# Impact of Cover Crops on Processing Tomato:
# Yield, Quality, Pest Pressure, Soil Health, and Economics.

2011 Final Research Report

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The small plot yields presented in this report are for comparative purposes only and may not accurately reflect commercial yields. We welcome any questions, comments, concerns on this report, particularly suggestions on how to improve or make the trials more meaningful.

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## Executive Summary:

Cover crops over the long-term may increase soil organic matter, soil and plant health and crop productivity. However the short-term impact of cover crops on processing tomato production is unknown. The objective of this project was to compare the impact of cover crops planted before processing tomato. The cover crops planted after spring wheat were 1) oat, 2) fall rye, 3) oilseed radish, 4) mix of oilseed radish and rye, and 5) no cover crop control. Results from two years indicate that the cover crops did not influence processing tomato quality (Agtron colour, pH or soluble solids – S.A. Loewen). None of the cover crops tested had any negative effects on soil pests (nematodes, wireworm, millipedes, cutworm, maggots) or the incidence or severity of common pests (bacterial spot, bacterial speck, bacterial canker, Colorado potato beetle, tomato hornworm, and stink bug – C. Trueman) when tested under a typical commercial spray program. Soil and plant nitrogen analysis suggests that growers do not need to modify N fertilizer rates when using cover crops before processing tomatoes. In both years, oilseed radish was the highest yielding and profitable cover crop (R.J. Vyn). In both years, all cover crops had as good as or better yields and profit margins compared to the no cover crop control. Considering that economic analysis included the cost to hire a custom applicator to plant and to control fall rye in the spring, economics should not be a limiting factor to planting a cover crop. These results were observed on a site with healthy, good tilth soil (sandy loam, OM 3.5%), perhaps greater differences would be observed on degraded soils.


## Introduction:

Soil and tomato plant health is one of the keys to viable crop yields. Cover crops have the potential to influence soil health as well as influence overall crop production in the following year. This project stems from processing tomato growers asking “what is the best cover crop for tomatoes?”.

## Objectives:

- To evaluate the impact of cover crops on processing tomato yield and quality
- To determine if there is a difference between early or late varieties
- To monitor insect and disease pressure on processing tomato among cover crop treatments
- To compare the effect of cover crops on soil health
- To assess the economics of cover crops in processing tomato production

**Methods:**

LOCATIONS: Ridgetown Campus research plots

DESIGN: Randomized complete block design    Replications: 4

Plot width: 20 ft    Plot length: 26 ft

PEST CONTROL: According to typical Ontario production practices.

ROTATION:

| | | | | |
|---|---|---|---|---|
| 2007 + 2008 | Processing peas followed by cover crops (see list below) | | | |
| 2008 + 2009 | Sweet corn followed by cover crops (see list below) | | | |
| Spring 2009 + 2010 | Spring wheat | | | |
| Fall 2009 + 2010 | Cover crops | 1) no cover crop | | |
| | | 2) oats | | |
| | | 3) fall rye | | |
| | | 4) oilseed radish | | |
| | | 5) fall rye and oilseed radish | | |
| Spring 2010 + 2011 | Plant processing tomatoes: | | 1) Early variety TSH 18 | |
| | | | 2) Late variety CC 337 | |
| | Tomato N fertilizer | | | Transplant starter to all treatments |
| | | | | 1) no nitrogen fertilizer applied |
| | | | | 2) 125 lb N/ac |

The zero N plots were included to exaggerate the potential impact of N tied-up or released by the cover crop.

Table 1. Site characteristics.

| Characteristic | | Ridgetown 2010 | Ridgetown 2011 |
|---|---|---|---|
| Variety | | CC337<br>TSH 18 | CC337<br>TSH 18 |
| Plant population (plants/ac) | | 12000 | 12000 |
| Plant spacing | | 18" on twin rows on 5' beds | 18" on twin rows on 5' beds |
| Cover crop planting date | | Aug. 24, 2009 | September 8, 2010 |
| Planting date | | May 26, 2010 | May 31, 2011 |
| Harvest date | | Aug 25<br>Sept 13-15 | Aug. 29-30<br>Sept. 13-14 |
| *Monthly rainfall:* | May | 122.2 mm | 154.6 mm |
| | June | 84.5 mm | 75.1 mm |
| | July | 136.0 mm | 70.0 mm |
| | August | 26.0 mm | 71.4 mm |
| | Sept 1-15th | 21.2 mm | 53.2 mm |
| *Soil characteristics:* | pH | 6.6 | 6.6 |
| | Soil texture | Sandy loam 62:22:16 | Sandy loam 62:22:16 |
| | % OM | 3.8 | 3.8 |
| | CEC (MEQ/1 00g) | 11.5 | 11.5 |
| | P (ppm) | 34 | 34 |
| | K (ppm) | 188 | 188 |
| | Ca (ppm) | 1719 | 1719 |
| | Mg (ppm) | 150 | 150 |

