ONFARM

How to Conduct On-farm Research:
Guidebook

WHAT IS ON-FARM RESEARCH?

Every year, your crop input suppliers, agronomist, or even the farm media will tell you about new crop production practices, seed varieties, fertilizer options, crop protection products, and technologies for your farm. You are faced with the decision of which products and technologies to incorporate into your operation.

Reviewing trial results from public or private research can certainly be valuable; however, because farm operations across Ontario are unique, understanding how a particular product or technology fits within your own production system is especially helpful.

Through on-farm research, you can test potential changes to your crop production system in your own fields. This allows you to set priorities, observe results firsthand, and make informed decisions about whether a change in management practice makes sense for your operation. Typically, a change should result in a short or long-term return on investment or meeting an environmental goal.

The people involved in on-farm research can vary by the project. On-farm research can be fully farmer led, where the farmer designs the research question and conducts the trial themselves. Farmers can also collaborate with their crop advisory teams (e.g., their agronomists or Nutrient Management Consultants). Finally, academic or industry researchers may ask farmers' permission to run trials in their fields and the researchers do all the work. Regardless of the players involved, a successful on-farm research project follows the same key guiding principles and methodology, which are outlined in this guidebook.

Through this Guidebook, you will learn:

- How to develop an on-farm research question
- How to design your trial
- How to collect data
- How to analyze your data
- What you can extrapolate from your data
- What resources you can access to learn more

> *"It's a good business practice to challenge your status quo. On-farm research provides a great way to learn and stay current with potential new technologies and practices, which enables you to get better at doing what you do."*
> – Greg Hannam, ONFARM

> *"My number one reason for conducting on-farm research is that you can't manage what you don't measure. A lot of great innovations and products are being thrown at farmers. But until you can see how these innovations and products will work within your ecosystem and management style, you're flying blind. I need to be able to understand how a new product or system change will work within my current practices to evaluate if it will be a good fit for my operation."*
> – Jennifer Doelman, ONFARM

OUR ON-FARM RESEARCH EXPERTS

Throughout this guidebook, two Ontario farmers share their experiences and lessons learned through on-farm research.

These farmers are participating in the On-Farm Applied Research and Monitoring (ONFARM) program, developed by the Ontario Ministry of Agriculture, Food and Rural Affairs and delivered by the Ontario Soil and Crop Improvement Association (OSCIA). This nine-year applied research initiative began in 2019 and it supports soil health and water quality research on farms across the province. This program is funded by the Sustainable Canadian Agricultural Partnership (Sustainable CAP), a five-year, federal-provincial-territorial initiative. A component of the ONFARM program uses a "side-by-side" approach to trials (explained in further detail below) while recognizing changes in soil across the field. ONFARM includes 25 soil health BMP trial sites and seven edge-of-field (EOF) sites across Ontario and is collaborating with The Soil Resource Group (SRG) to investigate the impact of best management practices on soil health and water quality. SRG conducts applied research in the agriculture and environmental sectors.

Let's Meet Our Experts

Greg Hannam operates Woodrill Farm Enterprises in Guelph with his family. They grow corn, soybeans and wheat. In his ONFARM trial, Hannam compares the use of municipal compost with and without a multi-species cover crop. Both municipal compost and cover crops are important parts of Hannam's regular farming practices. His soil health goals are to improve soil structure and organic matter levels to increase the long-term viability of his soils to produce crops.

Jennifer Doelman operates Bonnechere Haven Farms in Douglas, with her partner, Michael and her family. They grow winter and spring canola, corn, hay, winter and spring wheat, and soybeans, incorporating covers crops and emphasizing reduced tillage. Jennifer is also a beekeeper and uses pollinator mixes in her field boundaries as a source of nutrition for her bees, native pollinators, and other beneficial insects. Through her ONFARM trial, Doelman studies the use of a cover crop and varying rates of biosolid pellets application. Her soil health goals are to increase soil resilience and biological processes to reduce risk and improve profitability.

> *Make a plan and don't try to boil the ocean. Keep it simple. Start small and hone your management practices over time.*
>
> – Jennifer Doelman

HOW DO YOU DEVELOP YOUR ON-FARM RESEARCH QUESTION?

A successful on-farm research program begins with an effective research question. Start by asking yourself – and your farm team, if applicable – what you want to learn.

