Suppression of Fusarium Wilt in Spinach Seed Production Using Compost

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Lindsey du Toit, Mike Derie, Barbara Holmes, & Caitlin Price Youngquist, WSU Mount Vernon NWREC
Spinach Seed Production in USA

- 'Coastal' PNW
- Cool/dry summer
- 800-1,000 mm rain annually
- Winter rainfall
- Acid soils
Spinach Fusarium Wilt

*Fusarium oxysporum f. sp. spinaciae*

8-15 year rotations between spinach seed crops in USA
Fusarium wilt of spinach

*Fusarium oxysporum f. sp. spinaciae*
Management of spinach Fusarium wilt

1. Long crop rotation: 8-15+ years
2. Partial resistance: Choice for contracted seed crops? Knowledge of susceptibility of parent lines?
3. Soil amendments:
   a. Biofumigant cover crops
   b. Agricultural limestone: increase pH, rates, # of applications
4. N-fertilizer: ammonium (11-52-0 = acidic) vs. nitrate vs. urea
5. Soil bioassay: Fusarium wilt risk assessment for field selection
6. Fungicides: Seed (thiophanate-methyl), foliar (prothioconazole)
7. Mechanisms of Fusarium wilt suppression by limestone
Spinach Fusarium Wilt
2006 Spinach seed crop limestone field trial

![Graph showing seed yield (lb/acre) vs. rate of limestone amendment (tons/acre). The graph compares seed yield for susceptible and moderate female spinach varieties. The graph shows that at 2.1 tons/acre, there is an increase in seed yield for both varieties, with the susceptible variety showing an even greater increase at 3.5 and 4.2 tons/acre.]

- Susceptible female
- Moderate female

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**Legend**
- Blue line: Susceptible female
- Black triangle: Moderate female
Spinach Fusarium wilt: 2009-2012 trial (PhD student, Emily Gatch)

Seed yield (lb/A)

Limestone rate (t/A)

- Susceptible
- Moderate
- Resistant

2009

2012

Lime rate (t/A)

0-0-0-2
Soil bioassay for Fusarium wilt risk prediction
Soil bioassay for spinach Fusarium wilt
(vs. real-time PCR soil assay: Okubara et al. 2013. Plant Dis. 97:927-937)
Risk assessment: Spinach Fusarium wilt soil bioassay

A. 2009–10 bioassay

B. 2010–11 bioassay

Field (soil) sample

- Partially resistant line
- Moderately-susceptible line
- Susceptible line
Risk prediction: Multiple regression analyses

**Susceptible inbred:**
\[
Y = -0.4556 - 0.0172(\text{rotation}) + 0.0854(\text{NH}_4^+ - \text{N}) - 0.3875(\text{soil pH}) + 0.4037(\text{buffer pH}) + 0.0056(\text{sand}) + 0.0245(\text{clay})
\]
\(R^2 = 0.3396 \text{ at } P<0.0001\)

**Moderate inbred:**
\[
Y = 1.0777 - 0.0136(\text{rotation}) + 0.0005(\text{V. dahliae}) + 0.0563(\text{NH}_4^+ - \text{N}) - 0.1528(\text{soil pH}) + 0.0045(\text{clay})
\]
\(R^2 = 0.3213 \text{ at } P<0.0001\)

**Resistant inbred:**
\[
Y = 0.6161 - 0.0094(\text{rotation}) + 0.0498(\text{NH}_4^+ - \text{N}) + 0.0003(\text{K}) - 0.0947(\text{soil pH})
\]
\(R^2 = 0.2415 \text{ at } P<0.0001\)

- pH, buffer pH
- N - NO\textsubscript{3} & NH\textsubscript{4}
- P
- K
- Ca
- Mg
- S
- B
- Fe
- Mn
- Zn
- Cu
- CEC
- OM
- EC
- Rotation
- % sand, silt, clay
- *F. oxysporum*
- *V. dahliae*
Effect of Proline on spinach wilt: 2012 field trial
du Toit et al. 2014. Plant Disease Management Reports 8:V280

**Severity of wilt (0 - 5 scale)**

- **Susceptible**
  - Proline: *5.1%
  - No Proline: *8.2%

- **Moderate**
  - Proline: 3.0%
  - No Proline: 2.8%

- **Resistant**
  - Proline: 2.5%
  - No Proline: 1.9%

**Seed yield (lb/acre)**

- **Susceptible**
  - Proline: *18.4%
  - No Proline: 11.4%

- **Moderate**
  - Proline: 10.0%
  - No Proline: 9.8%

- **Resistant**
  - Proline: 6.9%

* = significant difference between Proline vs. control plots (P < 0.05)
Compost suppression of Fusarium wilt
2013 Proline & compost spinach trial
Wilt incidence (7/02) & severity (7/24)

Significantly fewer wilted plants & less severe wilt in compost plots vs. control plots or Proline plots ($P<0.05$)
2013 Proline & compost spinach trial
Spinach biomass (7/09) & marketable seed yield

Significantly larger plants & greater marketable seed yield in compost plots vs. control plots and Proline plots.
Plant nutrient analyses (7/09/13)

Compost significantly increased:
K (by 15%)
Mg (6%)
S (8%)
Zn (13%)
Cu (15%)

Secondary root formation

Soil analyses

Compost significantly increased:
5/20 (3 weeks after planting)
NO$_3$ (231%), Na (33%), S (56%), Zn (48%),
EC (192%), salts (192%)
8/15 (~seed harvest)
NO$_3$ (25%), K (23%), Na (5%), CEC (30%)
2014 Compost spinach trial
Wilt severity (7/18) & marketable seed yield

**Severity of wilt (0 – 5) on 7/18**

- Susceptible: Control - 2%, Topsin - 5%, T+Proline - 10%, T+P+Compost - 10%
- Moderate: Control - 4%, Topsin - 14%, T+Proline - 15%, T+P+Compost - 2%
- Resistant: Control - 3%, Topsin - 2%, T+Proline - 2%, T+P+Compost - 2%

**Marketable seed yield (g/140 plants)**

- Susceptible: Control - 8%, Topsin - 22%, T+Proline - 126%, T+P+Compost - 11%
- Moderate: Control - 13%, Topsin - 8%, T+Proline - 13%, T+P+Compost - 5%
- Resistant: Control - 2%, Topsin - 5%, T+Proline - 10%, T+P+Compost - 3%
Summary of 2013 & 2014 Spinach Trials

- Compost can enhance spinach seed production
  - Improved spinach stand by 11-15% in 2013 (not in 2014)
  - Reduced wilt incidence/severity in both years
  - Increased spinach biomass & marketable seed yield
  - Economic viability? Supply? Other composts?
- Proline also suppressed Fusarium wilt & increased seed yield
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