Ag Innovations Series

TECHNICAL BULLETIN

Peer-reviewed research findings and practical strategies for advancing sustainable agriculture systems

Farmer Umi Martin is pruning mango trees in one of the two orchard systems he evaluated during a multi-year research project on his farm. His goal is to give small-scale farmers new opportunities by showing that high-density, low-cost mango production is possible in Hawaii. *Photo by LD Productions (SARE grants FW17-034 and FW21-375)*

10 Steps for Conducting Research on Your Farm or Ranch

Introduction

If you're a farmer or rancher, you deal with the realities and challenges of agriculture in your daily life. And you probably have ideas of how to do things more sustainably. But farms and ranches are very complex, and making a major change—whether it's in growing a crop, managing a pest or marketing a product—comes with risk because you don't know how it'll turn out. This is where research can be a valuable tool.

The purpose of research is to generate information to answer questions. In many ways, the very best people to conduct research are producers themselves. You understand what kinds of information you need to help you make sound decisions, streamline your work, and take excellent care of your land and water, your animals, your crops and your family, while also staying profitable. A research project on your farm could give you the answers you seek and help others as well. This workbook is designed to help your research project succeed!

Using This Workbook

This workbook will help you turn your ideas into a clearly defined research project that you can do on your farm. We'll walk you through each step, from the idea phase all the way through implementation and the final presentation of results. These steps, which we've structured as learning lessons, are:

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Available at:
www.sare.org/research-workbook or order free hard copies at (301) 779-1007.

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SARE Sustainable Agriculture Research & Education

Participants at a field day are learning about the results of a farmer's research project on the use of no-till methods in organic vegetable production. *Photo courtesy of Sandra Dietz (SARE grant FNC23-1370)*

- Lesson 1: Identify Your Research Question
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- Lesson 10: Considerations, Tips, and Tidbits[1]

We recommend you read through all 10 lessons before getting started on your own research project. This will give you a clear idea of what to expect from the process. Each lesson also contains a set of assignments and self-assessments that you should come back to and complete when you've arrived at that step in your project. These prompts are designed to keep you on track to achieve your research objectives and provide actionable, robust solutions for your operation.

The Project Journal

By their nature, research projects are usually complex to manage, and keeping yourself organized is critical to success. That's why we recommend starting a project journal. This is an excellent practice that will greatly improve your analysis, interpretations and reporting. Starting this journal now will help you stay organized with your ideas, plans, notes and sources of key information as you go along. Also, you can use it for the assignments in this workbook. Later on in the project you can use the same journal for recording data and any trends, insights, or observations.

Additional Resources

We provide examples where appropriate, and Lesson 10 includes some advice from people who have experience managing SARE's Farmer/Rancher Grant programs. This workbook won't teach you everything you need to know about experimental design, statistics, and other complex topics, but it'll help you find the additional resources you need.

We've also included a short section of additional on-farm research resources, and a Sample Forms section with templates of important documents that you may need during your project.

Grant Considerations

If your research involves external funding, the exercises in this workbook will help you prepare grant proposals and fulfill program requirements. The document templates in the Sample Forms section may be especially useful if you plan to apply for a grant as part of your research project. Please be aware that using this workbook doesn't guarantee success in competitive grant programs, including those offered by SARE.

About the Photos in This Guide

All of the photos we included in this workbook were taken from SARE-funded projects, either farmer-led projects or ones that took place on farms through collaboration with state Extension specialists. If you're interested in learning more about a project, visit projects.sare.org and search by the grant number(s) we include with each caption.

DIG DEEPER INTO ON-FARM RESEARCH

This workbook will help you create a plan for your own research project. It's a companion to SARE's technical bulletin *How to Conduct Research On Your Farm Or Ranch* (www.sare.org/research), which provides more detailed information on some of the key lessons outlined in this workbook. For example, we recommend you refer to *How to Conduct Research On Your Farm Or Ranch* when learning about complex topics such as experimental design and statistical analysis of data.

[1] While not addressing a required step in the research process, this lesson discusses important topics such as where to look for expert support and applying for a grant for your project.

Lesson 1: Identify Your Research Question

The first step in developing a research project is to define the problem you want to solve or the question you want to answer. Sustainable agriculture is constantly evolving, with new challenges and innovations emerging every day. Your task here is to choose a specific question that, if solved, would allow you to improve your operation in a meaningful way.

When setting out to learn more about your initial research idea, it can be very helpful to attend university field days on related topics. These farmers are talking during a University of Maine field day for blueberry producers. *Photo courtesy of Lily Calderwood (SARE grant LNE25-483)*

Become (Even More of) an Expert

Once you've identified the general problem you'd like to solve, collect as much information about the issue as you can. This will help you build your project on a solid foundation of knowledge and find the best solution possible. It will also ensure that you're filling a gap in the current body of knowledge, therefore providing new and useful information.

The first source of information you should look to is your own experience. What have you observed? What ideas have you tried, and what was the result? You can expand on your own experience by talking to your neighbors and other producers. Often, conferences and field days hosted by universities or industry groups include presentations and working groups focused on current issues. Ask lots of questions, taking thorough notes as you learn.

Talking with other farmers is a great way to bring your research question into focus, and it can open the door to collaboration. Iowa farmers Bob Recker (left) and Mike Cook (right) worked together on a project to study the use of cover crops in wide-row corn. *Photo courtesy Practical Farmers of Iowa (SARE grants FNC21-1297 and FNC22-1348)*

Also, read up on your problem. Published information can range from bulletins available through your county Extension office or USDA service center, to magazine articles, e-newsletters, and trade journals. Depending on the nature of your question, you might also find good information in scientific literature.

As you find useful publications, keep copies in your files to refer to later. In case you decide to write up the results of your project for a publication, you'll need to properly cite your sources and provide references to them.

Focus Your Question

As you gain knowledge about your problem, use it to refine and focus your question. The more specific you can be about your research question, the easier it'll be to design a project that can answer it.

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For example, consider the question, "Do cover crops help improve soil health?" Your first thought might be that the obvious answer is yes, because most folks have heard of the benefits of cover crops. But if you decide you want to act on this information and use cover crops on your own farm, suddenly things aren't so simple. For example, what aspect of soil health do you need to improve? Which cover crop varieties or combinations might help you the most? When and how should you add cover crops to your rotations to see the benefits you're hoping for? How will you measure what you want to know? Could certain cover crops cause more problems than they solve? Though most farmers appreciate the general benefits of cover crops, many have questions about how to use them effectively.

By focusing on real-world questions, you can build a research project on your farm to provide answers that you and others can act on.

Lesson 1 Worksheet Identify Your Research Question

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

The following questions will help you refine the question that will form the basis of your research project. These assignments are just for you and anyone you choose to share them with, so please complete them as thoughtfully as possible, and don't hesitate to go back and change answers as you work through the lessons. Use the self-evaluation questions in the next section to help make sure you get the most out of this assignment.

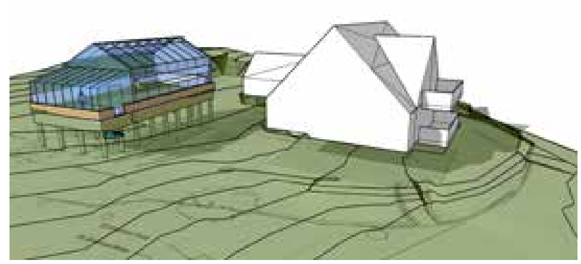
1. List a few sources of information about the topics related to your problem or question. Remember, this can include both publications and people—yourself, your neighbors, or others in the farming community. The more, the better! Remember to keep track of these resources for your reference and for citation later on. Your project journal would be a great place for this information.
2. Consider including SARE's database of funded projects (projects.sare.org) in your background research at this time. This is particularly important if you're using this workbook because you plan to apply for a SARE grant. If you find useful information or inspiration, take notes in your project journal. List a few of the relevant project number(s) and title(s) here too, so you can easily reference them again.
3. Summarize what you learned from all the resources you've found that helps you think about potential solutions to your problem. You can be brief here if more detailed notes are in your project journal.
4. Does the information you found in published or online resources align with your own observations or those of your neighbors? If not, how can this be explained? Note that any differences between your experiences and the generally accepted assumptions could point to an important research question.
5. Do you feel you've identified an area where the available information doesn't adequately answer an important question? Describe this knowledge gap.
6. If you found an answer to your initial question, are there any follow-up questions you could address with your project?
7. Before you move on to Lesson 2, state your research question as clearly as possible. Keep in mind that your project can and will evolve as you move forward.