**Results:**

YIELDS (Table 2):

- In 2011, marketable processing yield was on average 36 ton/ac for the early variety and 51 ton/ac for the late variety.
- There was no difference between the two varieties in how they responded to the cover crops tested.
- The no cover crop control treatment had lower yield than oilseed radish for processing tomato red, marketable, and total yields. In both years, tomatoes yielded well after oilseed radish.
- In all cases yields with a cover crop were as good as or better than having no cover crop.
- Yields were higher with N fertilizer than with starter only.
- Ethrel® was not used.

Table 2. Impact of cover crop, N fertilizer and variety on processing tomato yields in 2010 & 2011.

| | ----------- 2011 ----------- | | | ----------- 2010 ----------- | | |
|---|---|---|---|---|---|---|
| | Reds only | Marketable | Total | Reds only | Marketable | Total |
| **Cover crop** | ----------- ton/ac -------- | | | | | |
| Oilseed radish | 45.7 a[a] | 52.7 a | 55.6 a | 43.9 | 46.4 ab | 51.4 a |
| Oat | 44.5ab | 51.0 ab | 53.1 ab | 43.1 | 43.1 ab | 45.7 ab |
| Fall rye | 46.0 a | 50.3 ab | 51.1 ab | 41.0 | 41.0 b | 43.2 b |
| Oilseed radish + fall rye | 41.7 ab | 47.5 ab | 49.5 ab | 46.9 | 46.9 a | 50.1 a |
| No cover crop | 39.8 b | 46.4 b | 48.1 b | 45.0 | 45.0 ab | 47.9 ab |
| **N fertilizer to tomatoes** | | | | | | |
| Starter N only | 39.7 k | 45.6 k | 46.9 k | 43.0 | 43.6 | 46.4 |
| Full N | 47.4 j | 53.6 j | 56.1 j | 45.0 | 45.4 | 49 |
| **Variety** | | | | | | |
| Early TSH 18 | 36.0 z | 45.8 z | 48.1 z | 35.6 | 36.2 z | 39.0 z |
| Late CC337 | 51.0 y | 53.4 y | 54.9 y | 52.4 | 53.0 y | 55.7 y |

[a] Different letters in each column indicates a statistical difference.

QUALITY:

- The cover crop combinations used in this trial had no negative effects on colour, soluble solids, or pH. In spite of the different cultivars used with their differences in harvest dates, these cultivars are remarkably similar in their performance from a practical quality standards standpoint.
- The statistical analyses showed a difference for Agtron colour between the two cultivars TSH18 (18) and CC337 (20). It is normal for different cultivars to have different Agtron colour values. The cover crop treatments did not have any negative effect on colour. In both cases the Agtron colour measurements indicated a very deep red colour and were well within industry accepted grading standards.
- The data analyses showed a difference for soluble solids between the two cultivars as well (TSH18 -NTSS=4.3 and CC337-4.1). This is also normal for different cultivars to vary for this trait.
- The pH was found to be consistently different between TSH18 (pH=4.2) and CC337 (pH=4.3). In both cases the pH was within normal limits to ensure food safety of processed products manufactured with these tomatoes.

ECONOMICS (Table 3):

- Across all plots, the oilseed radish and oats treatments had significantly greater profit margins than that of the no cover crop control
- Among the cover crop treatments, the rye/ oilseed radish treatment had the lowest profit margin, which was significantly lower than the oilseed radish treatment
- Profit margins were greater for the late variety than for the early variety and greater for plots with nitrogen applied than for plots without – in all cases profit margins were highest for either the oilseed radish treatment or the oats treatment
- Overall, the results indicated that economic benefits may exist with the use of cover crops before tomatoes, particularly with oilseed radish and oats.