Ideas for research questions can come from many places. Keep track of them throughout the growing season so you can revisit them during winter planning.[1] Some good sources include:

- Questions that come up during the growing season (e.g., will applying biosolids help reduce fertilizer costs while maintaining or increasing your corn yield?)
- Practices your neighbours are trying
- Demonstrated at ONFARM event or hosted by your local Soil and Crop Association.
- Conversations with your agronomist, CCA, or other advisors
- Articles, research updates, or newsletters from trusted agricultural organizations
- New products or practices you hear about through local trials or field days

Jot those ideas down as they come up so you can revisit them when you develop your crop plans for next year.

Once you have gathered a few ideas, the next step is to turn them into clear, focused research questions. A well-crafted research question is the foundation of a successful on-farm trial.

What makes a strong research question?

In simple terms, your research question should determine if a management practice affects an outcome.[2] Your research question should be:

- **Specific** – Focus on one change in practice
- **Straightforward** – Make sure it is easy to understand and explain
- **Measurable** – Ensure the results can be tracked using data you collect

Typically, you will want to explore whether a change in practice could lead to long-term economic and/or environmental benefits.

Examples of research questions:

- Does an application of biosolids help reduce my fertilizer costs while maintaining or increasing my corn yield?
- Does a cover crop help to address my soil health goals of improving organic matter?
- Does an application of manure help to improve soil life to boost productivity and profitability?
- Does reduced tillage improve water retention in my soil, as measured by soil moisture during dry spells?

Case study: Cover crops and Digestate on a Dairy Farm

Research question: What are the economic and agronomic impacts of combining cover crops with anaerobic digestate applications on a dairy farm over a three-year crop rotation?

One ONFARM trial tested how combining cover crops and organic amendments could benefit a dairy farm with an anaerobic digester. After harvesting winter wheat in 2020, the farmer planted an oat cover crop and applied digestate (3,500 gal/acre) a month later. The oats grew better with the digestate and were harvested as silage that fall.

In spring 2021, another digestate application was made before planting silage corn. After corn harvest, cereal rye was seeded as a cover crop. It overwintered and received a spring digestate application (4,750 gal/acre), then was harvested as silage before planting grain corn in 2022.

The farmer saw economic benefits from combining cover crops with digestate. The feed value of the oats and rye helped offset costs, and the nutrients from digestate improved yields. Over the three-year trial, the combination treatment earned a net return of $679.67 per acre. This highlights how livestock farms can benefit from integrating cover crops with organic amendments.

HOW DO YOU DESIGN YOUR TRIAL?

"Side-by-side" Demonstration

The most basic trial design is a simple splitting of your field, or a "side-by-side" demonstration. Typically, in this approach, you manage one half of your field following your standard practices and alter one practice in the other field. It is essential to keep all other management practices consistent across both sections of the trial. Otherwise, you will not know which change resulted in any differences you observe. If available, it is also a good idea to capture a GPS map or drone image of the site at the start of the trial, as this can help with planning, monitoring, and interpreting results later.

Think about your team!

Before getting started, make sure everyone involved in the fieldwork understands the trial plan. Have a list of who is involved (e.g., sprayers, contractors, family, staff) and keep them updated throughout the project. Clear communication helps avoid mistakes and ensures the trial runs smoothly from start to finish.

> *"Don't forget about the rest of your team. You need buy-in if you're going to do on-farm research. Make sure they understand the plan and why it is important. You need your team on board to carry the trial through to successful completion."*
>
> – Jennifer Doelman

Side-by-side demonstrations are a great starting point for farmers new to on-farm research because they keep the setup and data collection simple. However, we know that most fields are not uniform which can impact results. For example, your field might have a sandy knoll, a low spot where water tends to collect, or other topographical and soil conditions that affect yields. Therefore, if your control outyields the treatment, it may be because that side of the field had better conditions, not because of the management practice itself.

It is best to pick a relatively uniform area for your trial, but if that is not always possible consider using a replicated and randomized trial design. This approach helps reduce the influence of field variability on your results.

Example 1 of a trial to answer: "Can Applying Biosolids Reduce Fertilizer Costs While Maintaining or Increasing Corn Yield?"