ASSIGNMENT SELF-EVALUATION

1. Do you feel confident that you have a sense of the state of knowledge surrounding your question?
2. Do you feel there's more you should understand before you move on?

Lesson 2: Choose Your Type of Research Project





Three types of research commonly used on farms to solve different kinds of problems or answer questions include an observational study (left), an experiment (middle), and an engineering project (right). *From left, photos courtesy of Kristen Loria (SARE grant LNE22-444), Josef Görres (SARE grant ONE21-391), and Derek Lowstuter (SARE grant FNC20-1234)*

Congratulations on forming a research question that will provide the foundation for your project! The next step is to decide how best to approach that question. Let's look at three common types of research that farmers use to learn and contribute to the body of knowledge in different ways.

Observation

Observation is the most basic type of research. All farmers and ranchers rely on observations to inform their day-to-day actions and long-term decision-making. While it's something we can do casually, observation becomes a useful research tool when you enhance the process by recording detailed data in a meaningful and careful way. For example, this can include quantitative weather observations, water quality measurements or soil test results.

Often, observational research can make a big difference to farmers by showing how trends in the larger world apply at the local scale. For example, as new crop varieties and livestock breeds enter the market, understanding how they perform with specific soil types, local climates or markets can make a real difference. You can gain these insights through on-farm testing and observation. Cultural, social and economic trends in local communities and markets can also be different compared to global or national trends.

Getting the most out of observational research requires that you carefully select your methods for collecting data and keeping records.

Engineering

Farmers work very closely with technology, machinery and other equipment, and can often solve production problems through engineering. For example, you might be able to improve farm operations by adapting harvest equipment to better handle a specialty crop, modifying a facility to reduce livestock stress, or redesigning a process to use less water or energy. When you have an engineering idea, you can figure out whether it is proving successful by describing the challenge you're trying to solve, documenting the design solution, and measuring its performance. This also allows you, the inventor, to bring the benefits of your engineering solution to others.

Experiments

Scientists use experiments to advance our understanding of natural processes. Maybe your research question involves an idea about how to improve something, or is about what's causing a particular problem. An experiment could help you to test your idea or explanation.

Experiments are structured around formal methods to test a hypothesis: a concise statement of what will happen under carefully controlled conditions if your guess about the process is correct.

For example, the causes of food spoilage were mysterious until the mid-19th century, when Louis Pasteur began conducting experiments. Bacteria were unknown at that time; Pasteur was the first to think that something in the environment was causing food to spoil. To test his guess about the role of contamination, he set up experiments involving sterile food samples. Some of these samples were exposed to the outside environment and others remained sealed. His hypothesis, based on the theory of contamination, was that the food samples stored openly would spoil, while the sealed samples would not. Pasteur's experiments supported his hypotheses and changed the world. You may recognize his name as the root of the word "pasteurize."

Making Decisions About Your Type of Project

Whether your research topic relates to crop or livestock production, marketing, social trends, ecological impacts, consumer preferences or any other topic in sustainable agriculture, you'll now need to decide whether your project will consist of observation, engineering, or experimental research.

You'll also need to start thinking about what data you want to collect. We go deeper into this topic in Lesson 4. For each research type, you can use many kinds of data, such as:

- physical and chemical measurements (such as soil texture or nutrient levels)
- biological measurements (such as plant growth, or pest and disease levels)
- surveys and questionnaires (such as customer taste preferences or buying habits)
- descriptions of animal behaviors (such as feeding preferences, grazing patterns, or temperament)
- inventory, marketing, and other economic data (such as input costs, sales records, customer feedback, or labor costs)

The lessons that follow will be useful no matter if your project is based on observation, engineering, or an experiment.

Lesson 2 Worksheet — Choose Your Type of Research Project

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

The questions in this assignment include example answers from two different scenarios. We carry these examples through each of the questions here to illustrate how you can use them to identify a research approach for your situation.

1. What is the problem you want to address?

   Example 1: *I'm a mushroom grower, and I use my spent mushroom growing medium as a soil amendment in my garden. I'd like to know if it would be worth making biochar from this medium; would it help my garden more?*

   Example 2: *I see studies that say consumers are unwilling to pay extra for labels like "pesticide free" or "climate smart" on their food. I wonder how much of that is because of a lack of knowledge about environmental risks in our food system. I also wonder what information consumers want, to help them make informed buying choices.*

2. What sort of solution do you need?

   Example 1: *I'd like to have a comparison of garden yields when adding mushroom medium versus biochar, just to see which gives me the better yields.*

   Example 2: *I want to understand what people know about how their food choices affect the environment and their health. I want to know the level of knowledge people have about the connections between environmental issues and food.*

3. What do you think might be the best research approach to try to solve this problem? Why do you think this approach will provide the best solutions for you? (Remember you'll have a chance to change this later if needed).

   Example 1: *An **experiment**. I have an existing practice and an idea for a new approach to it. Also, I have an idea which approach might be better, so I can use this as my hypothesis. I would like to know if it really will work out as I predict. Whether it does or doesn't, I think this might be useful for both me and other growers to know.*

   Example 2: *I don't have a preconceived notion of people's level of knowledge about environmental issues or interest in them, but I think it's important to understand this when communicating with the public about sustainable food products. How can I describe the health and environmental benefits of my products in a way that makes sense to people? I think I would get a clearer answer if I don't start with too many assumptions, so I don't think it makes sense to test a hypothesis. An **observational study** would be a better choice.*

4. Briefly describe a general plan for how you might go about this research. This plan doesn't need to provide a lot of detail, as that will come in later lessons.

   Example 1: *I could make some biochar and use it in part of the garden while just using the spent growth medium in the other part. I would keep records and compare yields.*

   Example 2: *I could create a quiz about environmental issues related to food, and ask people to take it. I could offer it in person or via social media, or both. I'm interested in learning about good methods for this type of project.*

ASSIGNMENT SELF-EVALUATION

1. Think about the problem you've identified and the research approach you've chosen. Imagine working through the project with everything going perfectly. Will the answers you find enable you to improve your operation in a meaningful way? Will this information help others as well?

2. Now imagine that your project encounters unexpected difficulties and doesn't go as planned. What might you learn? Sometimes, great information comes from "failed" projects!

Lesson 3: Develop a Hypothesis or Research Objective

This lesson is most relevant when you've chosen to conduct an experiment. We've included brief sections at the end to discuss how you can adapt the concepts outlined here for both observational and engineering projects.

When Conducting an Experiment

The research hypothesis is the basis of an experiment that's designed to test a guess or idea about how something works. To conduct an experiment, a researcher sets up a controlled situation in which the outcome tells us whether or not the guess is correct. The **hypothesis** is some version of this if-then statement:

This plot is from an experiment that a Wisconsin farmer set up to test their hypothesis that adding straw mulch and wine cap mushrooms to their fields could improve plant vigor and yield in their main cash crops. This plot shows tomatoes growing among one of the treatments: the addition of both straw and mushrooms. The project included another treatment, mulch only, as well as control plots. *Photo courtesy of Lindsey Bender (SARE grant FNC20-1208)*

TABLE 1. Examples of Dependent and Independent Variables

VARIABLE TYPE	DEFINITION	EXAMPLES
Independent	factors you can control	crop variety, fertilizer type or amount, irrigation levels, pest control tactics
Dependent	factors you measure	crop yields, soil nutrients, soil moisture, pest numbers

"*If* my guess is correct, *then* the following will happen."

For example, consider an experiment to test the idea that water stress influences the development of heat in peppers. You might divide a field into plots and irrigate the peppers in a controlled way. Some plots receive normal irrigation, while others are given several lower rates of irrigation. Your hypothesis might be that the peppers grown in dry plots will score higher on the Scoville scale for heat than the ones grown with irrigation.

To develop your hypothesis, take the question you developed in the last lesson and think about it now in terms of exploring the relationship between two (or more) variables. A **variable** is any factor that can change and be measured to determine how it affects an outcome. The variable you have direct control over, or can change, is called the **independent variable**. The **dependent variable**, by contrast, is something you can't control, and is influenced by the independent variable. The dependent variable is what you measure during research. Essentially, the independent variable is a cause, while the dependent variable is an effect. In the pepper scenario we just presented, the amount of irrigation you provide to the plots is your independent variable, and the Scoville scores that result is your dependent variable (Table 1).

