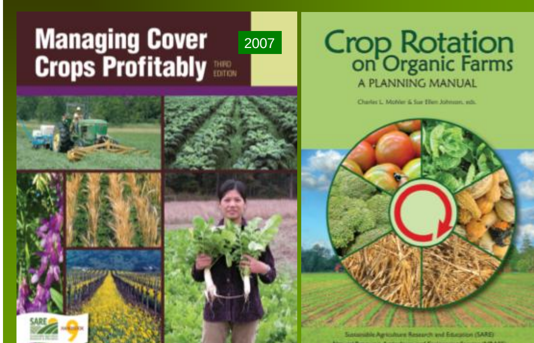


Larkin et al, 2011

The Larkin group acknowledges that the DS system is not economically viable. However they assert that *"a form of this DS rotation, incorporating the DS principles into a single rotation year followed by a more conventional, profitable crop in the third year, may have potential for improved sustainable potato production."*

Larkin et al, 2011

Resources



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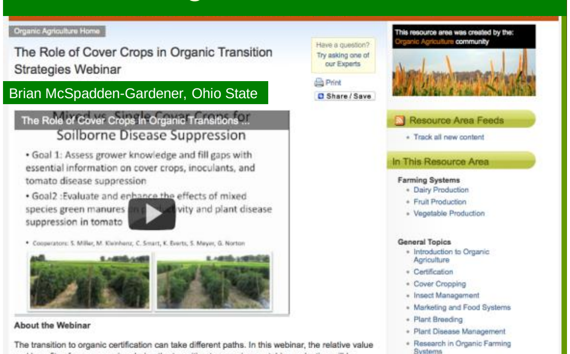

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