Evaluation of the value of cover crops on nitrogen cycling and pest management in vegetable production.

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Agricultural Adaptation Council
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**Executive Summary:**
A field experiment was established in 2006 in a co-operator’s field in a pea - cover crop - sweet corn rotation near the University of Guelph Ridgetown Campus. The four cover crop treatments were 1) oats, 2) rye, and 3) oilseed radish+rye (OSR+rye) along with a 4) no cover control. Nitrogen treatments in the sweet corn were 0 and 140 kg N/ha. The objectives were to study effect of various cover crops on: N cycling, weed dynamics, and insect and disease pressure.

Cover crops had no influence on either marketable or total sweet corn yield. Therefore covers do not adversely affect nor boost sweet corn yields. As expected, marketable and total sweet corn yields were higher with 140 kg N/ha compared to no fertilizer. By October, 2.5 months after cover crop planting, compared to the no cover control, all cover crops lowered soil mineral N in the fall by N uptake into shoots. However, compared to oats or rye, OSR+rye is considered ‘leaky’ because soil nitrate levels increased by mid December due the frost kill of oilseed radish. Based on yields in the zero N control and soil mineral N over the sweet corn season, the three cover crops tested do not appear to release or trap more N. Thus, growers do not need to modify N fertilizer rates in sweet corn with cover crops. Based results from 1 rotation, from a N perspective, oats is recommended because the plants absorb a lot of N in fall, but do not breakdown quickly and therefore oat residue is on the surface in the spring to protect against soil and wind erosion.

With a typical post application of herbicide, all three cover crops reduced broadleaf weeds in the sweet corn crop compared to the no cover control. Cover crops do not increase or decrease grass weed species compared to the no cover control. Therefore from a weed management point of view, any of the three cover crops are recommended. Cover crops had a significant impact on pest populations in the sweet corn crop. But it was not possible to recommend on cover crop to suppress insect and disease pressure because some covers had higher pressure with one pest but lower with another pest. Similarly, in the no cover control some pests were higher and some were lower. Therefore, cover crop selection will depend on grower specific pest problems.
Research Results and Conclusions:
Project Objectives
- To quantify N uptake and release by the cover crop and amount of N remaining in the soil the following spring
- To estimate N release from different cover crops to the next season’s sweet corn crop
- To determine if cover crops actually contribute a substantial N credit to the following crop, which is currently part of nutrient management plans
- To assess, through collaboration, the effect of various cover crops on weed dynamics, insect and disease pressure, soil quality, and cost-benefit analysis

Table 1. Activities undertaken to achieve project objectives

<table>
<thead>
<tr>
<th>Date</th>
<th>Crop</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2006</td>
<td>Peas</td>
<td>Planting</td>
</tr>
<tr>
<td>July 2006</td>
<td>Peas</td>
<td>Harvest</td>
</tr>
<tr>
<td>August 2006</td>
<td>Cover Crop</td>
<td>Planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil and Plant N Sampling</td>
</tr>
<tr>
<td>September 2006</td>
<td>Cover Crop</td>
<td>Weed Dynamics</td>
</tr>
<tr>
<td>October 2006</td>
<td>Cover Crop</td>
<td>Soil and Plant N Sampling</td>
</tr>
<tr>
<td>December 2006</td>
<td>Cover Crop</td>
<td>Plant Sampling</td>
</tr>
<tr>
<td>May 2007</td>
<td>Cover Crop</td>
<td>Soil and Plant N Sampling Weed Dynamics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planting</td>
</tr>
<tr>
<td></td>
<td>Sweet Corn</td>
<td>Soil and Plant N Sampling</td>
</tr>
<tr>
<td>June 2007</td>
<td>Sweet Corn</td>
<td>Soil and Plant N Sampling</td>
</tr>
<tr>
<td>July 2007</td>
<td>Sweet Corn</td>
<td>Pest and Disease Sampling Soil and Plant N Sampling Weed Dynamics</td>
</tr>
<tr>
<td>August 2007</td>
<td>Sweet Corn</td>
<td>Soil N Sampling Pest and Disease Sampling Weed Dynamics Harvest</td>
</tr>
<tr>
<td>September –November 2007</td>
<td></td>
<td>Analysis of Soil and Plant N</td>
</tr>
<tr>
<td>November 2007</td>
<td></td>
<td>Report and Expenses to AAS and FVGO</td>
</tr>
</tbody>
</table>

Cover Crop and N Rate Effect on Sweet Corn Yield
Cover crops of oats, rye and oilseed radish + rye (OSR+rye) were planted with a drill at approximately 72, 60 and 8+30 lb/ac, respectively. The trial included a no cover crop control. Cover crops had no impact on total and marketable sweet corn yield (Table 2). As expected the grower rate of 140 kg/ha N had significantly higher total and marketable yields than the 0 N treatment. The average total yield from the 0 and 140 kg/ha N treatments was 6.8 and 10.5 t/ha. Yield with fertilizer was lower than the
provincial average (12.5 t/ha in 2006) due to lack of rain in 2007; only 65.5mm of rain between May 1 and July 31 with the 30 year average for these months is 249mm. The average marketable yields were 7.3 and 4.1 t/ha for the 140 kg/ha N and 0 kg/ha N treatments, respectively. But the low marketable yields were due to the rigorous determination of non-marketable cobs. Each harvested cob was inspected for appropriate size and pest and disease damage both on the inside and outside of the cob. This screening was necessary for the pest and disease component of the project and resulted in a more stringent determination of marketable yield than is the industry standard. Therefore total yield was more accurate of actual grower yields.

