Cool Farming Options, Pulse Canada

Cool Farm Tool Pilot on Canadian Navy Beans
February 2012

Introduction

Pulse Canada, the Canadian industry association of peas, lentils, dry beans and chickpeas, is the sponsor for this project, with Heinz UK as a partnering company. Pulse Canada has investigated the use of the Cool Farm Tool (CFT) to develop an on-farm carbon footprint of navy bean production in Canada. The numbers developed from this project must comply with PAS 2050, the UK standard for assessing life cycle greenhouse gas emissions from goods and services. This action is in response to many retailers’ goals of having carbon footprint labels on grocery items in their stores.

Because agrifood supply chains are increasingly asking suppliers to provide GHG information about their crops, Pulse Canada’s goal for this project was not simply to produce an aggregate number at the end of the project, but to learn as much as possible about the process and the state of the science of greenhouse gas measurement in agriculture.

Two greenhouse gas measurement tools were evaluated as part of this project, the Cool Farm Tool and Holos, an on-farm carbon calculator developed by the federal Department of Agriculture in Canada. The information below will only show data from the CFT.

Farming system

The focus crop for this project is navy beans (Phaseolus vulgaris), also know as white pea beans, grown in Ontario and Manitoba. One of the most common markets for this crop is for canned baked beans in tomato sauce.

None of the farms investigated were irrigated, and this particular dry bean would not typically be irrigated. A common rotation in Ontario is a 3 or 4-year rotation with corn, winter wheat and soybeans; while in Manitoba, the rotation length and content varies, but can include wheat, canola, oats, potatoes, corn and soybeans. Tillage is typically more intensive in Ontario, with many producers using moldboard ploughs, while in Manitoba tillage in grain production is typically less intensive. However, in row crops like dry beans and corn, inter-row cultivation is a typical practice in Manitoba to warm the soil and to manage weeds.

Pulse Canada requested the aid of local bean buyers to distribute questionnaires to navy bean producers. Questionnaires from 34 producers were submitted to Pulse Canada and the responses were used to populate both the CFT and Holos calculators.
Results by farm

The 34 farms studied represent a wide range of acreage; farm sizes range from 23 to 640 acres. Yields ranged from 0.5 to 1.5 tonnes/acre (an average of 1 tonne/acre).

Figure 1 shows the range of emissions from the navy bean production, with Ontario farms shown in blue, and Manitoba farms shown in red. The farms in Ontario had a higher yield than the farms in Manitoba even though typically more nitrogen fertilizer was used on the Manitoba farms. This may be due to the colder temperatures and shorter growing season in Manitoba. The higher nitrogen application rate and lower yield in Manitoba is responsible for this region having higher emissions on a per area and per tonne basis.

In addition, the higher diversity of land management practices in Ontario had a big impact on emissions, in particular carbon stock changes. Practices such as cover cropping with red clover, reduced tillage, and fertilization with manure were common in Ontario, sequestering carbon into the soil. On the other hand, five farms in Ontario produced beans on land that had been producing perennial forages, and the tool calculated a large emission from released soil carbon for these farms.

Figure 1

<Diagram: Emissions by Farm (kg CO2e per tonne)>

Blue= Ontario
Red= Manitoba

Average emissions for by farm are as follows:

<table>
<thead>
<tr>
<th>Average Emissions by Tonne</th>
<th>198 kg CO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Emissions by Hectare</td>
<td>411 kg CO2e</td>
</tr>
</tbody>
</table>

Figures 1, 2, 3 and 4 all show the farms arranged in the same order. From this we see that performance on a per area basis is similar though not identical to performance on a per tonne basis (it may be more surprising how similar these graphs are than how different they are – the difference is expected due to variations in yield). It is also interesting to note
the lack of correlation between N application rates and performance. Figure 3 shows N rates by farm. From this comparison, a few individual farms stand out.

- 24M stand out as one with particularly high emissions despite low N application rate and extremely high yields. This puzzling combination is explained by the fact that farm 24M is one of three farms that recently converted 100 percent of its cropland from grassland.

- On the other hand, farm 16E is interesting for having land use change (100 percent 15 years ago) but not remarkably high overall emissions. This is due to an N application rate of zero and the addition of a cover crop once every four years (starting 10 years ago).

