Farm Innovation Program (FIP)
Final Reporting Templates

The FIP Agreement, Schedule "C" Reporting and Claim Requirements, outlines the specific submission dates for your project reports.

Please note that the Knowledge Transfer Plan and Translation section may require input from both the commodity association and the researcher, if both parties are undertaking knowledge transfer activities.

(Add additional rows if needed)

Farm Innovation Program - Final Report

Please note that the final payment for projects will not be released until a final report has been submitted and accepted by the AAC. Final Reports must be a minimum of two pages and should answer all of the questions outlined below and be **submitted by the completion date of the project and/or no later than December 1st, 2012.**

Applicant Name:	**Fresh Vegetable Growers of Ontario**
Project Title:	**Adding Carbon Waste to Minimize Nitrogen Loss After Cole Crop Harvest.**
FIP Project Number:	1175
Reporting Period:	Final Report 2011-2012
Date of Submission:	30 September 2012
AAC Program Coordinator:	Daryl Vermey

Executive Summary

Executive Summary should be one page maximum and include a brief summary of activities to date, objectives or goals accomplished and highlights of achievements and reach of project to date and/or issues that have affected success of the project to date:

Cole crops pose a high risk of nitrogen (N) loss after harvest due to high N content in crop residues. By adding material with a high carbon content, such as used cooking oil, and wheat straw, soil microbes tie up N, which is not subjected to loss from the field. Application of carbon waste to soil in laboratory and small plot field studies have demonstrated lower soil mineral N concentrations with no impact on crop yield in the following year. The next step of this project was to evaluate this technology in large field scenarios on multiple grower sites.

Three on-farm grower trials were studied in fall 2011 and over the growing season 2012. After cole crop production in 2011 (Brussels sprout, cabbage, and cauliflower), the crop residue was either incorporated (typical practice), removed, or incorporated with used cooking oil. Used cooking oil was hand applied but growers would use a liquid manure spreader or injector. Soil samples in each treatment were collected from the 0-60 cm profile for mineral N (nitrate and ammonium) analysis in the fall 2011, spring 2012, and at crop harvest in 2012. Fresh market tomatoes, soybean, and corn were produced during the following growing season in 2012 and yield was collected.

Cole crop residues left in the field can contain up to 300 lb N/ac, which eventually leach from the field. During the fall season after cole crop harvest, applying used cooking oil lowered soil mineral N in 0-60cm depth by over 35% compared to leaving the residue in the field ($P<0.1$). Similarly in the spring following cole crop harvest, used cooking oil lowered soil mineral N by 44% compared to the typical practice of incorporating crop residue ($P<0.05$). Thus, the results suggest that the potential for N loss was lower with used cooking oil in the fall and following spring.

Obviously, N is needed for crop growth and one must evaluate the next growing season. In 2012, the summer after cole crop production, growers produced tomatoes, soybeans or corn with their normal N fertility program. The soil mineral N at tomato, soybean, or corn harvest in the top 60 cm soil was not affected by the previous year's treatments; there was no difference between treatments. Thus, it is suggested that used cooking oil may reduce N loss during periods of high risk for loss (fall to spring), without negatively affecting subsequent soil N fertility for crop production.

Treatments of cole crop residue incorporation, crop residue removal, or adding used cooking oil did not affect corn or soybean yield. Unexpectedly, tomato yield with used cooking oil (35.5 t/ac) was higher compared to the other two treatments (30-31 t/ac) ($P=0.022$). Because the higher yield was only observed in one site, we are not promoting used cooking oil to boost yield. But, growers should not expect a negative effect on yield after applying used cooking oil in the fall, despite a reduction in soil mineral N in the fall and spring.

Similar to on-farm trials, research data from fall 2009 + 2010 and the following cropping season of 2010 + 2011 showed that used cooking oil consistently immobilized soil mineral N in the fall and spring but had no effect on soil N or crop yield during the following growing season. Moreover, in 2011 and 2012 research trails, economists Dr. Richard Vyn determined that under a typical grower N fertilizer program, there was no difference in profit margins between applying used cooking oil and the typical grower practice of leaving the crop residue in the field. Thus the financial risk to growers of adopting this new technology appears low.

A better management plan (BMP) has been developed for used cooking oil to trap N and minimize N losses, based on research results and grower on-farm trials. As opposed to having growers cut back on N fertilizer, potentially at the expense of yield, the new BMP provides viable option for cole crop growers to limit N losses. For restaurants, used cooking oil is a waste product, thus the cost to the grower may be as little as the application cost of running a manure spreader or injector filled with oil down the field.