Here's another example: Imagine you're an aquaculture farmer and you want to test if a water additive will improve how many fish eggs survive during shipping. You set up the experiment by placing the eggs in the shipping containers and adding varying amounts of the additive to each one. You control the amount of additive in each container of eggs, so that's the independent variable. The percentage of eggs still alive in each container after shipping depends on the effects of the additive; therefore it's the dependent variable. Your hypothesis in this case is that the percentage of eggs that survive will go up as the amount of additive goes up.

The farmers at Honey Brook Organic Farm in New Jersey make their own compost using the traditional windrow method, which requires the use of machinery to turn piles. They wanted to see if they could save on labor, fuel and machinery costs through the use of an aerated static pile system (pictured here under construction), so they conducted a side-by-side comparison of the two techniques. *Photo courtesy Sherry Dudas (SARE grant FNE21-979)*

This model is one of many design plans that a Maine oyster farmer created for their engineering project. They wanted to modify an existing solar-powered raft system they use in their operation, with an eye toward improving its reliability and efficiency. *Photo courtesy of Luke Saindon (SARE grant FNE25-131)*

Lesson Adaptation for Engineering Projects

Engineering projects focus on creating a solution that "works." It's almost as if your hypothesis is that your design will do the job required, where previously existing solutions didn't. For this type of project, defining your objective means setting the criteria for how you'll determine if your efforts have been successful. To solve the problem you identified, what exactly does your invention need to be able to do?

Express the criteria for success in specific, quantitative terms. For example, if you have an idea for how to remove moisture in stored berries to slow spoilage, success would be demonstrated by both a decrease in relative humidity in the storage container, and an increase in the number of days that pass before spoilage occurs.

Lesson Adaptation for Observational Research

While observational research doesn't require a hypothesis or benchmarks for success, getting specific about what you hope to learn is still important. In fact, while it isn't necessary, you can also view observational research in terms of independent and dependent variables. For example, if your observations relate to understanding peoples' taste preferences across generations, you could view the age of survey respondents as an independent variable, and what you want to learn about their changing preferences is like a dependent variable. Think about how to quantify your question in these terms.

Pennsylvania agroforestry farmer Erik Hagan did an observational project to explore cooperative marketing opportunities for the American chestnut. Here, a member of his project team is collecting taste test data from members of the farming community at the Pasa Sustainable Agriculture Conference. *Photo courtesy Erik Hagan (SARE grant FNE18-896)*

Lesson 3 Worksheet Develop a Hypothesis or Research Objective

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

1. **For an experiment**, state your hypothesis. To give context, start by quickly summarizing the project.

   Example: *I plan to test the effectiveness of a parasitic wasp in controlling a specific species of caterpillar causing damage to my broccoli crop. As soon as I see a full hatch of caterpillars, I plan to install several large screen enclosures and introduce the wasps into some of them. My hypothesis is that the plants in enclosures containing the wasps will exhibit less damage from caterpillars than the plants without wasps. The wasps are my independent variable, and caterpillar damage to plants is my dependent variable.*

   For observational research, state what you hope to demonstrate. To give context, start by quickly summarizing the project.

   Example: *I want to do a better job of managing weeds. In order to do that, I need to learn about the timing of life stages of the weeds on my farm. To get this information, I'll walk transects on my farm every week throughout the growing season, recording weed species and growth stages. My objective is to construct a timeline of the growth stages of important weed species, which I hope will help inform my weed management decisions in the future. The dates I choose for scouting represent my "independent variable," and the data I record about weed growth are my "dependent variables."*

   For an engineering project, start by quickly summarizing the project to give context. Then, describe in quantitative detail the criteria for success. If appropriate, contrast this with the situation you're facing without your solution available.

   Example: *My objective is to develop a screen system to clean camelina seed, one that's capable of removing pennycress seed as well as hulls and chaff. I will consider my project a success if I can achieve output with at least 95% pure camelina seed from a sample that has at least 15% contamination by pennycress seed. With the currently available screen system, the best I have achieved is 76% purity. My "independent variable" would be the configuration of my screen system that I think can improve purity (e.g., the number of screens and mesh size), and my "dependent variable" is the level of purity that different configurations achieve.*

2. **For experimental research**, answer the following questions. Remember that doing so for engineering and observational projects isn't necessary, but can be helpful:

   a. What is/are the independent variable(s)?

   b. What is/are the dependent variable(s)?

ASSIGNMENT SELF-EVALUATION

1. Does your hypothesis or research objective meet all of these criteria?
   - ☐ It is clear, specific and objective; it's not dependent on questionable assumptions
   - ☐ It is based on a solid foundation of knowledge. There should be good reasons to think your project will produce useful results; you're moving beyond speculation.
   - ☐ It fills a knowledge gap. You should be contributing new information, not just confirming existing knowledge.
   - ☐ It is repeatable. If someone else were to repeat the project in the same way, under the same conditions, they should get the same results.
   - ☐ It is testable using measurable, quantitative observations, not opinions, judgments or interpretations.

2. Look back at your work from the previous two lessons. If you meet your new research objective or support your hypothesis, will it provide an answer to your initial question (or the beginning of an answer), or represent a step toward a solution to your problem? Please explain.

Lesson 4: Design Your Project

The Baltimore farmers who organized this research project used both qualitative and quantitative data to study the sustainable production of grains, corn and legumes in urban systems. Among other datasets, they measured corn yields after hand harvest (left), and took photos of corn and bean plots as a visual record of crop establishment and growth based on different planting dates (all photos were taken on 10/18 as indicated). *Photos courtesy of Denzel Mitchell Jr. (SARE grant FNE22-021)*

Thinking through all the details of your project before you start the work is critical to your success. The following considerations will help you design your project, regardless of which project type you've selected.

Experimental design can be complex. We'll outline the topic in this lesson, but we also recommend you read the "Basics of Experimental Design" section in SARE's technical bulletin, *How to Conduct Research On Your Farm Or Ranch* (www.sare.org/research). This is also a good time to find local specialists who can work with you on your project, such as Cooperative Extension staff. Try to find a person who can help with both experimental design and the collection and analysis of data, which we discuss in lessons 6 and 7.

Data

All types of research will involve collecting, recording and managing data. One of the most important decisions you'll make as you design your project is selecting exactly what data you need to collect to answer your question.

Quantitative data is in the form of numbers. If your question is related to crop yields, you might choose to measure the weight of the entire harvest per acre, or some subset of that. For projects involving some aspect of soil health, you may be collecting samples and sending them to a lab. Lab results will include quantitative measurements of amounts of nutrients or other substances in the soil sample, for example. For market or public opinion data, you may be conducting a survey by phone, online, or in person. Quantitative results from this type of data collection could include the percentage of survey respondents giving certain answers.

By contrast, **qualitative data** is descriptive information that isn't expressed in numbers. Qualitative information can include survey or interview responses, photos, or detailed notes.

Whether it is qualitative or quantitative, the data you use should be a reliable indicator of whatever you're trying to demonstrate. It should be responsive to the processes involved and sensitive enough to demonstrate what you're trying to show, within the timeframe of your project. For example, dynamic soil properties, such as organic matter content, respond to farming practices more readily than static properties that don't change with time or treatment, such as soil texture (or, the relative amounts of sand, silt, and clay).

You'll also need to decide how much data to collect. One way to collect more data is to repeat the same experiment multiple times. This helps control for changes in moisture, temperature, and so on, over the course of the repeated trials. The more repetitions or samples your project includes, the more confident you can be in your conclusions. At the same time, you should carefully consider your limitations in time, space, funding, and so on, and keep your plans realistic. It's helpful to consider exactly how you'll use the data you collect; what will it tell you?

Managing Variables

Think about what you'll learn from the data you collect. This information will help you to understand relationships between the important variables you've identified. Whether or not your project involves testing a hypothesis, you need to understand the forces bringing about your results. Could the story emerging from your data be caused by something other than what you're testing? Are there processes going on that may confuse the story? As you design your project, think about how to eliminate or reduce the effects of unrelated factors.

Also, it's important to make sure that conditions affecting the various parts of the project are as similar as possible. For example, in livestock experiments where you're planning to compare different groups of animals, make sure the groups are composed of animals of similar sizes, ages, breeds, sexes, and so on, so that any differences you observe between groups can't simply be attributed to those factors. For crops, ensure that soil types, slope, watering, plant variety, and other factors are as similar as possible in compared plots (Figure 1).