Table 2. Total Yield for each Cover Crop under the 0 and 140 kg N/ha fertilizer. Treatments with different letters for each yield type indicate a statistically significant difference.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>0 kg N/ha Treatment</th>
<th>140 kg N/ha Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Cover</td>
<td>5.0 a</td>
<td>9.3 b</td>
</tr>
<tr>
<td>Oats</td>
<td>8.6 a</td>
<td>11.6 b</td>
</tr>
<tr>
<td>OSR+Rye</td>
<td>8.6 a</td>
<td>10.7 b</td>
</tr>
<tr>
<td>Rye</td>
<td>5.1 a</td>
<td>10.4 b</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>6.8</strong></td>
<td><strong>10.5</strong></td>
</tr>
</tbody>
</table>

Cover Crop Biomass Production
In December, OSR+rye and oats had higher biomass production than rye (Figure 1a). Rye is typically slow to establish. The following spring, there was less cover crop biomass in the OSR+rye treatment compared to oats or rye (Figure 1b). Overall, all of the three cover crops established well and put on enough biomass to protect soil from wind and water erosion.
**Figure 1a – Cover Crop Biomass Production (kg/ha) collected in the fall of 2006.** Cover crops with different letters indicate a statistically significant difference.

**Figure 1b – Cover Crop Biomass Production (kg/ha) collected in the spring of 2007.** Cover crops and dates with different letters indicate a statistically significant difference.

**Cover Crop Nitrogen Uptake**

In the fall of 2006 the N content of the cover crops was 2.98, 2.06 and 1.84% for rye, oats and OSR+rye, respectively. Based on %N content and biomass accumulation, two months after cover crop planting, N uptake in the above ground tissue was not different between the three cover crops (Figure 2). In December, oats had higher N uptake than rye, which is consistent with biomass production at this time. Therefore, oats appears to have the higher potential to trap N from leaching and in the fall.

In the spring of 2007, N in cover crop was higher on May 15th than on May 3rd (Figure 3). As well, rye had significantly higher plant N uptake than the other two cover crops, which again is consistent with rye growth at the time period. Thus, the quantity of N in plant biomass is not immediately available for loss before sweet corn planting.
Figure 2 – Quantity of N (kg N/ha) in cover crop plant tissue collected 2 months (October) and 4½ months (December) after cover crop planting in August 2006. Cover crops with different letters indicate a statistically significant difference.

Figure 3 – Quantity of N (kg N/ha) in cover crop plant tissue collected 9 months (May 3rd) and 9½ months (May 15th) after cover crop planting in August 2006. Cover crops and dates with different letters indicate a statistically significant difference.

Soil Nitrogen Concentrations
Soil mineral N (nitrate-N and ammonium-N) was quantified nine times between August 2006 – August 2007 (Table 1). Over the entire sampling period, under the 140 kg N/ha treatment, there was no difference in the soil mineral N concentrations between the no cover and the oats treatments (Figure 4). OSR+rye had significantly lower soil mineral N than the no cover treatment, while rye had significantly lower soil mineral N than both the oats and the no cover treatments. It is important to note that these differences
in soil mineral N were not significant enough to affect sweet corn yield. The drought likely effected corn yield more than minor difference in soil N concentrations.

During 2006, soil mineral N was significantly higher in August than in December for all treatments. Compared to the 0N control, all three cover crops trapped N in biomass and lowered soil mineral N in October. By mid-December, soil mineral N was lower in the oats and rye treatments compared to OSR+rye mix and no cover. Oilseed radish is considered ‘leaky’ because it traps N but quickly breaks down and releases mineral N after frost kill. Therefore, based on results from one year, oats or rye are preferred.

In 2007, the first sampling date had significantly lower soil mineral N concentrations than any of the other 2007 dates. Soil mineral N levels peaked in early July for all of the cover crop treatments, while the no cover treatment peaked in mid June. This may have implications on soil N management should trends continue when the experiment is repeated. But because there was no difference in sweet corn yields between cover crop treatments when no fertilizer was applied, the cover crops did not significantly tie up or release N during the sweet corn growing season.

![Figure 4](image)

**Figure 4** – Soil mineral N (nitrate-N and ammonium-N) content from 0-90cm depth in the pea-cover crop – sweet corn rotation. See Table 1 for crop stage at each sample date. Cover crops and dates with different letters indicate a statistically significant difference.