Detailed Description of the Project

1. Identify overall project objectives reached:

All project objectives have been reached and are listed below:

1) Evaluate effect of adding carbon waste to the following crop yield
2) Assess applicability and limitations of large scale application of carbon waste using grower equipment in grower fields
3) Evaluate costs associated with application of carbon waste
4) Promote adoption of this innovative approach to vegetable growers

Although results are given in other sections, details given below describe how project objective were reached:
OBJECTIVE #1: In addition to the research trial on campus, we conducted 3 on-farm trials. We were fortunate to be able to apply all treatments at all sites in the fall (despite the excessive rainfall in 2011) and followed crop yield in 2012. Each site had different cole crops (Brussels sprout, cabbage, and cauliflower) and following crops (fresh market tomatoes, field corn and soybean). Thus we were able to test more crops than we had anticipated.

OBJECTIVE #2: Although we evaluated the applicability of large scale grower application, we were not able to test the equipment on grower fields (see section 4). Regardless, we identified grower technology available for use and highlighted cautions within the new BMP.

OBJECTIVE #3: A full economic profit-margin analysis was conducted on the research trial by Dr. Richard Vyn. Cost of adopting the new BMP appear quite low or not statistically different from the typical grower practice.

OBJECTIVE #4: This project has been picked up by the Ontario Farm newspaper and was highlighted on OMAFRA's Radio Report, which reaches well over 12,000 people each. Posters were presented at the Southwestern Agricultural Conference (SWAC – Ridgetown), with 1500+ registered participants. Now that on-farm trial results have been completed and because they demonstrated effective N immobilization in the fall and spring with no crop injury or yield lag in the following season, we are comfortable fully promoting the use of used cooking oil as a BMP practice for vegetable growers, particularly cole crop growers.

2. Identify all activities undertaken to reach the project objectives (link these activities to the Milestone Performance as per Schedule "B" Part III of the Agreement):

All activities were undertaken as outlined in the proposal, except: "*Apply carbon waste - evaluate field scale application of carbon wastes".* See section 4 for explanation.

See below for completed activities as proposed:
Fall 2011 – *Research trial*: Apply carbon waste to cole crop research trial (already completed)
Winter 2012 – *Research trial*: analyze soil samples, final report to OMAFRA New Directions
Winter 2012 – *On-Farm trials*: Contact growers to participate in field studies
Spring 2012 – *Research trial*: Take preplant soil N samples, plant the 'following crop'.
Summer 2012 – *On-Farm trials*: Harvest cole crops, take soil N samples and apply carbon wastes
Summer 2012 – *Research trial*: Harvest 'following crop', take soil and plant samples
Summer 2012 – *On-Farm trials*: Harvest 'following crop', take soil and samples
September 2012 – *Research and On-Farm trials*: Final reports submitted to growers and funding agency

3. Identify the outputs created as a result of the activities undertaken (if materials are produced, a sample should be included in the report):

A new BMP factsheet has been created. The BMP will be distributed through FVGO and on Dr. Van Eerd's website. As well, the BMP will likely be incorporated to the new Soil Management BMP book produced by OMAFRA through the OFA and AAFC.

4. Explain changes or issues affecting completion of activities:

The project was successfully completed. However, the excessive amount of rain in the Fall 2011, really limited our ability to access field sites. We made the decision not to run a large grower-sized manure spreader/injector across grower fields. Likely, it would have been too difficult to separate the potential effect of compaction from the intended treatment of applying used cooking oil. Not to mention the need to effectively clean out the grower equipment. Therefore, we felt it necessary to apply the product by hand in smaller plots rather than the intended field-size equipment. Regardless we were able to evaluate grower cropping systems.

Based on experience, any liquid manure spreader or injector will work to apply the used cooking oil. Growers should definitely not use their sprayers. The oil would be too difficult to clean up and had too much debris (small food particles) would clog lines/nozzles. There are many custom application companies that deal with liquid manure, lagoon waste, and/or biosolids. Based on conversations, their equipment could easily apply the used cooking oil. Thus, application technology should not be a major limitation with used cooking oil.

5. Identify the project inputs used to complete the activities and during the course of the project (include: farmer(s) involved, funding level, financial contributions, staff resources, other resources, etc.). If you did not access all of the FIP funding, or If your actual budget is different from the approved budget, please explain why and outline the reason(s) for those variances. All categories that are over/under budget should be discussed:

Farmer(s) involved: The involvement of 3 individual growers through the on-farm trials. On-farm trials facilitated informal discussions with other growers, their employees and agricultural industry personnel, that may have reach another 30 people.

Funding level and financial contributions: FIP funding of $27,000 direct and $6750 overhead

Staff and other resources: Research technician: set up, manage, and collect data from on-farm trials. Undergraduate students (4): periodically collect soil and crop samples from on-farm and research trials. PhD graduate student: manage and collect data from research trial and analyzed and summarized data from all trials.

Budget: All FIP Funding was accessed.