In projects involving land areas, plant or animal populations, or human groups, you may be collecting data to understand differences across a population or area. Your data needs to accurately represent whatever you're sampling, so you'll want your samples to represent the variability that exists. In general, if the population or area you're sampling is highly complex or variable, it takes more samples to capture its characteristics. To make sure your data tells a complete and accurate story, you need a good sampling plan. For example, if you're collecting soil samples in a field, ensure that you sample different areas across the field. Or if you're surveying people, you might focus on a population that's within the same generation. There are many different methods you can use to ensure a representative sample of an area, including using random locations or a grid pattern of locations.

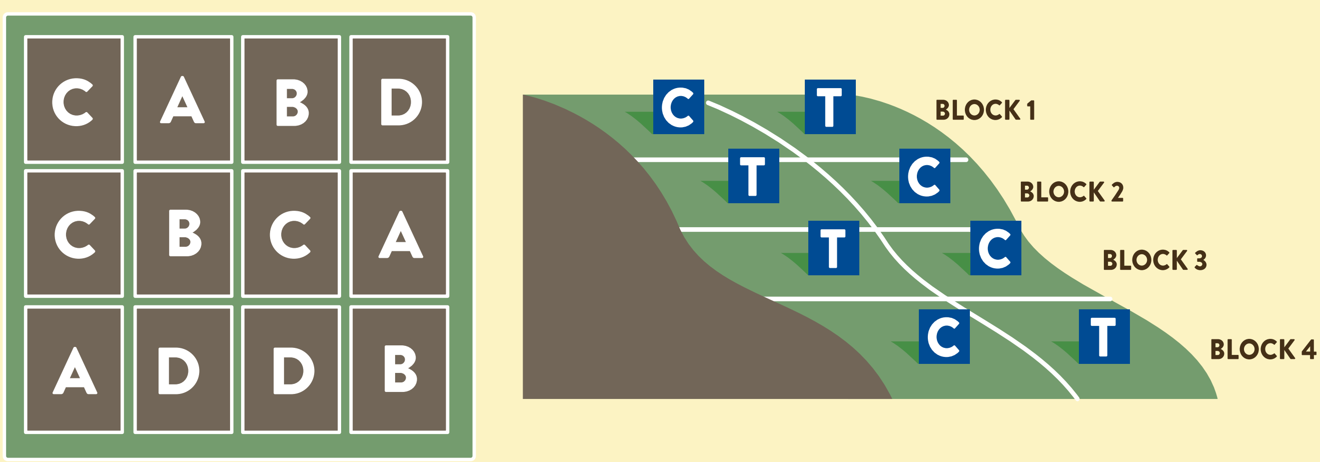
Researchers themselves are another important variable that can influence research outcomes. A well-designed project needs to consider ways to manage bias in data collection and interpretation. Simply stated, bias is the tendency of observers to see what they want or expect to see. There are many ways to reduce the influence of bias in data collection, such as assigning data collection to someone unfamiliar with the premise of the research and selecting sampling locations in a systematic way.

Project Design Considerations for Experimental Research

Hypothesis-testing experiments require a rigorously structured design to isolate the variables and produce reliable information. One important way to do this is to divide the experimental area or population into two or more groups and compare how they respond to different conditions. One of the groups or plots is called the **treatment**, and it receives the input, or treatment, you're testing. The other group is the **control**, and it doesn't receive the treatment. For example, if you're testing the effect of a feed supplement on animal performance, the treatment group receives the supplement and the control group doesn't.

The control group is your baseline—eventually you'll compare the performance of the treatment group to the performance of the control group, allowing you to see if the treatment offers a valuable change. Ideally, other than receiving the treatment, the treatment group, or plot in the case of a crop study, is identical in every way to the control. Many variations on this design are possible, including combinations or levels of treatments, but in all cases the control is an important part of experimental design.

FIGURE 1. Examples of How to Design an Experiment



Design the layout of your experimental plots to make conditions as uniform as possible. A completely randomized design (left) works best in tightly controlled situations with uniform conditions. On the right is an example of how to design a project when conditions are variable, in this case due to a sloped field. The field is divided across the slope into blocks, and within each block the plots are placed randomly. This does two things: It makes conditions consistent within each block, and it captures the range of field variability when all blocks are taken together. These examples are from SARE's technical bulletin; visit www.sare.org/research to learn more about this topic.

Lesson 4 Worksheet Design Your Project

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

The following assignments are provided to help you develop your research project. Later lessons will have you dive deeper into important parts of project design. And remember, we recommend you seek out additional support, through both publications (see www.sare.org/research) and consultants, as you do this assignment.

1. Describe your project design, using a slight variation on the classic list of questions:
   - **WHAT** do you plan to do? What sort of experimental design will you use? What data will you collect?
   - **HOW** will you set up and conduct your project? Is there a published method you'll follow? How many animals, plots, people, or other elements will your project involve?
   - **WHERE** will you conduct your project? Do you have access to the land or facilities you need? Is the layout of the experimental design practical to manage with the equipment you have?
   - **WHEN** does the project begin and end? How long will it take? Is this timeline consistent with constraints, such as the time limits for a grant-funded project? When will you apply your treatments? When will you collect samples, and how frequently will you collect them?
   - **WHO** will do the work involved in this project? Think about who will obtain supplies, set up the project, collect and analyze data, write reports, and conduct any outreach activities, such as field demonstrations. Identify any outside contributors such as laboratories to analyze samples or process images. This person or people will need to balance the project with their regular duties.
2. Restate your hypothesis in terms of the specific data you plan to collect.

ASSIGNMENT SELF-EVALUATION

1. Does your design have an appropriate control? If no control is needed, explain why not.
2. What's the relationship between the data you plan to collect and your hypothesis or objective? Have you selected the most reliable indicator of the effect you want to show?
3. Look at every kind of data you plan to collect. Is each piece necessary for determining whether your hypothesis or objectives are supported? If it's not necessary, collecting it is potentially a waste of your time and money.
4. If your data doesn't show what you think it will, what will you learn from this? Remember not to get discouraged by this outcome—even if it's not what you expected, you can still learn something that's potentially of value to you.
5. If you run this experiment, could your results be explained by any variables other than what you're testing? If so, is there a way to adjust your design to minimize the effects of those variables?

Lesson 5: Take a Closer Look at Your Plan

You can design an elaborate, scientifically sound experiment on paper, but when it comes to implementing it in the field, it's easy to discover a wide range of pitfalls or limitations. To ensure success, dig into the fine details of your plan to identify any potential bottlenecks in things like space, time, machinery, materials, or budgets. As you examine your plan, make sure to include all phases of the project, including data analysis and outreach. These and other important phases are addressed in later lessons.

Locations: Fields, Plots, Pens, and Facilities

Where will your project take place? Think in detail about how the location may affect your results. If you're doing crop research, is there an area in your field with enough space to lay out test plots and controls, where conditions are uniform enough to provide valid comparisons? Recall from the last lesson that it's important to eliminate as many variables as possible. When growing a crop as part of your research, there are many ways that the location of individual plots can influence the results, if you aren't careful. For livestock projects, can you separate animals getting different treatments and still ensure they all have access to shelter, water, and so on?

Materials, Equipment, and Methods

Think through each phase of your project and list out the supplies and equipment you'll need to complete it. Do you have these things on hand? If not, how can you get them? If your project involves outside services, such as soil sampling by a laboratory, list these as well.

If your research is centered around people, such as marketing or social science projects, think about how you'll engage with them. If you plan to use a survey, who is your target audience and how will you reach these people? How might the details of your outreach method influence your results?

Personnel

Who will be doing the work? Is any training required to enable team members to do the work? Will you need additional hired labor, or support from outside consultants? If you're preparing a proposal to request funding for your project, you may need to list the people involved, including their qualifications to perform the tasks required.

Budget

Running into a budget shortfall is a notorious risk for any project, and on-farm research is no exception. Even when you're

To ensure your project's success, dig into the fine details of your plan to identify potential bottlenecks.

not seeking outside funding for your project, it's essential that you understand the costs of implementing your plan. This includes not just the costs for materials, but also for the time that everybody is putting into the project. This labor cost often gets underestimated.