Table 3. Profit margins over fertilizer and cover crop costs, broken down by treatment ($/ha).

| Cover Crop | All | Early | Late | With N | Without N |
|---|---|---|---|---|---|
| None | 10,453 c | 9,713 b | 11,194 b | 11,855 a | 9,051 b |
| Oats | 11,413 ab | 10,633 ab | 12,194 ab | 12,322 a | 10,505 a |
| OSR | 11,774 a | 10,979 a | 12,570 a | 12,194 a | 11,354 a |
| Rye | 11,208 abc | 10,337 ab | 12,078 ab | 12,277 a | 10,138 ab |
| Rye/OSR | 10,550 bc | 9,378 b | 11,722 ab | 10,604 b | 10,496 a |

## INSECTS AND DISEASE:

*Foliar Disease Severity 2010 & 2011 (Table 4 & Table 5)*

- Bacterial spot, bacterial speck and bacterial canker were all very low in both years of the trial and no differences were observed among treatments (Table 4). There were no differences among cover crops, nitrogen rate, or tomato variety for any of these factors, except for bacterial disease in 2011, which was higher in the early TSH18 variety than the late CC337 on July 4. Bacterial canker was not observed in 2011.
- The incidence of early blight was also very low in both years, and no differences were observed among treatments for the number if leaves with early blight lesions (Table 5).
- Septoria leaf spot was observed in 2011 but not in 2010, and there were no differences in the incidence of this disease among cover crop treatments or nitrogen rates in 2011 (Table 4).
- The levels of defoliation caused by early blight, septoria leaf spot, and bacterial disease in both years, and the incidence of blossom end rot in 2010 were not different among treatment factors (*data not shown*).
- Fungicides and copper were applied to the trial in both years, and probably account for the relatively low foliar disease levels.

**Table 4.** Bacterial disease incidence on foliage in tomatoes grown after five different cover crops and two different nitrogen rates in 2010 & 2011.

| | # Infected leaves on 5 plants [a] | | | | | |
|---|---|---|---|---|---|---|
| | Bacterial Spot / Speck | | | | Bacterial Canker | |
| | 2010 | | 2011 | | 2010 | |
| **Cover crop** | June 21 | Aug 8 [b] | July 4 [b] | July 20 [b] | July 22[b] | Aug 8[b] |
| Oilseed radish | 0.0 ns [c] | 0.6 ns | 0.1 ns | 0.0 ns | 0.2 ns | 1.8 ns |
| Oilseed radish + fall rye | 0.0 | 2.6 | 0.4 | 0.1 | 0.2 | 1.0 |
| No cover crop | 0.0 | 0.4 | 0.2 | 0.0 | 0.0 | 0.6 |
| Oats | 0.0 | 2.8 | 0.1 | 0.1 | 0.0 | 0.9 |
| Fall rye | 0.0 | 1.4 | 0.3 | 0.0 | 0.0 | 0.6 |
| **N fertilizer to tomatoes** | | | | | | |
| Starter N only | 0.0 ns | 1.8 ns | 0.2 ns | 0.0 ns | 0.1 ns | 1.4 ns |
| Full N | 0.0 | 1.3 | 0.3 | 0.1 | 0.1 | 0.8 |
| **Variety** | | | | | | |
| Early TSH 18 | 0.0 ns | 2.0 ns | 0.4 b | 0.1 ns | 0.0 ns | 1.2 ns |
| Late CC337 | 0.0 | 1.1 | 0.1 a | 0.0 | 0.2 | 0.9 |

[a] The number of infected leaves or fruit on five plants was recorded.
[b] Data is not normal and could not be normalized using square root or log transformation.
[c] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

**Table 5.** Incidence of early blight and septoria leaf spot on foliage in tomatoes grown after five different cover crops and two different nitrogen rates in 2010 & 2011.