While running a trial to answer the research question above, your "control" would be your standard fertilizer program, and your "treatment" would be a biosolids application combined with a reduced fertilizer program. In consultation with your agronomist, Certified Crop Advisor (CCA), Professional Agrologist (P.Ag.), or Nutrient Management Consultant you would come up with a reduced fertilizer program based on your soil test results and the nutrient contents of the biosolids. Apply the standard fertilizer rate to one half of the field, and the biosolids with reduced fertilizer rate on the other half.

Your trial design could look like the following:

Understanding Field Research Terms

Control: Your standard management practice.
Treatment: The single management practice that changes across a trial.

Case study: Cover Crops on a Grain Farm

Research question: How do different cover crop strategies, including bio-strip planting, affect corn yield, weed control, and potential soil health benefits in the first year of use?

An ONFARM grain farmer compared three different cover crop (CC) treatments following winter wheat. One treatment used a "bio-strip" approach which uses two rows of cover crops (a mix of cereal, legumes, and brassica) planted with two rows left bare to create strips for planting corn the following year. The other two treatments tested different cover crop mixes. A no-till corn planter was used to plant corn directly into the unplanted strips. Herbicide was used before seeding the cover crops to reduce weeds and manage volunteer winter wheat.

Corn yield and revenue were used to compare the three treatments but no major yield increase was expected in the first year. It was found that the cover crops helped suppress weeds, supported soil life, added organic matter, and contributed some nitrogen. These benefits are harder to measure in dollars in the short term.

Replicated and Randomized Trial

Repetition is key for accurately comparing control and treatment results. This means you want to compare control and treatment practices in more than one section of a field. The number of times each grouping of a treatment (or treatments) and a control is repeated in a field is known as a replication.

It is best to have three replications in your trial.[3] If you have the resources (i.e., space in the field, sufficient product, etc.), consider doing more replications. This gives you a backup if something goes wrong in one replication (e.g., if your planter has a brief issue and your seeding rate drops). More replications also make it easier to detect a difference between the control and treatment(s).[4]

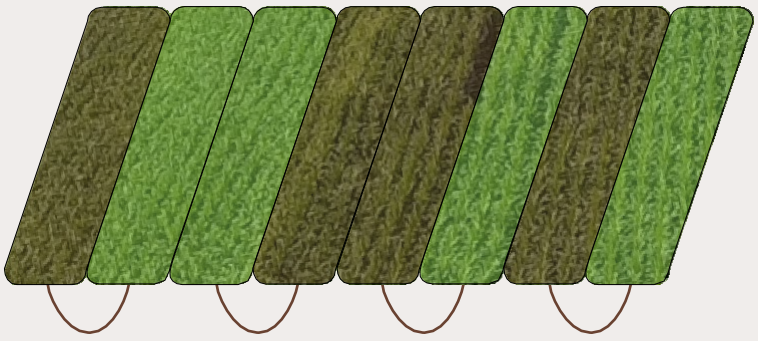
Instead of repeating the control and treatment(s) in the same order each time, it is best to randomize within each replication. This helps remove bias and improves the reliability of your results.

The Ecological Farmers Association of Ontario provides a good overview of how to generate the randomization for your trial. Using a replicated and randomized design helps reduce the effects of field variability and gives you more reliable results.

Example 2 of a trial to answer: "Can Applying Biosolids Reduce Fertilizer Costs While Maintaining or Increasing Corn Yield?"

While running a trial to answer the research question above, in a replicated and randomized trial, you would have multiple groupings of the same-sized treatments and controls. You would also switch up the order of the treatment(s) and control within each replication. In this case, we applied our control (standard fertilizer program) and the treatment (biosolids plus reduced fertilizer program) in four sections of the field or four replications.

Your trial design could look like the following:



LEGEND:

Control

Treatment

Rep = Replication

HOW DO YOU COLLECT DATA?

Your data collection system can be as simple or as detailed as you like. Some people prefer a notebook and photos, while others use digital tools, apps, or spreadsheets. Choose what works best for you and make sure you collect good, consistent data for both your control and your treatment.

Accurate records throughout the season will help you answer your research question and make decisions with confidence.

Below, you will find examples of the types of data to collect before and at planting, during the growing season, and at harvest.

> *"Keep records and notes on everything you do. Even though you have the best intentions when implementing a trial, you won't remember the details two weeks or two months from then. Recordkeeping is super important."*
>
> – Greg Hannam

TYPES OF DATA TO COLLECT ANNUALLY

Timing: Before and at planting

At the start of each control or treatment, place flags and/or wooden stakes labelled with the control or treatment number and replication number. These flags and markers will serve as handy reference points throughout the season. Make a map, even a hand-drawn one, of the field to indicate the order of the controls and treatments and any errors made during planting or product application.