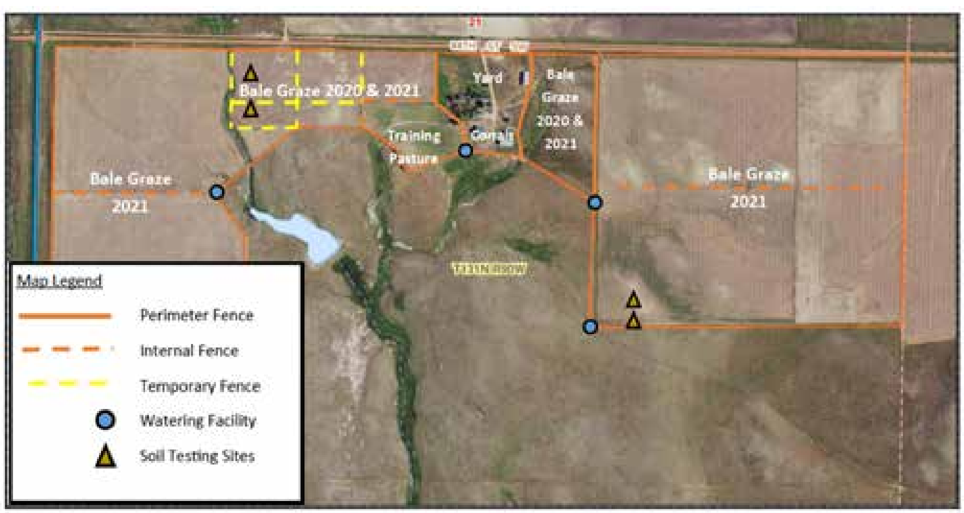
While guesswork may be necessary when estimating some expenses, a clear idea of the overall costs is necessary to the success of the project.

Timeline

Time is as limiting a resource as money. The most obvious time limitations apply to grant-funded projects: The planned activities must be completed within the timeline the grant requires. Growing seasons, market cycles and personnel availability can also create bottlenecks. For example, you may want to avoid committing yourself to a heavy data-collection workload during busy seasons on the farm or when an off-farm job is making demands on your time. Similarly, young people may have limited availability to assist with projects during the school year or a sports season.

Communicating Results

After you've collected and analyzed all of your data, and answered your questions, it's time to present your findings to others. Whether you plan a demonstration of your engineering solution, a field tour of your pastures, or a conference presentation, your outreach is your chance to show people what you've learned. Like every other phase of your project, your outreach will require careful planning. We address this topic in more detail in lesson 9.



A satellite map like this one can be useful when designing a field experiment. This map, created by a North Dakota rancher for a project on multi-species bale grazing, shows her plan for grazing areas, types of fencing, soil testing sites, and locations of watering facilities. *Photo courtesy of Erin Gaugler (SARE grant FNC20-1218)*

Lesson 5 Worksheet Take a Closer Look at Your Plan

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

Sample forms are provided in Appendix 2 to help you complete assignments 3, 4, and 5.

1. Describe the specific locations and plots you'll use to carry out your research. For an animal-related project, describe where the animals will be throughout the entire year, ensuring they have access to water and shelter at all times, and if or how you'll keep the treatment animals separate from the controls. It's often useful to create maps and drawings of research areas.
2. Make a complete list of what you'll need to purchase, lease or create to complete the project, and what resources you already have.
3. List each person involved in the project, along with their duties. Remember to address these tasks:
   - Setting up the project that you planned (starting the experiment, developing an observational plan, or construction of an engineering project)
   - Crop and animal care
   - Data collection
   - Data analysis and statistics
   - Writing and reporting
   - Outreach events, such as a field day, if you plan to host one to share results
4. Prepare a detailed budget. Research prices for any purchases and leases that you'll require. Estimate labor costs using a reasonable hourly rate for each person involved. Include unit costs for any outside services, such as lab analysis, subscriptions, or printing. Also consider providing stipends to other project participants who are providing expertise and support to the project. If you're applying for grant funding, be aware of any restrictions on allowable expenses for the funding request.
5. Create a timeline of the project workflow. Include target dates as well as any deadlines for all activities.

ASSIGNMENT SELF-EVALUATION

1. Do you have access to enough space, fencing, animal watering infrastructure, and so on, to conduct the project as described? Can you spare the necessary facilities for the entire duration of the project? Do you need to seek out someone with additional expertise?
2. Look over your locations, livestock, and crops. Are there any differences between the treatment and control groups or plots that could influence your results (for example, soil types, landscape setting, site history, or animal characteristics)? For an engineering project, does the testing environment mirror the original problem? If you see differences, is there a way to minimize their effects?
3. Examine your project timeline.
   - If you're seeking a grant for the project, can you complete the project within the grant's specified timeline?
   - Will the people involved be available during the times of year when the work will take place?
4. Examine your budget.
   - Will funds be available to cover all expenses?
   - Is every budgeted item necessary for the plan you laid out in Lessons 4 and 5?
   - If you're using your budget for a funding proposal, does each expense comply with the grant's guidelines?
5. Look over all of the lists you've just created. Do they make sense together? Does each item support the overall goals as you've stated them?
6. How do the answers to the above questions change if conditions change? Think about the weather, markets, health, life events, and so on.

Lesson 6: Collect and Manage Data

In this lesson, we transition from planning your project to implementing it. We'll share some best practices for collecting data during your project.

This person is taking biomass samples using a tool called a quadrat, which allows for all collected data to be in the same unit of measurement. Also shown here, data is being recorded on paper using a standard form. *Photo courtesy of Walton Andrews (SARE grant OW24-008)*

Collecting Field Data

Data must be collected in an organized and consistent manner. A successful project requires close attention to accuracy, consistency and completeness of data collection the entire time. The units you use must be the same throughout the dataset, and every piece of information must be clearly labeled with the date, data collector, and identifying information such as field location or experimental group, as applicable. When collecting data on paper, consider making printed field forms for consistency and ease of use. When collecting data electronically, create a spreadsheet or database.

Soil Tests and Other External Lab Data

If your research involves laboratory analysis of samples, such as soil, water, or feed, be sure to follow the lab's instructions for collecting and processing samples. Take special care to note the date, location and any other identifying information about the sample on the bag or container. Be sure to designate a folder (digital or physical) to store results in as you receive them. In your project journal, carefully note the dates when the samples were sent, when you received the results, and where you're storing this information.

Quality Assurance and Quality Control

Generating robust, high-quality data requires planning and sound practices. **Quality assurance** (QA) means making sure you collect good data. One important element of QA is making sure that every person involved in data collection is well trained to perform the process. Consistent use of terminology, units, and protocols are also important. Depending on the nature of your research, you may have other ideas for a QA plan.

Quality control (QC) is the process of correcting and recording any errors that do occur, to prevent them from damaging the analysis. Eliminating duplicates, correcting data entry mistakes, and discarding incomplete or questionable records are all important QC activities. If multiple data collectors are working together, regularly checking for errors or omissions in each other's data can be a great practice.

Keeping Data Organized

Data can accumulate quickly, and keeping it well organized is necessary to prevent an overwhelming mess. Good data management practices can save time and frustration. Paper forms should be filed regularly, as well as observations you might be entering into your project journal. For electronic data, be sure to keep track of the locations of important folders, and back up your data regularly. Consider creating a master document specifying what data is where, the meaning of acronyms and abbreviations, and any other items that might become unclear later.

Lesson 6 Worksheet Collect and Manage Data

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

1. List each type of data you'll collect.

   Example: *Rain gauges at all locations will be emptied after each precipitation event within the study period; the amount of water will be recorded.*

2. For each data type (such as a soil test, measurement, photo, or observation) describe your procedure in detail. Where appropriate, cite the published protocol.

3. What can you do to eliminate or reduce bias in your data collection process?

4. Describe how you'll record the data you collect. Will you maintain a field notebook? Are there paper or electronic forms you'll enter data into? How will you make sure your data stays safe from loss or damage?

5. Describe your QA/QC plan to ensure good data.

   Example: *Data will be collected on paper forms. At the end of each day, the data sheets will be checked for accuracy and completeness, and the person performing this check will sign the bottom of the sheet.*

ASSIGNMENT SELF-EVALUATION

1. As your experiment progresses, frequently look back through your project journal and the answers to the questions above. Consider:
   - Are you keeping up with your planned data collection schedule?
   - Is all of the data you've collected stored safely and organized properly?
   - Are you adhering to your QA/QC plan? How can you improve this process?

2. Are you taking notes in your project journal to help you remember key observations, unexpected events, and questions that emerge from your project?