| | # Infected leaves on 5 plants [a] | | | | |
|---|---|---|---|---|---|
| | Early Blight | | | Septoria Leaf Spot | |
| | 2010 | 2011 | | 2011 | |
| **Cover crop** | Aug 8 [b] | July 4 [b] | July 20 [b] | July 4 [b] | July 20 [c] |
| Oilseed radish | 0.3 ns | 0.5 ns | 0.7 ns | 0.1 ns | 5.0 ns |
| Oilseed radish + fall rye | 0.0 | 0.2 | 1.2 | 0.0 | 3.6 |
| No cover crop | 0.1 | 0.2 | 0.6 | 0.0 | 3.6 |
| Oats | 0.3 | 0.6 | 1.8 | 0.0 | 3.4 |
| Fall rye | 0.0 | 0.2 | 1.6 | 0.0 | 3.7 |
| **N fertilizer to tomatoes** | | | | | |
| Starter N only | 0.2 ns | 0.3 ns | 1.1 ns | 0.0 ns | 4.2 ns |
| Full N | 0.1 | 0.4 | 1.3 | 0.0 | 3.5 |
| **Variety** | | | | | |
| Early TSH 18 | 0.2 ns | 0.4 ns | 1.0 ns | 0.0 ns | 5.2 b |
| Late CC337 | 0.1 | 0.3 | 1.4 | 0.0 | 2.7 a |

[a] The number of infected leaves or fruit on five plants was recorded.
[b] Data is not normal and could not be normalized using square root or log transformation.
[c] Data in these columns was normalized using a square root transformation; back transformed means are shown here.
[c] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

*Foliar Insect Damage (Table 6)*

- There were no differences among treatments for the level of feeding damage caused by tomato hornworm in 2010 and 2011, or Colorado potato beetle in 2010 (Table 6).

**Table 6.** Foliar insect damage from Colorado potato beetle (CPB) and tomato hornworm (THW) in tomatoes grown after five different cover crops and two different nitrogen rates in 2010 & 2011.

| | CPB (2010 only) [a] | | | | THW[a] | |
|---|---|---|---|---|---|---|
| | Incidence | | Defoliation | | # Defoliated Branches | |
| **Cover crop** | June 21[b] | July 7[b] | June 21[b] | July 7[b] | July 26 (2010)[b] | Aug 11 (2011)[c] |
| Oilseed radish | 0.1 ns[d] | 0.1 ns | 0.1 ns | 0.3 ns | 1.3 ns | 3.7 ns |
| Oilseed radish + fall rye | 0.3 | 0.2 | 3.4 | 0.8 | 2.6 | 3.5 |
| No cover crop | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 | 3.2 |
| Oats | 0.1 | 0.1 | 0.4 | 0.4 | 3.4 | 4.6 |
| Fall rye | 0.1 | 0.1 | 0.1 | 0.1 | 2.8 | 3.7 |
| **N fertilizer to tomatoes** | | | | | | |
| Starter N only | 0.2 ns | 0.1 ns | 1.6 ns | 0.2 ns | 2.2 ns | 3.7 ns |
| Full N | 0.1 | 0.2 | 0.1 | 0.5 | 2.0 | 3.8 |
| **Variety** | | | | | | |
| Early TSH 18 | 0.2 ns | 0.1 ns | 1.5 ns | 0.1 ns | 1.8 ns | 3.5 ns |
| Late CC337 | 0.1 | 0.2 | 0.2 | 0.6 | 2.5 | 4.1 |

[a] For CPB, incidence is the number of leaves with feeding damage on five plants, and defoliation is the estimated amount of defoliation on the same five plants. For tomato hornworm (THW), the number of defoliated branches in the whole plot was recorded.
[b] Data is not normal and could not be normalized using square root or log transformation.
[c] Data in these columns was normalized using a square root transformation; back transformed means are shown here.
[d] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

*Disease and Insect Damage on Fruit (Table 7 & Table 8)*

- The incidence of bacterial spot and speck was higher in the late harvested CC337 than the earlier harvested TSH18 in 2010, but not in 2011 (Table 7). This could be an indication of more favourable conditions for infection later in the season in 2010, as well as different levels of disease tolerance in the two varieties.
- There were no differences among treatments for the incidence of stink bug damage in either year.
- There were no differences in the incidence and severity of anthracnose in 2010 (Table 8). The incidence and severity of anthracnose on fruit in 2011 was higher in the late CC337 than the early TSH18.
- The statistical analysis indicated that cover crop response under the two nitrogen rates was different for anthracnose severity in 2011, and different among variety for the full nitrogen treatments. However, further analysis indicated that within these factors the differences observed among the cover crop treatments were not statistically significant (Table 7).