Benefits & Impact

6. Compare final project results with the expected short term results and explain any differences:

This project reached expected short term results. Through on-farm and research trials, this project allowed for the creation of new BMP of adding carbon waste after harvest to minimize N loss. This technology may allow cole crop and other vegetable growers to manage N. This may be particularly important to protection source water.

7. Explain if the final project results are satisfactory:

Final project results are satisfactory. There were no concerns. The on-farm technology and resulting BMP were as anticipated. Moreover, there appears to be growing farmer interest based on newspaper articles and inquires to OMAFRA staff and industry personnel.

8. Identify the public good/benefit of the project to date:

There is increased pressure from society on growers to protect consumers and the environment; this is particularly true for fresh fruit and vegetable growers. Providing growers with technologies, such as demonstrated in this project, that protect consumers and the environment will create a competitive and innovative sector. This BMP will benefit growers (by maintaining crop productivity and improving resiliency), the government (by evaluating assumptions of nutrient management regulations), all Ontario citizens and the environment (by minimizing contamination from soil erosion and leaching).

9. Explain how many on farm technologies the project has assessed:

One on-farm technology was assessed. The project evaluated using carbon waste, such as used cooking oil, to trap soil nitrogen after cole crop harvest. This on-farm strategy was developed into a new BMP for cole crop and other growers.

10. Explain how the project success will be measured in the long-term (include the indicators outlined in Schedule "B" of the Agreement):

The proposed long term results are still expected. Focusing on post-harvest N dynamics has expanded on the fundamental understanding of N dynamics in horticultural systems. With the increased knowledge of N cycling outside of the main crop season, strategies that minimize N loss while maintaining crop productivity may be implemented. Most of the previous N research has studied in-season management with less regard to what happens after harvest or to the following crop. Long term success can be evaluated by tracking grower use patterns through consultation with OMAFRA staff.

11. If applicable, indicate how this initiative will be economically viable and self-sustaining from this point forward. Explain what the next steps are for this initiative:

The cost of implementing the BMP of applying used cooking oil after cole crop harvest involves an extra trip down the field with an applicator, typically a manure spreader or injector. Used cooking oil is a waste product and typically there is no fee. Thus, the cost of this BMP is unlikely to be cost prohibitive and should be self sustaining. The next step is to promote the results and BMP through grower reports and meetings.

12. Indicate the current actual financial impact to farmers who may adopt the technology versus the estimated impact (see question '6.e.' in the application):

The financial impact is difficult to precisely estimate. The application of carbon waste involves driving a tractor with spreader/injector through the field. However, the used cooking oil is readily available, often considered a waste product, and may be given to grower at no cost rather than pay for tipping fees at disposal sites or perhaps growers may have to pay trucking fees. So cost to grower is likely to be minimal.

Moreover, there was sufficient data from the research trails in 2011 and 2012 for Dr. Richard Vyn to run economic analysis. Results showed under a typical grower N fertilizer program, that there was no difference in profit margins between applying used cooking oil and the typical grower practice of leaving the crop residue in the field. Thus the financial risk to growers of adopting this BMP appears low, based on profit margin analysis.

The impact benefit to growers is also difficult to estimate because the main benefit is reduced N losses to the environment. In USA, growers are paid $50/ac to plant cover crops. This payment is to offset costs of planting a cover crop and to pay growers for the environmental benefits (minimizing nutrient loss and erosion) cover crops provide. Thus, one might suggest $25/ac as an environmental benefit of adding carbon waste.

Another potential benefit is that the new BMP is expected to provide options for cole crop growers to minimize N loss, particularly those on high sands where groundwater resources need to be protected. In Ontario cabbage studies, applying N fertilizer at the rate need to maximize yields and economics increased income as high as $2,450/ac compared to when N fertilizer was applied at the OMAFRA recommended rate. Thus, the new BMP allows growers to apply the N fertilizer needed to maximize yield but still minimize N loss.

13. Indicate the target audience and the total number of people reached by this project:

The target audience is cole crop growers and ultimately other vegetable growers. Three growers were directly involved in the project because the on-farm trials were on their farm.

Over the past two summers, the project has been highlighted at two field days at Ridgetown Campus: 1) the Vegetable Open House in July with 50-70 growers/industry reps. And 2) Cover Crop Open House in October with 40 people.

The project was highlighted in Ontario Farmer and Today's Farmer which reaches thousands of growers and agribusiness personnel. As well, this project will be presented at the 2013 Southwest Agricultural Conference, Ridgetown (1200+ participants), where we will reach approximately 200 growers and agribusiness personnel. A radio report was written and recorded by L.L. Van Eerd. On October 2nd 2012, it will be broadcasted on local farm radio stations (coverage area of Windsor to Woodstock with an average of 14,600 listeners during the 12:15 to 12:30 timeslot) and available on OMAFRA website.