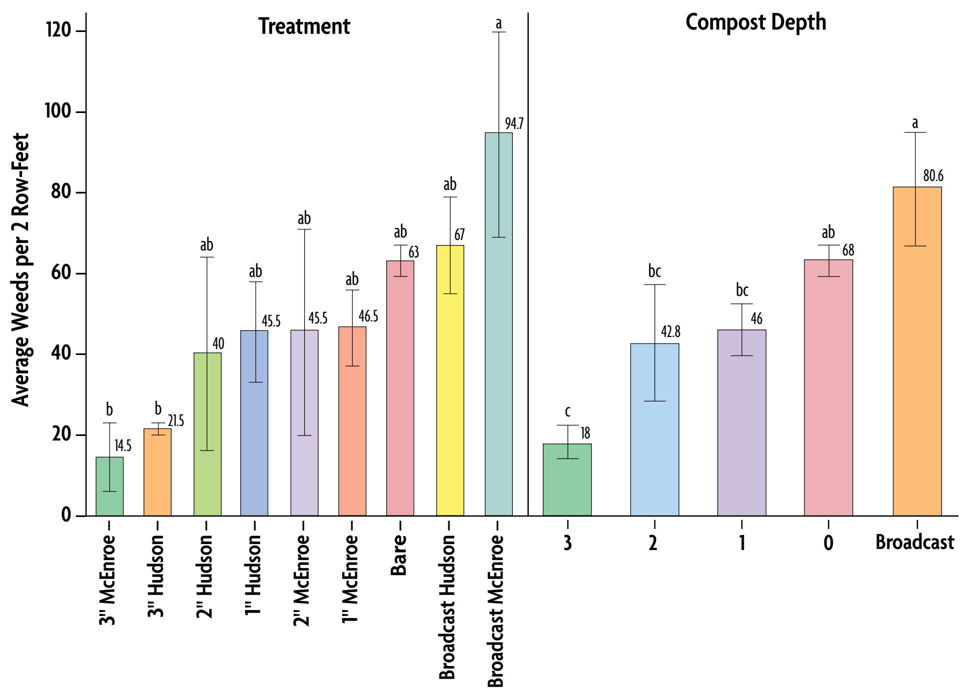
Lesson 7: Analyze Your Data

The world is awash in data, and now your desk is too! Once you've collected your data, it's time to turn it into information that brings understanding. To do this, you'll need to calculate and present various statistics from your data. Refer to SARE's technical bulletin, *How to Conduct Research On Your Farm Or Ranch* (www.sare.org/research), for an excellent introduction to statistical approaches for agricultural research.

Statistical analysis can be a complicated topic and it's vital to your project that you do it correctly, **so we recommend seeking help with this step**. Consider whom you can reach out to for assistance analyzing your data, such as the math department at a local college, your Extension service, or even a high school teacher who's seeking an applied project for an advanced class.

To prepare your data for analysis, you'll start by ensuring that all of your datasets are assembled and all quality control (QC) activities are complete. Once you have all of your data together, compiling this information into a table will enable you to perform your analyses.

Example of Data Analysis: Weed Density on August 18



This graph is from a New York farmer's research project on growing carrots in strips of compost to improve germination and weed control. They used different incorporation depths and two brands of compost (Hudson and McEnroe). The graph shows the relationship between method and weed presence, and includes the concept of statistical significance through the use of error bars with each bar value. The error bars represent the variability (or "margin of error") by providing a visual range of the probable values that could occur. The length of each bar indicates how variable, or "noisy," that data can be. Any two values whose error bars don't overlap, or don't share a letter, are significantly different from each other. *Photo courtesy of Benjamin Shute (SARE grant FNE23-068)*

Basic Statistical Concepts

Summary statistics are used to describe what you observed. For example, we often hear things described in terms of averages. The most commonly used type of average is the mean, calculated as the sum of a list of numerical values divided by the number of values in the list. There are other ways we use statistics to describe a dataset, such as how widely the values vary and how the differences are distributed.

Your project may also require statistics to demonstrate comparisons, such as when an experiment compares a treatment group with a control group, to determine if the treatment brought about an effect. If the two groups are different, statistical tests can determine if the difference is statistically significant. In scientific studies, **significance** is a rigorous assessment that reveals how likely it is that the difference you observed could have happened by random chance. If we're interested in the relationship between one variable and another, statistical tests are used to determine a correlation. It should be noted that even if two variables are correlated, this doesn't necessarily prove that one is caused by the other.

Data Visualization

Whatever type of statistical analysis you use for your project, you'll display your information in a visual way to help your audience understand your results. From a simple table to various kinds of charts and graphs, visualizing your data is an important part of connecting the data with your initial question and supporting your conclusion and interpretations. Maps, photos, and diagrams can also provide context and understanding.

There are many ways to visually represent data and help tell the story of your research project. Here's a creative way a farmer shared pumpkin yields when evaluating different management strategies and pumpkin varieties. *Photo courtesy of Riley Sowle (SARE grant FNC23-1393)*

Lesson 7 Worksheet Analyze Your Data

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

If you need help with any of the following questions, or if you're unsure of your answers, Lesson 10 contains some suggestions of where to find help.

1. Ensure that all of your data has passed QC checks. What were the most common errors you found?
2. Enter all data into one or more tables for analysis (you don't need to include your table on this sheet). The first column should contain the identifier for the observations (such as a plot or sample number), and each subsequent column should represent a variable. Each row should represent an individual observation. Be sure to clearly label the column headers and to specify the units you're using.
   Example:

Ear tag number	Calving date, 2025 (MM/DD)	Calf weight (pounds)	Calf sex (M/F)	Calf VIGOR score (1-25)
247-A	2/25	68	F	23
329	2/25	77	M	19
515	2/27	69	F	21

   Please list the title(s) of your table(s) here. Also list the column headers for each table.
3. List some of the useful summary statistics you might use to describe your data.
4. List any statistical tests you'll perform to understand your results. Identify people or other resources you'll use to ensure you perform these tests and interpret their results correctly.
5. Given the nature of your data and analyses, what types of graphs do you feel would best express your findings? Are there any other visuals that you'd include?
6. Does anything stand out from your analysis that surprises you?

ASSIGNMENT SELF-EVALUATION

1. Does your analysis tell a story? Is there a "take-home message?"
2. Do the results of your analysis match with your impressions and experience throughout the project?
3. Could someone who is completely unfamiliar with your projects understand what your results mean? If not, what can you do to make things clearer?

Lesson 8: Draw a Conclusion

An urban nonprofit in Denver did an agricultural research project to evaluate crop production strategies between solar panel rows on their 3-acre solar farm. While their research remains ongoing, they're learning that some cool-season crops thrive in the shaded microclimate and require less irrigation, while pest pressure and labor are challenges that still need to be addressed. *Photo by Cliff Grassmick, Sprout City Farms (SARE grant FW23-413)*

Once you've completed your project and analyzed your data, you're ready to reach a conclusion. By this point you probably have a sense of the results of your project, but now you can formalize the answer that emerges from your research.

It's highly likely that you learned many things from your project. All of these things are important, but at this point you must focus your attention on results directly tied to your initial hypothesis or objective.

- For an **experimental project**, did your data support your hypothesis?
- For an **engineering project**, did your invention succeed in its task, based on your criteria for success?
- For an **observational project**, did you learn new things that can inform your production or marketing practices in the future?

To get to these answers, you'll need to assemble the results of your data analysis, expressed in terms of these questions.

...at this point you must focus your attention on results directly tied to your initial hypothesis or objective.

Lesson 8 Worksheet Draw a Conclusion

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

1. As it's appropriate for the type of analysis you performed, create a quantitative statement of your findings. Make sure it's clear and concise.

   Example for an observational study, where the goal is to determine attitudes of local Generation Z farm children toward regenerative agriculture: *Approximately 75% of surveys sent were completed and returned. Of these respondents, 58% hoped to return to the farm and take over operations. Of these, 85% expressed the intention to significantly depart from their parents' management strategies to become more regenerative and sustainable.*

   Example for an experimental project, comparing two feed supplements for laying hens to increase the concentration of omega-3 in eggs: *The eggs from the hens fed supplement A had 0.34g of omega-3 per 100g of egg. The eggs from hens fed supplement B had 0.72g of omega-3 per 100g of egg. The control had 0.27g of omega-3 per 100g of egg. Thus, while both supplements did increase the omega-3 content of our eggs, supplement B almost tripled it compared to the control, whereas supplement A only offered a modest increase.*

   Example for an engineering project, designing an AI-powered sensor to detect the presence of a canine animal in a sheep enclosure: *The goal was to detect the presence of a dog within 10 minutes of arrival in the pen at least 60% of the time. When the prototype was tested by introducing dogs to the enclosure, it achieved detection within 10 minutes only 43% of the time with one farm dog, but 49% with the other.*

2. State whether or not you supported your hypothesis, achieved your purpose, or met your criteria for success.
3. Revisit the question you set out to answer in Lessons 1 and 2. Clearly state what your results mean in terms of your initial question and project objective.
4. Discuss how this finding is directly important to sustainable agriculture. How might other farmers or ranchers utilize what you've learned?
5. If the results of your analysis didn't show exactly what you expected, why not? Please describe what you learned from the unexpected outcome.
6. Describe further research that could build on the knowledge you've gained.
7. What advice would you have for someone undertaking a similar project?