**Table 7.** Incidence of bacterial disease and stink bug damage in tomatoes grown after five different cover crops and two different nitrogen rates in 2010 & 2011.

| | % bacterial spot or speck[a] | | | % stink bug damage[b] | |
|---|---|---|---|---|---|
| | 2010 | 2011 | | | |
| **Cover crop** | Greens | Greens [c] | Reds [c] | 2010 [c] | 2011 [d] |
| Oilseed radish | 22.7 ns [e] | 6.6 ns | 6.7 ns | 4.9 ns | 2.2 ns |
| Oilseed radish + fall rye | 19.8 | 4.7 | 5.6 | 7.0 | 2.8 |
| No cover crop | 22.5 | 6.3 | 6.1 | 5.2 | 5.0 |
| Oats | 28.3 | 5.3 | 7.6 | 5.5 | 3.3 |
| Fall rye | 29.8 | 5.0 | 6.4 | 6.4 | 2.2 |
| **N fertilizer to tomatoes** | | | | | |
| Starter N only | 25.5 ns | 4.5 ns | 5.3 ns | 6.5 ns | 3.4 ns |
| Full N | 23.8 | 6.7 | 7.7 | 5.1 | 2.8 |
| **Variety** | | | | | |
| Early TSH 18 | 5.7 a | 4.1 ns | 5.8 ns | 6.3 ns | - |
| Late CC337 | 43.5 b | 7.2 | 7.1 | 5.3 | - |

[a] The percentage of tomatoes with spot or speck symptoms in a random sample of 50 fruit.
[b] The percentage of tomatoes with stink bug damage in a random sample of 50 red fruit.
[c] Data in these columns was normalized using a square root transformation; back transformed means are shown here.
[d] Only early tomatoes were evaluated for stink bug damage in 2011.
[e] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

**Table 8.** Anthracnose incidence and severity in tomatoes grown after five different cover crops and two different nitrogen rates in 2010 & 2011.

| | 2010 | | 2011 [c] | | | |
|---|---|---|---|---|---|---|
| | | | | Severity | | |
| | | | | | ------------- Full N ------------- | |
| **Cover crop** | Incidence (%)[a,c] | Severity [b] | Incidence (%) | No N [c] | TSH18 [c] | CC337 |
| Oilseed radish | 6.6 ns [d] | 4.7 ns | 17.0 ns | 9.2 ns | 2.5 ns | 24.7 ns |
| Oilseed radish + fall rye | 8.3 | 5.3 | 17.4 | 6.9 | 3.6 | 23.5 |
| No cover crop | 9.7 | 7.4 | 19.8 | 16.4 | 2.5 | 12.7 |
| Oats | 7.1 | 4.6 | 17.0 | 12.2 | 2.1 | 14.0 |
| Fall rye | 7.3 | 5.0 | 14.0 | 7.2 | 4.4 | 10.3 |
| **N fertilizer to tomatoes** | | | | | | |
| Starter N only | 7.5 ns | 5.3 ns | 18.7 ns | - | - | - |
| Full N | 8.0 | 5.5 | 16.4 | - | - | - |
| **Variety** | | | | | | |
| Early TSH 18 | 6.2 ns | 4.2 ns | 7.9 a | 5.3 a | - | - |
| Late CC337 | 9.5 | 6.6 | 27.2 b | 16.5 b | - | - |

[a] The percentage of tomatoes with anthracnose symptoms in sample of 50 red fruit are reported for incidence.
[b] Tomatoes were sorted into classes 0 to 3, where 0 = no symptoms, 1 = one lesion, 2 = two lesions, and 3 = three or more lesions. A disease severity index (DSI) was calculated using the following equation: DSI = ∑[(# class 0 samples*)+(# class 1 samples*1)+(# class 2 samples*2)+(# class 3 samples*3)]/[(# classes – 1)*number samples]*100.
[c] Data in these columns was normalized using a square root transformation; back transformed means are shown here.
[d] Different letters in each column indicates a statistical difference, P ≤ 0.05, Tukey's adjustment. NS = not significant.

## SOIL HEALTH

- No vine decline symptoms were observed.
- No corky root symptoms were observed on plants dug on Aug 16th.

### *Soil insects/worms:*

- In each plot, 3 carrot bait stations (each with three 2" carrot pieces) were buried 6" deep on 17 May 2011. The soil surface was covered with black plastic to retain water and warm soil. Baits were removed on 24 May and inspected for presence of wireworms, millipedes, cutworm and maggots.
- There were no statistical differences between cover crops in the number of wireworms, millipedes, cutworm and maggots. Overall, numbers were quite low.