Data to collect:

- Field length
- Planting date and rate
- Hybrid/variety
- Weather and soil conditions (i.e., temperature)
- Locations of controls, treatments and replications
- Soil analysis

> *"Be patient as you go through the process. As farmers, we have the greatest intentions and can set up all kinds of trials when we plant or spray but we're always crunched for time at harvest. Be patient to make sure you harvest the data you set up through a trial. Do not rush through harvest and destroy all the work you did earlier in the year."*
>
> – Greg Hannam

Timing: Throughout the growing season

During the growing season, consider collecting both quantitative and qualitative data.

Data to collect:

- Insect and disease pressures
- Weather data (i.e., temperature and rainfall)
- Agronomic monitoring, including:
  - Plant counts (emergence, establishment)
  - Weed counts or weed pressure
  - Notes from field walks (e.g., difference in visible health, colour, and growth progress between the control or treatment(s))
- Photos of the control and treatment(s)

Quantitative data includes daily high and low temperatures and total amounts of rainfall. You may consider investing in an on-farm weather station or may opt to access regional data online. The Government of Canada, for example, releases monthly climate summaries for weather stations across the country.

Qualitative data includes observable differences between the control and treatment(s). You may consider pulling sample plants periodically throughout the growing season to observe differences in crop staging, plant health, root architecture, etc.[5] Ensure you pull the plants from similar areas of the field and make notes about what you see. Take photos of these samples and clearly label whether they are from the control or treatment(s).

This data will help you make sense of your trial results at the end of each growing season.

Timing: Harvest

Harvest is a busy time, so prepare in advance. Set up a simple paper or digital template to record yields, etc., during harvest and prepare sample collection bags for your harvested grain. Medium or large freezer bags work well; be sure to label them with the replication and control or treatment numbers.

Data to collect:

- Yields
- Test weight
- Moisture
- Grade

You may opt to collect the key data from your yield monitor. Alternatively, you can measure each treatment or control strip using calibrated scales on your grain buggy or arrange for a weigh wagon and operator to assist you when you harvest your trial. No matter which equipment you use (i.e., yield monitor, weigh wagon, moisture tester, etc.), it should be calibrated. Your local agricultural service technician and/or scale service provider can assist with calibrating your equipment.

Before harvest begins, review roles and responsibilities for data collection. If you use grain buggy scales or a weigh wagon, ensure you unload your combine into the grain buggy/weigh wagon after harvesting each control or treatment in each replication. Have the operator record each harvest weight on the template and pull a representative sample for each control or treatment.

HOW DO YOU ANALYZE YOUR DATA?

After you finish harvest, you are ready to analyze your data.

You can determine the moisture of the samples you collected using a handheld moisture meter. You can use this tool from the Canadian Grain Commission to calculate your test weights.

You can also calculate the yields in bushels/acre for each control or treatment (check out Purdue University's helpful resource for calculating harvest yields). Seed companies also typically have fillable Excel spreadsheets for calculating yields from plots; consider contacting your local farm input dealer to see if they have a template to share.

If you conducted a side-by-side trial, you could compare the yield, test weight, moisture, etc., of the treatment(s) versus the control, keeping in mind that field variability may have influenced your results.

If you conducted a randomized and replicated trial, you could use statistical analysis to understand whether the difference between your control and treatment(s) "is by random chance or due to the treatment you are testing."[6] Sustainable Agriculture Research and Education provides a good overview of the relevant types of statistics;[7] your agronomist, CCA, or P.Ag. may also be able to help you with this work.

WHAT CAN YOU EXTRAPOLATE FROM YOUR DATA?