ASSIGNMENT SELF-EVALUATION

1. Are your statements supported by the data and analysis?
2. What new questions arose during the project?
3. If you could redo the project, what would you do differently?

Lesson 9: Communicate Your Results

Your research can only help people if it reaches them. Communicating with others about your research is a critically important part of your project, allowing the benefits of your findings to extend beyond your own operation. Outreach can take many forms, depending on the community you'd like to reach. Think about your potential audience and how they get their information; this can guide your decisions on what form your information products might take. Here are some possible methods of telling your story.

The Research Report

However you plan to reach your target audience, it's a good idea to write a traditional report describing your project, methods, and results. Putting this report together will help you describe and clarify what you've learned from your project. If you got a grant for your research, a final report may be required. If not, you can use your report as a record of the project and a basis for publications. As you write your report, you can use the template in the Sample Forms section as a general guide.

Hosting a Field Day

Sometimes, the best way to understand something is to see it for yourself. Hosting your neighbors at your farm or ranch can be a great way to showcase your research and discuss important questions. You can hold this type of event during the growing season when crops or animals are visible and the question or problem is easily demonstrated; the results and analysis might not be finalized until after the field day. A physical demonstration could be an exciting way to showcase a successful engineering project.

If you're interested in hosting a field day, consult SARE's *Farmer Field Day Toolkit* (www.sare.org/farmer-to-farmer). You might also consider collaborating with an agricultural organization, Extension, or others who have experience planning, promoting, and hosting field days.

Presenting at a Conference or Industry Event

Many farmers enjoy attending events such as regional agricultural fairs, Cooperative Extension workshops, and conferences. These can be a great opportunity to showcase your project with a booth, poster, or presentation.

Article in a Trade Journal or Scientific Literature

Consider writing an article for a magazine or journal with circulation among your peers. If your local county or university Extension agent provided assistance or support for your project, they might coauthor or publish your article. A scientific article in a peer-reviewed journal is also a possibility, especially if you're partnering with a college or university. Another good option is to reach out to journalists at local radio, TV, and newspaper outlets with information about your project, including both what you're trying to achieve and why it's important to farmers and communities in the area.

Connecting with the local media can be a great way to share your project with others in your area. Here, a reporter from the Milwaukee Sentinel (left) talks with a research team member about a project on the use of cover crops and reduced tillage with Indigenous corn varieties, conducted by tribal farmers on the Oneida and Menominee reservations. *Photo courtesy of Lea Zeise (SARE grant FNC21-1316)*

Farmers at a field day learn about a research project that explored perennial crop alternatives to corn silage for Vermont dairy farms. *Photo courtesy of Scott Cleveland (SARE grant FNE23-042)*

Social Media

Popular social media platforms and other online forums can be an effective outreach tool to build interest and enthusiasm. You can use social media to direct traffic to your operation's website or blog, where you can present more detailed information. An engaging online presence can also generate business and lead to partnership opportunities. The ease of setting up access to these platforms, however, can be deceiving. Consistently creating high-quality content for social media requires skill and discipline, and success isn't guaranteed.

Lesson 9 Worksheet | Communicate Your Results

Visit www.sare.org/research-lesson-worksheets to download this worksheet for your personal use.

ASSIGNMENT

1. Describe the audience you'd like to reach to share your research and results.
2. What are the most important things your audience needs to understand about your project?
3. Where does your intended audience get the kind of information your project will provide?
4. State your plan for communicating the knowledge gained in your experiment to this audience.
5. Ask someone else to look over your results, preferably someone who represents your intended audience and is unfamiliar with your project. Describe their response. How might you best help them to learn from your project and be excited about it?

ASSIGNMENT SELF-EVALUATION

1. Think about your target audience. How does the problem you addressed in your project affect them? Or, what parts of your experience with this project will they find most interesting?
2. Will your outreach help your audience to understand how your project applies to them and helps them solve the problem you started with? How could you improve in this effort?
3. How have you optimized your message to fit the delivery method you intend to use?

   Example: *Since I plan to present my findings via social media, I have broken my discussion into small points that can be presented in 30-second video clips.*

4. Do you have the skills to implement your communication plan? If not, whom can you ask to help you with this?
5. What are the costs associated with this plan? Are they accounted for in your project budget?

Lesson 10: Considerations, Tips, and Tidbits

This lesson doesn't cover a required step of the research process, but it does offer a variety of topics we hope will be useful to you as you plan and conduct your project.

Over the years, the owners of The World Is Your Oyster Farm in Maine have developed a good working relationship with Dana Morse, the aquaculture lead for the Maine Sea Grant (second from right). Here, co-owner Luke Saindon (third from right) poses with Morse and other University of Maine Extension researchers while the team visits the farm to collect data for a project they collaborated on. *Photo courtesy of Luke Saindon (SARE grant FNE25-131)*

Getting Help

Research is difficult, but you don't have to approach it on your own. Consider seeking professional help with any part of your project that you feel would benefit from it. Some places to turn include:

- your county Extension office
- Extension specialists at your state's land grant university who organize on-farm research projects in your area of interest
- your local USDA Natural Resources Conservation Service (NRCS) office
- any local nonprofits or producer networks with experience in collaborative research and demonstration projects

Funding Your Research

Conducting research on your farm or ranch can mean extra time, supplies, and space, all of which cost money. In addition, if your research involves trying a novel specialty crop or technique, you may be concerned about the risk of reduced income in case things don't go as you expect. For these reasons, you may want to seek outside funding to help manage these expenses and risks.

A variety of organizations and agencies provide grants and funding opportunities for farmers, including SARE. A brief list of places to start looking for on-farm research funding is provided in the Resources section. Be sure to also look into opportunities offered by local organizations interested in your topic. Foundations focused on a wide range of subjects, including pollinators, wildlife, youth engagement, and so on, can be great sources of funding for projects, including research. In some cases, these programs can complement one another by funding different parts of a project.

As you investigate funding options, be sure to ask about your eligibility early on, as some sources only fund 501(c)(3) nonprofits, others only fund farms or ranches, etc.

The templates in the Sample Forms section might be especially useful for you as starting points if you're preparing a grant application. If you are, be sure to tailor these forms to the grant program's application requirements as needed.

To learn more about applying for a SARE grant, visit www.sare.org/grants, and contact the appropriate regional office for more information. We also provide some general information about SARE grants on the last page.

Letters of Support

Funding proposals often require a letter of support from someone not involved in the project. For sustainable agriculture projects, this letter might come from Extension personnel, a university researcher, a staff person or leader of an agricultural organization, a customer, or another producer. Whether or not such a letter is required for your project, reaching out for support and engagement from within your community can be well worth the effort. As the project progresses, consider keeping in touch with the person about how the project is going and what you're learning.

Legal and Ethical Issues

As you develop your project, be aware of any legal and ethical issues that may apply to your plans. Here are a few examples of what you might need to consider.

Living subjects

If you're seeking grant funds and your project involves livestock, it's likely you'll be asked to document their care to meet federal, state, and local rules regarding the care of research animals. These rules are designed to ensure that animals are provided with adequate shelter, food, water, etc., for their year-round comfort and safety.

Social Science

For human subjects, one issue to be aware of is privacy. If you're planning to make your results public, be aware of the need to obtain permission before using photos of a person or private property other than your own. Avoid including any personal information such as full names, addresses, or finances without clear written permission.

Writing for Publication

When submitting written materials for publication, you must take care to ensure any statements you make are your own, unless you properly credit the source. If you mention information you got from another source, including published research, you need to cite them as a reference. There are a few citation formats used by research-based publications, including APA, MLA and Chicago. You can learn more about these formats online.

Notes on Soil Tests

Soil health and soil testing often come up in the context of on-farm research in sustainable agriculture, in both crop and livestock systems. So, we'll share a few thoughts about soil testing here.