### *Nematodes (Table 10):*

- Nematode samples were taken on May 18th, before tillage and Roundup® spray to kill rye.
- There were no differences between cover crops in pin, stunt and soybean cyst nematodes.
- There were less root lesion nematodes in rye compared to oilseed radish, but no differences with the other cover crops. Lower root lesion nematodes in rye may be because nematodes were in rye roots and not in the soil sample. Therefore, one should not conclude that fall rye lowered root lesion nematodes per say.

Table 10. Spring nematode counts taken on May 18th 2011 prior to tillage.

| | Root lesion | Pin | Stunt | Soybean cyst | Eggs |
|---|---|---|---|---|---|
| **Cover crop** | -------------- | count/kg soil | | --------------- | /100g soil |
| No cover crop | 2380 ab[a] | 0 ns | 300 ns | 0 | 0 |
| Oats | 2190 ab | 30 | 460 | 0 | 0 |
| Oilseed radish | 3680 b | 10 | 450 | 0 | 0 |
| Oilseed radish + fall rye | 3320 ab | 10 | 310 | 0 | 0 |
| Fall rye | 1515 a | 10 | 460 | 0 | 0 |

[a] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

## NITROGEN DYNAMICS:

### *Tissue N (Table 11 and 12)*

- Cover crop was only significant for the amount of N in tomato shoots in 2011, where the only difference was that oilseed radish had higher N content in shoots than the no cover crop
- Full N was consistently higher than the starter N only treatment for %N and amount N in both fruit and plant tissue
- Variety was occasionally significant but neither the early nor the late variety had consistently higher tissue N values

Table 11. Nitrogen concentration (%) and content in tomato fruit (marketable yield) in 2010 and 2011 [a].

| **Cover crop** | 2010 | 2011 | 2010 | 2011 |
|---|---|---|---|---|
| | % | | lb/ac | |
| Oilseed radish | 2.85 ns | 2.78 ns | 85.3 ns | 122 ns |
| Oat | 2.62 | 2.61 | 102 | 119 |
| Fall rye | 2.74 | 2.44 | 93.3 | 115 |
| Oilseed radish + fall rye | 2.57 | 2.58 | 86.2 | 104 |
| No cover crop | 2.74 | 2.5 | 94.3 | 104 |
| **N fertilizer** | | | | |
| Starter N only | 2.58 j | 2.46 j | 84.2 j | 96.9 j |
| Full N | 2.81 k | 2.7 k | 99.2 k | 129 k |
| **Variety** | | | | |
| Early TSH 18 | 3.36 y | 2.56 ns | 89.1 ns | 104 z |
| Late CC337 | 2.03 z | 2.6 | 94.3 | 122 y |

[a] Different letters in each column indicates a statistical difference, P ≤ 0.05, Tukey's adjustment. NS = not significant.

Table 12. Nitrogen concentration (%) and content in tomato shoots in 2010 and 2011 [a].

| | 2010 | 2011 | 2010 | 2011 |
|---|---|---|---|---|
| **Cover crop** | % | | lb/ac | |
| Oilseed radish | 1.67 ns | 1.45 ns | 29.2 ns | 26.7 b |
| Oat | 1.46 | 1.33 | 21.1 | 24.1 ab |
| Fall rye | 1.48 | 1.23 | 21.1 | 19.6 ab |
| Oilseed radish + fall rye | 1.60 | 1.37 | 23.3 | 25.4 ab |
| No cover crop | 1.63 | 1.26 | 26.0 | 17.5 a |
| **N fertilizer** | | | | |
| Starter N only | 1.47 j | 1.24 j | 21.2 j | 18.3 j |
| Full N | 1.64 k | 1.42 k | 26.1 k | 27.0 k |
| **Variety** | | | | |
| Early TSH 18 | 1.82 y | 1.36 ns | 22.6 z | 22.0 ns |
| Late CC337 | 1.29 z | 1.31 | 24.8 y | 23.3 |

[a] Different letters in each column indicates a statistical difference, P ≤ 0.05, Tukey's adjustment. NS = not significant.