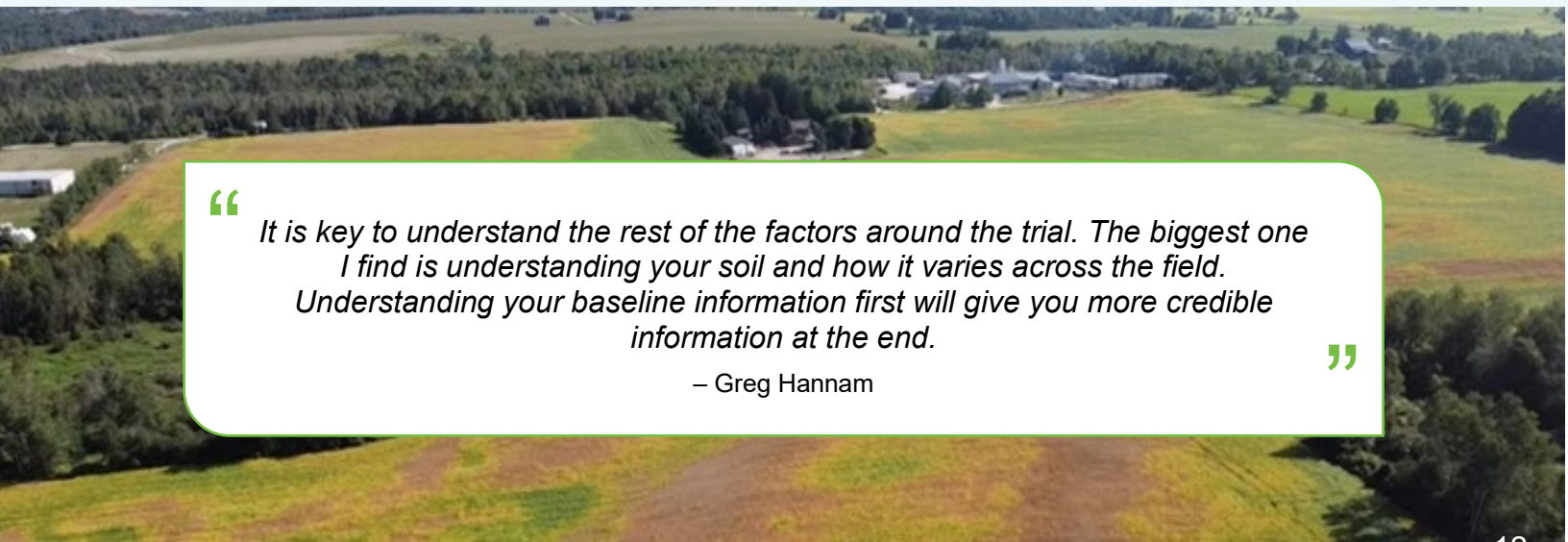
Once you analyze the data taken over the year, take the opportunity to reflect on the broader picture. Consider whether the trial answered your research question. If the trial did not answer your question, consider if growing conditions affected your results. For example, maybe your field was hit with a disease that decreased yields. It is generally worthwhile running the trial again next year, both to see if more favourable conditions lead to better results and to confirm whether your findings remain consistent.

Remember, on-farm research is a continual learning journey. If you saw promising results from your trial, consider repeating the trial in a different field next year or testing more acres under the new production practice. If you do not see the desired results, consider the factors that may have caused this outcome and revise your on-farm research process or treatments for next year. By repeating the trial over several years, you can analyze the consistency of results. And, if you conduct the trial several times in the same field, you can see if "compounding" results occur. For example, you may see that the use of biosolids help reduce the cost of fertilizer while increasing crop yields.

Reflect on the management practices associated with your treatment(s). Did they produce a return on investment? Would it be feasible and worthwhile to implement the changed management practices on more acres? Some benefits are not easily measurable, so rely on your knowledge and experience when deciding whether to adopt new management practices on your farm.

If possible, compare your results to what other farmers and researchers are sharing through grower or social networks, or extension resources. These comparisons can help to contextualize your results and provide insights into whether your observations are part of a larger trend. The ONFARM program shows the benefits of a grower network in advancing on-farm research and knowledge of best management practices.

Finally, consider your experience with the on-farm research process more generally. What lessons did you learn? How could you improve or streamline this process for your next trial?



> *"It is key to understand the rest of the factors around the trial. The biggest one I find is understanding your soil and how it varies across the field. Understanding your baseline information first will give you more credible information at the end."*
>
> – Greg Hannam

On-Farm Trial Planning Worksheet

Use this worksheet to help plan, refine, and carry out your on-farm research project.

What do you want to learn?

Write a clear research question (e.g., does reduced tillage improve soil moisture after rainfall). Feel free to work through the worksheet and come back to this question.