Cover Crop Effect on Weeds in the Sweet Corn Crop

The sweet corn crop was treated post-emergent with Primextra II Magnum and Banvel at the recommended rate. There was no significant difference in grass weed biomass in the sweet corn crop between any of the cover crop treatments or the no cover control (Figure 5). Weedy grass biomass significantly increased over the 3 sampling dates, which is typical in sweet corn production. Broadleaf weed biomass did not
increase over the season. There were significantly fewer broadleaf weeds in all three cover crop treatments compared to the no cover control (Figure 5). Therefore, all three cover crops may be used to reduce broadleaf weed biomass in sweet corn. Thus growers should have little concern that these cover crops will increase weeds in their sweet corn crop.

![Graph showing biomass production]

**Figure 5 – Grassy and broadleaf weed biomass production between May and August 2007.** Cover crops with different letters indicate a statistically significant difference.

**Cover Crop and N Rate Effect on Pests in Sweet Corn**
The following pests were scouted for throughout the sweet corn growing season: wireworm, European corn borer (ECB), corn earworm (CEW), other chewing insects, rust smut and Northern corn leaf blight (NCLB). There was a difference between 0 and 140 kg N/ha treatments in pest pressure, but considering that N fertilizer is required for sweet corn production only results from the fertilized plots will be presented. Overall, at 140 kg N/ha there was no consistent trend in insect and disease pest pressure between cover crops (Table 3). Some pests were lower, some higher with or without cover crops. Therefore, based on one year results it is difficult to recommend one cover to reduce pest pressure. But if a grower is particularly concerned about smut, for instance, then the oilseed OSR+rye mix should be avoided.
Table 3. Pest pressure in fertilized 140 kg N/ha plots as influenced by cover crops.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Cover crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>European corn borer</td>
<td>Oats highest pressure</td>
</tr>
<tr>
<td>Corn earworm</td>
<td>All covers higher pressure than no cover control</td>
</tr>
<tr>
<td>Wireworm</td>
<td>No difference between cover crops</td>
</tr>
<tr>
<td>Other insects</td>
<td>All covers higher pressure than no cover control</td>
</tr>
<tr>
<td>Smut</td>
<td>Oilseed radish/rye mix highest pressure</td>
</tr>
<tr>
<td>Rust</td>
<td>No cover control highest pressure</td>
</tr>
<tr>
<td>Northern corn leaf blight</td>
<td>No cover control highest pressure</td>
</tr>
</tbody>
</table>

European Corn Borer (ECB)

Oat at 140 kg/ha of N had the greatest larvae counts and were significantly different from the other cover crop treatments (Figure 6). ECB larvae and adults (Figure 7) increased throughout the season. Within southwestern Ontario, ECB has a bivoltine life cycle; which is consistent with observed data (Figure 7)

![LSMean vs N Dose for ECB](image)

**Figure 6** – The effect of a cover crop and N dose for ECB between May and August 2007. Cover crops with different letters indicate a statistically significant difference.

![European Corn Borer Seasonal Activity](image)

**Figure 7** – ECB Seasonal Activity between June and August 2007
Growers do not have the information needed to credit N applications for the cover crop. This cover crop research will provide growers with knowledge on the quantity and timing of N released from the cover crop to the succeeding crop in vegetable production systems. Moreover, there is little information on cover crop effect on multiple production factors such as N, weeds, insects, and disease, soil quality and cost-benefit analysis. Soil quality and cost-benefit analysis are forthcoming. Long-term goals include the development of best management practices of using cover crops that optimize crop yield and quality, reduce N losses, minimize pests and enhance economic returns.

One M.Sc. graduate student position was created and two full-time research assistants were employed during the summer months. This research project supported one M.Sc. graduate student, who started in May 2007 and one undergraduate research assistant during the summer and one part-time assistant during the fall. These university students were hired to assist with the plot work, such as establishing field plot experiments, site preparation, planting crops, applying fertilizer, soil sampling, plot maintenance, harvesting vegetable crops, assessing plant and yield quality parameters, and recording data.

**Technology Transfer Activities:**
Primary Target:
Ontario fresh vegetable producers are the primary target of this research, along with relevant OMAFRA staff, and industry consultants. It is estimated that that at least a third and all of the producers and OMAFRA staff, respectively were reached by this project to date by the technology transfer activities described below.

Support Identified:
The Fresh Vegetable Growers of Ontario, Agricultural Adaptation Council, the Canada-Ontario R&D Program, and the Ontario Ministry of Agriculture, Food, and Rural Affairs were listed as supports in the acknowledgements of all reports/papers. As well, these organizations were acknowledged as a sponsor in all presentations.

**Method of Technology Transfer:** *Bold names indicates principle presenter/writer.*

**Awards**

**Presentations**


Field Days and Tours

Technical Reports and Abstracts


Radio Reports
Van Eerd, L.L. 7 August 2007. Cover your assets: plant cover crops to protect your soil.
Acknowledgements: Funding for this project was provided in part by Agriculture and Agri-Food Canada through the Agricultural Adaptation Council CORD IV program. Other sources of funding include the Fresh Vegetable Growers of Ontario, Ontario Processing Vegetable Growers, Ontario Food Processors Association, and Ontario Ministry of Agriculture, Food and Rural Affairs as well as in-kind analysis from Agri-Food Laboratories Ltd., and A&L Laboratories Inc. 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.