Knowledge Transfer Plan & Translation

14. Indicate how information has been communicated with industry for the duration of the project (refer to the plan developed as part of question 7 in the final funding application):

Information Requested	Commodity Association Activities	Researcher Activities
Indicate the type and number of communication materials that were developed (i.e. brochure, display, CD/DVD, poster, website, handbook, etc.) and how they were distributed:	No KTT activities to date. FVGO will post report on website and in the package at the AGM. As well, a popular press article will go into the FVGO newsletter in mid October.	• A BMP Factsheet was developed and submitted to AAC and OMAFRA for approval. See attached. The factsheet is a one-page step-by-step instructions on and benefits of using carbon waste to minimize N loss. Printed material can be distributed at grower meeting, which occur over the winter. As well, the material will be available online on Dr. Van Eerd's website. • Poster displayed at Southwest Agricultural Conference, Ridgetown in 2011 and 2012 (1200+ participants) • Poster at Fruit and Vegetable Convention, St. Catherines 2011 (**800+ participants**) • Congreves, K.A., Voroney, R.P., O'Halloran, I.P., Van Eerd, L.L. 2012. Influence of used cooking oil on the fate of broccoli residue-derived 15N in the autumn. Production Systems Research Expo, Ontario Ministry of Agriculture, Food, and Rural Affairs, Guelph ON. 19 June 2012. Poster Presentation. `1

Indicate the number of presentations that were made and the total audience reached:		• Field day presentation 2011 and 2012 at the Vegetable Open House. Each year there were approximately **50-60 growers and industry personnel.** • On the program for 2013 Southwest Agricultural Conference, Ridgetown (**1200+ participants**) to discuss research results. • 2012 Canadian Society of Soil Science Poster Presentation. (**250+ researchers and extension participants**) • 2011 Soil Science Society of America Oral Presentation. (**75 researchers and extension at the talk**) • 2011 Canadian Society of Horticultural Science Oral Presentation (**35 researchers and extension at the talk**) • 2011 Canadian Society of Agronomy Poster Presentation (**250+ researchers and extension participants**)
Indicate the number of scientific and popular press articles that were developed and how they were distributed:		Congreves, K.A., R.J. Vyn, L.L. Van Eerd. 20xx. Post-harvest organic carbon amendments to minimize nitrogen losses in cole crop production. Agronomy: Special Issue- Sustainable Crop Production. *Submitted August 11th 2012* . Congreves, K.A., R.P. Voroney, I.P. O'Halloran, L.L. Van Eerd. Broccoli residue-derived nitrogen immobilization following amendments of organic carbon: An incubation study. Canadian Journal of Soil Science. *Manuscript accepted for publication, 2012*.
Identify any other communication activities, including but not limited to internet publications, advertising, billboards, radio and television broadcasts:		Radio report. L.L. Van Eerd. September 2012. Trapping Nitrogen with Restaurant Used Cooking Oil. (**14,600+ listeners during noon Farm Show**)
Indicate if any project materials have been made available for use in the French language:		none

15. Indicate when AAFC/OMAFRA/AAC were identified as a supporter throughout the period of the project:

During PowerPoint presentations, identifiers (Growing Forward, Canada, Ontario, AAC logos) were on the acknowledgement slide and or on posters. AAC, Growing Forward and the FIP program were verbally acknowledged during field day talks. The following was written in the acknowledgement section of scientific articles and popular press articles written by L.L. Van Eerd. "This project was funded in part through *Growing Forward,* a federal-provincial-territorial initiative. The Agricultural Adaptation Council assists in the delivery of *Growing Forward,* programs in Ontario."

Conclusion & Final Comments

16. Provide a discussion of lessons learned, recommendations and overall perception of project success:

Lessons learned and recommendations for the grower: Although used cooking oil is a liquid, growers should not use a sprayer to apply it. There is a lot of sticky sediment that will clog nozzles and will make cleaning out the sprayer difficult.

Looking forward: it is possible that with more large anaerobic biodigesters, there may be more competition for restaurant used cooking oil as a carbon source. This may limit the availability or increase the cost of used cooking oil.

Project success: The project was successfully executed in all aspects including grower participation, data collection/analysis and reporting. In speaking to a company that custom applies manure, they have had people inquire about spreading restaurant used cooking oil. Thus, interest appears to be growing. Interest may grow this fall and in the following year as more growers adopt the BMP.

Media Coverage – *If possible please provide a copy of the media coverage for our files*

Date	Source	Title	Reach	FIP Recognition (Yes/No)
6 Mar 2012	Ontario Farmer	Restaurant oil helps solve N leaching	Approx. 20,000 subscribers	I'm not sure if the paper picked it up, but Growing Forward and FIP was verbally acknowledged during my field talk, which the reporter attended.
6 Sept 11	Today's Farmer	Research focuses on nitrogen sponge effect	?	See above

(Add additional rows if needed)