My research question:

_____

_____

_____

Remember:

Specific – focus on one change in practice

Straightforward – Make sure it is easy to understand and explain

Measurable – Ensure the results can be tracked using data you collect

What will you test?

New practice or product:

_____

_____

_____

What will you compare it to (your control):

_____

_____

_____

Why does this matter to your farm?

- ☐ Cost savings
- ☐ Soil health
- ☐ Yield
- ☐ Environmental benefits
- ☐ Other:

_____

How will you set up the trial

- ☐ Side-by-side
- ☐ Replicated and randomized

# of replications: _____

Location: _____

Who's involved?

_____

_____

_____

What will you measure and how?

What (e.g., yield, soil moisture, crop health, input costs)	How (what tools and methods are needed)	When will measurements be taken	Who will take the measurements

What's your starting point (baseline)?

(e.g., soils test results, previous yield, past practices)

_____

_____

_____

How will you track results?

- ☐ Field notebook
- ☐ Photos
- ☐ GPS and/or drone images
- ☐ Yield monitor
- ☐ Maps
- ☐ Other:

WANT TO LEARN MORE?

If you want to learn more about on-farm research, start by visiting the ONFARM website. Then, check out these additional resources:

- BC Forage Council. (2016.) A Guide to On-Farm Demonstration Research: How to Plan, Prepare and Conduct Your Own On-Farm Trials. Retrieved from: https://www.climateagriculturebc.ca/app/ uploads/FI03-On-Farm-Demonstration-Research-Guide.pdf

- Ecological Farmers Association of Ontario. (n.d.) Farmer-Led Research. Retrieved from: https:// efao.ca/farmer-led-research/

- Jeremy Boychyn. “Simple Steps for On-Farm Trials.” *Better Farming Prairies*. July/August 2020. Retrieved from: https://www.betterfarming.com/flippingbook/better-farming-prairie/2020/july/#40

- Organic Seed Alliance. (2014.) Introduction to On-Farm Organic Plant Breeding. Retrieved from: https://seedalliance.org/publications/introduction-to-on-farm-organic-plant-breeding/

- Practical Farmers of Iowa. (n.d.) Farmer-Led Research. Retrieved from: https://practicalfarmers. org/programs/farmer-led-research/

- Sustainable Agriculture Research & Education. (January 2017.) How to Conduct Research on Your Farm or Ranch. Retrieved from: https://www.sare.org/wp-content/uploads/how-to-conduct- research-on-your-farm-or-ranch.pdf.

Need help with learning about your soil and soil testing?

- Check out OMAFA’s list of accredited soil testing labs to find a lab near you: https://www.ontario.ca/page/soil-leaf-and-petiole-tissue-and-forages-and-feed-testing-labs
- Check out OMAFA’s soil data map to learn more about your soil: https://www.ontario.ca/page/soil-data

ENDNOTES

1 Jeremy Boychyn. “Small Steps for On-Farm Trials.” *Better Farming Prairies*. July/August 2020, 41. Retrieved from: https://www.betterfarming.com/flippingbook/better-farming-prairie/2020/ july/#40

2 Jeremy Boychyn. “Small Steps for On-Farm Trials.” *Better Farming Prairies*. July/August 2020, 41. Retrieved from: https://www.betterfarming.com/flippingbook/better-farming-prairie/2020/ july/#40

3 Ecological Farmers Association of Ontario. (2021.) Farmer-Led Research FAQ. Retrieved from: https://efao.ca/farmer-led-research/.

4 Ecological Farmers Association of Ontario. (2021.) Farmer-Led Research FAQ. Retrieved from: https://efao.ca/farmer-led-research/.

5 OMAFRA’s Agronomy Guide for Field Crops provides a helpful overview of plant growth stages. See Ontario Ministry of Agriculture, Food and Rural Affairs. (2017.) Agronomy Guide for Field Crops. Publication 811. Retrieved from: https://www.ontario.ca/files/2022-10/omafra-agronomy-guide-for-field-crops-en-2022-10-13.pdf.

6 Ecological Farmers Association of Ontario. (2021.) Farmer-Led Research FAQ. Retrieved from: https://efao.ca/farmer-led-research/.

7 Sustainable Agriculture Research & Education. (January 2017.) How to Conduct Research on Your Farm or Ranch. Retrieved from: https://www.sare.org/wp-content/uploads/how-to- conduct-research-on-your-farm-or-ranch.pdf, 16-19.