If you plan to use soil testing in your research, make sure to select the most appropriate test. Most laboratories run comprehensive tests that provide a lot of information, which can include various measurements of soil organic content, different forms of soil nitrogen, and concentrations of minerals and other nutrients. Some, such as the Haney test, are focused on demonstrating healthy microbial activity.

Soil tests can certainly provide essential information. But, their usefulness depends on your understanding of how the data they provide relates to your research question. Also, tests can be expensive, so it's important to make sure you're not paying for information you don't actually need. Finally, time is an important consideration; specifically, whether a soil test can capture changes due to the management practices you want to evaluate within the time period of your project.

Tips from SARE

The following is a list of tips offered by SARE staff members who support producers as they conduct on-farm research through our regional Farmer/Rancher Grant programs. We've already addressed many of these ideas in previous lessons, but we thought it would be helpful to share their advice directly with you.

- Before getting started, identify the right study design, in other words, an experimental design, an observational study, or other.
- Narrow your research question to one specific farming practice, for simplicity and ease of setting up your research design.
- Be clear about the problem you are addressing.
- Review the information that is already out there. A literature review can show what's already been done, support your plans, and help to show what you are looking to do differently.
- The more you put into developing your research design the easier it will be to complete the project and/or to adapt to unforeseen circumstances.
- Be transparent in your research design, so that the methodology can be reproduced or can be built upon by others.
- Consider if a real time, side-by-side comparison will strengthen your findings, since comparing to past years has limits (changes in the amount of precipitation, temperatures, etc.).
- Clearly define your basis for comparison by identifying your control or your baseline.
- Make a plan for recording data before the project starts: Who will do it? How often? Where (in a notebook? via an online form or spreadsheet?)?
- Maintain good recordkeeping of your research methodology and data collection.
- Select a long enough time period that measurable changes should occur.
- Seek out an expert to review your research design.
- Consider how you will pay yourself (or a team member) to carry out the project. Do not underestimate the time it takes to conduct research.
- Research raises more questions. It's okay if you don't come to the conclusion you expected based on the results, or if the research takes you down a different path.
- Finding out what doesn't work is as important as finding out what does work.

A farmer in Minnesota included laboratory soil testing in a project to evaluate the effect of no-till methods on soil health and crop productivity in organic vegetable systems. They attached test results to treatment rows as a way to prompt discussion and learning during field days they hosted as part of the project. *Photo courtesy of Sandra Dietz (SARE grant FNC23-1370)*

Resources

Here we offer a selection of useful resources that can be found online or through state Extension offices on various topics related to conducting on-farm research.

On-Farm Research

General Info and Tips

Many state Extension offices have staff and resources that can help you through the research process. Two in-depth guides on research for farmers include:

- *How to Conduct Research On Your Farm Or Ranch* (SARE)
  www.sare.org/research
- *Farmers Guide to Conducting On-Farm Research* (Organic Farming Research Foundation)
  ofrf.org/reports/farmers-guide-to-conducting-on-farm-research

Sources of Funding

- SARE, a program of the USDA National Institute of Food and Agriculture (NIFA)
  www.sare.org/grants/
- *Building Sustainable Farms, Ranches and Communities*, a guide to federal funding opportunities, updated with each Farm Bill
  www.sare.org/federal-funding-guide

Selecting Indicators: A Sampling of Data Collection Methods

The following guides are available online through the USDA Natural Resources Conservation Service (NRCS):

- *Cropland In-Field Soil Health Assessment*
- *Guide to Pasture Condition Scoring*

Communication

- *The Farmer Field Day Toolkit*
  www.sare.org/resources/the-farmer-field-day-toolkit/

Sample Forms

The forms provided here will help you to assemble information that will be valuable to you as you plan and execute your project. If you're seeking external funding, the granting organization is likely to request similar information, though formatting requirements may differ. Brief samples of these forms are provided on the next page, and blank forms are available for download at the link below. These forms include:

- A project timeline
- A proposed project budget
- A proposed project personnel list
- Outline sections for a final report

Visit www.sare.org/research-workbook-forms to download blank forms for your personal use.

Project Timeline

Project Name ______________________________

Date ______________________________

Season/timeframe	Activity	Person(s) Responsible	Deadline
Example: Year 1 Spring	Lay out research Plots	Jennifer	March 16

Proposed Project Budget

Project Name ______________________________

Date ______________________________

Category*	Item	Unit price	Number of units	Total
Example: Rental equipment	No-till drill	$200/day	4 days	$800

*Categories: Equipment purchase and lease, facilities rent, supplies, labor (including project layout, crop and livestock care, data collection, data analysis, communications, etc.), services, travel, shipping, plants and seeds, animals, etc.

Proposed Project Personnel Plan

Project Name ______________________________

Date ______________________________

Activity	Person	Available dates	Training needs
Example: Operate survey booth at county fair	Kaitlyn Doe	Until Sept. 9	None

Outline Sections for a Final Report

Title Section	For some submissions a full, formatted title page is required. At a bare minimum, provide the project title, your name and the date of the report. Your address and other contact information, the name of a granting organization, and other identifying information may be included.
Abstract	This brief, succinct summary of the purpose, process and results of your project is required for most scientific publications as well as many conference presentations. It can also be used as the summary or description for document metadata for search engine optimization purposes.
Introduction and Background	Describe the problem you set out to solve, with enough background information for a reader unfamiliar with the project to understand why the project is important. Then summarize the approach you decided to take to solve the problem.
Materials and Methods	This is where you describe exactly what you did. This section can include a description of the spatial setup of fields, animal pens, facilities, etc. It will also describe what data you collected, including the protocols and methods you used in data collection. If samples were sent in for laboratory analysis, that should be described here as well.
Results and Analysis	A table summarizing all of the data collected should be provided here. Follow this with a description of the statistical tests performed, and the results (findings). Use charts, graphs, maps, or other visualizations to help the reader understand these results. It's important to remain objective here. Subjective interpretations, conclusions, opinions and explanations are important, but shouldn't be mixed with the objective observations. It's best to keep your subjective comments for the next section.
Discussion	Here is your chance to talk about the importance of your finding and discuss how it fits into the broader world. You have the freedom to discuss surprising things you learned while doing your project, but stay relevant to your initial question or problem. Discuss the reasons for any unexpected failures or shortcomings with your project. It's also important to mention any followup research that might help extend the knowledge gained from the project.
Conclusion	Clearly state what these results mean in terms of your initial question and project objective. Was your hypothesis supported, or your engineering criteria met? Did you demonstrate a meaningful phenomenon or trend? How does this relate to your original problem, and how does it solve similar problems for others?
Citations	If you referred to statements or work by anyone else, you'll need to properly credit the original author.
Appendices	Any related information that doesn't fit in the above sections can be placed here, appropriately labeled. For example, you summarized your data in a table or the "Results" section of your report; if it's important to provide the raw data, you can include it here.

New Mexico ranchers Emily Cornell (left) and Zachary Withers (right) worked together on a project to see what effect compost would have on the health of their rangelands. *Photo by LD Productions (SARE grant FW20-363)*

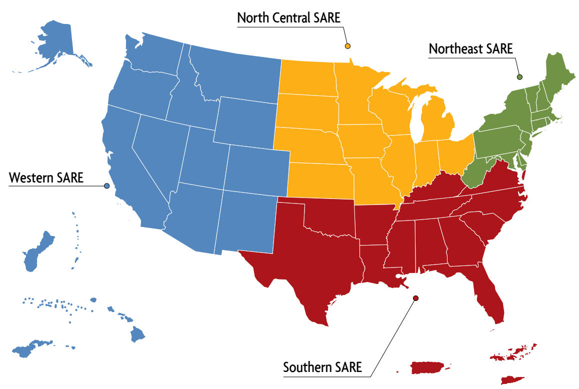
SARE Grants for Farmers and Ranchers

Visit www.sare.org/grants to learn more.

- Available to producers in the United States and its island protectorates
- Grants fund projects that advance new concepts in sustainable agriculture
- Awards can range from $5,000–$35,000, and projects are 1–3 years*
- Proposals are accepted on an annual cycle and awards are made through a competitive review process
- Visit **projects.sare.org** to explore previously funded projects led by producers

Stay up to date

Sign up for grant news from your region (see map) at **www.sare.org/subscribe**.



**These details vary by region and are subject to change (see map).*

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National Institute of Food and Agriculture

Sustainable Agriculture Research & Education