*Soil N (Table 13 and 14)*

- The 2011 preplant soil N levels were high at all three depths
- Preplant soil N was almost always significant with oilseed radish most frequently having the highest soil N
- No cover crop did not always have the lowest preplant soil N levels but was often not different from that of the other cover crops
- At harvest, there were no differences between soil mineral N for the cover crop treatments in 2010 while in 2011 differences were seen at the 1-2' and 2-3' depths, however no consistent trend was observed
- At harvest, soil mineral N levels did not differ between the starter N only and the full N treatments in all depths for both 2010 and 2011
- In 2010, early harvest variety consistently had higher soil N levels at each of the depths however this trend was not observed in 2011
- Soil and plant N analysis indicates that growers do not have to modify N fertilizer rates when using these cover crops before tomatoes

Table 13. Soil mineral N (nitrate-N and ammonium-N) at preplant and harvest from three sampling depths in 2010.

| Cover crop | ----------- Preplant ----------- | | | ----------- Harvest ----------- | | |
|---|---|---|---|---|---|---|
| | 0-1' | 1-2' | 2-3' | 0-1' | 1-2' | 2-3' |
| | ----------- lb/ac -------- | | | | | |
| Oilseed radish | 16.9 b [a] | 17 c | 9.92 d | 4.86 ns | 3.59 ns | 2.16 ns |
| Oat | 13.5 a | 9.06 b | 3.80 bc | 5.49 | 3.84 | 2.42 |
| Fall rye | 12.7 a | 3.23 a | 0.93 a | 5.93 | 3.66 | 2.59 |
| Oilseed radish + fall rye | 15.2 ab | 5.32 a | 2.14 ab | 6.23 | 3.80 | 2.49 |
| No cover crop | 12.9 a | 8.42 b | 5.87 c | 5.12 | 3.23 | 2.52 |
| **N fertilizer** | | n/a | | | | |
| Starter N only | | | | 5.53 ns | 3.33 ns | 2.61 ns |
| Full N | | | | 5.52 | 3.91 | 2.26 |
| **Variety** | | n/a | | | | |
| Early TSH 18 | | | | 9.55 z | 6.19 z | 4.3 z |
| Late CC337 | | | | 1.50 y | 1.06 y | 0.58 y |

[a] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

Table 12. Soil mineral N from preplant and harvest sampling in 2011.

| Cover crop | Preplant 0-1' | Preplant 1-2' | Preplant 2-3' | Harvest 0-1' | Harvest 1-2' | Harvest 2-3' |
|---|---|---|---|---|---|---|
| | lb/ac | | | | | |
| Oilseed radish | 67.3 ns | 129 c[a] | 77.7 c | 25.2 ns | 15.4 c | 10.7 b |
| Oat | 55.2 | 106 bc | 61.6 bc | 26.2 | 12.2 bc | 5.96 a |
| Fall rye | 55.0 | 38.2 a | 32.4 ab | 21.6 | 10.2 ab | 5.52 a |
| Oilseed radish + fall rye | 53.4 | 66.3 ab | 25.6 a | 26.1 | 10.5 abc | 8.27 ab |
| No cover crop | 47.1 | 54.1 a | 34.3 ab | 18.7 | 6.4 a | 6.21 ab |
| **N fertilizer** | | n/a | | | | |
| Starter N only | | | | 22.7 ns | 10.6 ns | 7.70 ns |
| Full N | | | | 24.4 | 11.3 | 6.98 |
| **Variety** | | n/a | | | | |
| Early TSH 18 | | | | 21.0 a | 11.3 ns | 8.70 ns |
| Late CC337 | | | | 26.1 b | 10.6 | 5.99 |

[a] Different letters in each column indicates a statistical difference, $P \leq 0.05$, Tukey's adjustment. NS = not significant.

**Conclusions 2010 and 2011:**

As a general principle of soil management, leaving plant residues in the soil has a positive influence on overall crop production. The results of this study indicate that cover crops with oilseed radish may be advantageous for processing tomato production. Economic analysis, which included the cost to hire a custom applicator to plant and to control fall rye in the spring, showed favourable profits for oilseed radish. None of the cover crops tested (oat, rye, oilseed radish or mix of rye&oil seed radish) lower yields or profits compared to the no-cover control. None of the cover crops tested had a negative influence on fruit quality or presence of /damage from common pests. Cover crops had no impact on tomato fruit and shoot plant tissue N, nor soil mineral N at harvest, which suggest that growers should not modify N fertilizer rates based on cover crop type. These results were observed on a field with healthy, good tilth soil (sandy loam, OM 3.5%), perhaps greater differences would be observed on degraded soils.