*Figure 2*

**Emissions by Farm (kg CO2e per ha)**
- **Blue** = Ontario
- **Red** = Manitoba
**Figure 3**

**N application Rates (kg/ha)**

![N application Rates graph]

**Figure 4**

**Yield per acre**

![Yield per acre graph]

**Statistical analysis on practices**

Management decisions that store carbon and land conversion that releases carbon are the most important factors in this system in terms of CO2e emissions. After these come the amount of N fertilizer used and direct and indirect N2O emissions. The effect of changes to carbon stocks are shown in Figure 5, a graph of annual CO2e emissions regressed against the portion of CO2 emissions that are due to carbon stock changes. This shows that only 3 percent of the variability in the performance of the farms on an area basis is driven by factors other than carbon stock changes.
When we take out carbon stock changes we can get a better look at the remaining factors that drive the variation in performance. Figure 6 shows the weaker but still significant correlation between performance and emissions from fertilizer production.

Figure 7 shows the relationship between performance and direct and indirect N₂O emissions. Though weaker still this correlation is still significant.
Baseline scenario

Another way to gain insight into the practices that make a difference for GHG performance in this system is by running scenarios. The data provided by individual farms for pulse production, enables us to create a “baseline scenario” based on average values from the 34 reporting farms. This scenario, input into the CFT, allows an experimental examination of the environmental and management factors that influenced the emissions outcome of pulse production. The baseline scenario results in emissions of 253.2 kg CO₂e both per acre and per tonne. These are equivalent because the average yield was one tonne per acre.

Pulse Baseline Scenario Inputs

<table>
<thead>
<tr>
<th>GENERAL INFO TAB</th>
<th>Value</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>Canada</td>
<td></td>
</tr>
<tr>
<td>Default Unit System</td>
<td>Metric</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>Navy Bean</td>
<td></td>
</tr>
<tr>
<td>Production Area</td>
<td>1 acre</td>
<td></td>
</tr>
<tr>
<td>Fresh Product from production area</td>
<td>1 tonne</td>
<td>Average of all 34 farms</td>
</tr>
<tr>
<td>Finished Product from production area</td>
<td>1 tonne</td>
<td>Same as fresh product</td>
</tr>
<tr>
<td>Climate</td>
<td>Temperate</td>
<td></td>
</tr>
<tr>
<td>Average Temperature</td>
<td>7.5° degrees Celsius</td>
<td>Overwhelmingly dominant temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CROP MANAGEMENT TAB</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Type</td>
<td>Dry Bean</td>
<td></td>
</tr>
<tr>
<td>Soil Texture</td>
<td>Medium</td>
<td>All files were the same</td>
</tr>
<tr>
<td>SOM</td>
<td>3.73</td>
<td>Average of all farms</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>Moist</td>
<td>All files were the same</td>
</tr>
<tr>
<td>Soil Drainage</td>
<td>Good</td>
<td>All files were the same</td>
</tr>
<tr>
<td>Soil pH</td>
<td>7.3&lt;pH&lt;8.5</td>
<td>All files were the same</td>
</tr>
</tbody>
</table>

Fertilizers *(Predominant fertilizers)*

<p>| Monoammonium phosphate - 11% N; 52% P2O5 | Product | Averages of where these fertilizers were used as a product |</p>
<table>
<thead>
<tr>
<th></th>
<th>Incorporated Current Tech</th>
<th>Averages of where these fertilizers were used as a nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muriate of potash / Potassium Chloride - 60% K2O</td>
<td>K2O 47.83 pounds/acre</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incorporate Current Tech</td>
<td></td>
</tr>
<tr>
<td>Urea - 46.4% N</td>
<td>N 40.57 pounds/acre</td>
<td>Averages of where these fertilizers were used as a nutrient</td>
</tr>
<tr>
<td></td>
<td>Incorporate Current Tech</td>
<td></td>
</tr>
<tr>
<td>Pesticide Applications</td>
<td>5</td>
<td>Average for all files</td>
</tr>
<tr>
<td>Residues</td>
<td>190.9 kg/ha</td>
<td>Predominant residue amount, all files had same management technique</td>
</tr>
<tr>
<td></td>
<td>Left on field,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incorporated or Mulch</td>
<td></td>
</tr>
</tbody>
</table>

The baseline model for pulse reveals the following representative distribution of emissions throughout the system in Figure 8:

**Figure 8**

![Pulse Baseline Emissions](image)

This average baseline scenario is without any sequestration or emissions related to tillage practices, cover cropping, land use change, manure use and thus reveals the dominant effect that fertilizer use and production play in the overall footprint. Pesticide emissions are significant because 5 applications is a relatively high number of applications overall.

**Baseline scenario with reduced tillage**

Almost 1/3 of farms examined in this study were practicing some sort of reduced tillage technique (1 farm converted from conventional to no-till and 10 from conventional to reduced till). Because this practice appears to be significant, we also created a baseline that demonstrates a shift from conventional to reduced tillage (1 year ago on 100% of the land).
Figure 9 demonstrates the dramatic effect that this change has on the footprint of the entire system; emissions drop from 253.2 to -312 kg CO₂e per acre and tonne.

**Further Comparison & Reduction Scenarios**

Seven scenarios were tested against the baseline to examine further potential for emissions reduction in pulse production. See Figure 10 for the results of all seven scenarios. There are a wide variety of factors that influence farmers’ decisions around management practices and the scenarios presented here are necessarily simplistic and do not capture many of the nuances that go along with each scenario. For example emission inhibitors are extremely expensive but there is an assumption when using them that less N will be needed or yields will improve thus compensating for some of these costs. We do not model either a reduction in N use or an increase in yield in this scenario despite the likelihood that one of these factors will play out.

1. **Reduced Tillage**: Changed baseline to reflect reduced tillage one year ago on 100% of the land. Emissions drop to -312 kg CO₂e per acre (or tonne).

2. **No Till**: Changed baseline to reflect shift from conventional to no-till one year ago on 100% of the land. Emissions drop to -751.6 kg CO₂e per acre (or tonne).

3. **Cover Cropping**: Changed baseline to reflect the addition of cover cropping one year ago on 25%. Emissions drop to 97.9 kg CO₂e per acre (or tonne).
4. **Intensive Pest Management**: Changed baseline to reflect an increase of pesticide applications from 5 in the base scenario to 7. Emissions increased to 269.8 kg CO$_2$e per acre (or tonne).

5. **Manure**: Changed baseline to reflect the addition of manure. Reduced monoammonium phosphate and urea applications by half. Added manure at the same rate that was reduced from monoammonium phosphate and urea (23.9 lbs/acre). Also included “started in incorporation” of manure 5 yrs. ago on 100% of the land on the CFT sequestration tab. With these changes, emissions dropped to 4 kg CO$_2$e per acre (or tonne).

6. **Land Use Change**: Changed baseline to reflect a change in land use from grassland to arable, 1 year ago on 50% of the land. Emissions increase to 674.4 kg CO$_2$e per acre (or tonne).

7. **Emissions Inhibitors**: Changed baseline to reflect a nitrification inhibitor for urea only. Emissions dropped to 236.1 kg CO$_2$e per acre (or tonne).

*Figure 10*

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Emissions (kg CO$_2$e per acre and per tonne) by Scenario Change (measured against baseline)

- **Baseline**
- **Reduced Till (16%)**
- **No Till**
- **Cover Cropping (on 25%)**
- **Intensive Pest Management**
- **Manure**
- **Land Use Change**
- **Emissions Inhibitors**

Overall, these results indicate that reduced/no tillage practices tend to have the most significant reduction potential for pulses. On the other hand, land use change from grassland to arable is the largest source of increased emissions.

The 30 percent adoption rate of reduced tillage by the farmers sampled provides a rough indication of the feasibility of this practice. Farmers in Manitoba, where the temperatures are cooler and the growing cycle shorter, have less flexibility and many perceive the need to till to warm and aerate the soil. In Ontario, reduced tillage is on the rise among farmers and
a future survey is likely to show higher rates of adoption. Other barriers and opportunities for GHG mitigation include the following:

- Reduced tillage requires an investment in equipment, and also requires a change in residue and weed management.

- Cover crops are limited agronomically and climatically. Red clover cover crop is only grown with winter wheat. In shorter growing seasons like Manitoba, considerations of success and cost/benefit limit adoption.

- Manure/compost is only available locally around livestock operations. Lack of proper management and over-application can cause excess fertility problems.

- Studies have shown that dry beans treated with rhizobial bacteria can successfully fix their own nitrogen. Breeding programs should focus on this trait, as dry beans that fix their own nitrogen from the air would be much more profitable to grow, and have less greenhouse gas emissions.

**Highlights of Engagement and Next Steps**

Pulse Canada took a number of steps to validate the results produced by the CFT, and to share these findings with the Sustainable Food Lab. In addition to comparing the results of the CFT to Holos, the results were compared to a number of Canadian studies to determine whether emissions were characteristic of Canadian conditions. We examined both the total and distribution of emissions resulting in the CFT to this research. Results from this work are not yet concluded with respect to the newest version of the Cool Farm Tool

Pulse Canada will be engaging producers that participated in this project by providing each producer with an individual report, highlighting their farm against the rest and explaining the practices that had the biggest impact on navy bean GHG emissions. Presentations of the project and results are planned for producers in Ontario, Manitoba and Alberta.