Conduct Your Own Garden Research

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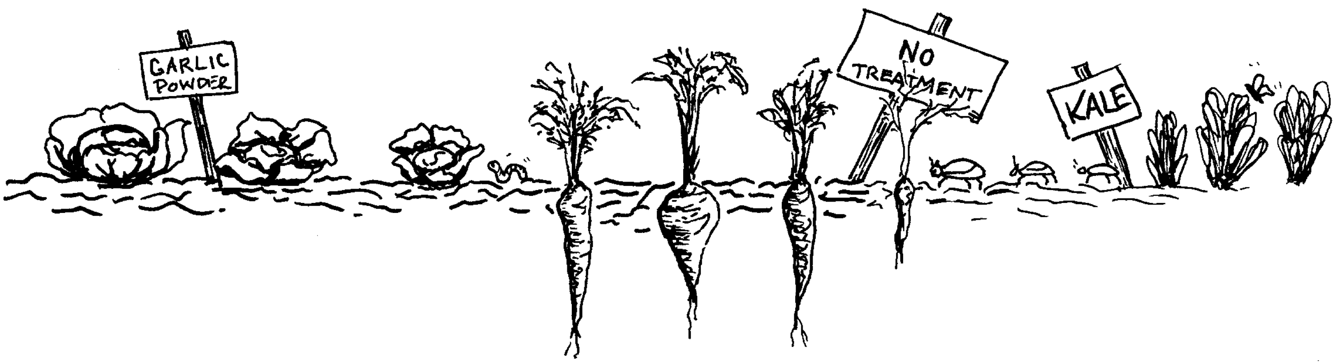

Will a new tomato variety yield more than your old favorite? Does garlic dust repel insect pests? What is the best green manure crop? If you are a market gardener, you probably have asked questions like these.

How do you know if a new idea or product will work in your garden? One way is to decide for yourself by doing your own scientific experiments and learning firsthand what works best. This publication will help you do your own research—from set up and design to making observations, recording data, interpreting results, and drawing conclusions.

Principles and definitions

Research may sound complicated or mysterious, but actually it is just a commonsense (and fun) way of asking and answering questions. The basic idea is separating true cause and effect from mere coincidence. A researcher recognizes that just because one event follows another does not necessarily mean the first event caused the second. The guiding principle of scientific research is making fair or unbiased comparisons. Putting that principle into action requires three ingredients: *check treatments, replication, and randomization.*

Check treatments—making comparisons

You begin research by identifying a treatment—the new idea, product, or practice you want to test. Treatments could be different plant varieties, different weed control methods, or anything else you'd like to investigate. You can test many treatments or just a few. Simpler usually is better—no more than three or four treatments in one experiment.

Every experiment must include a check treatment, which is no treatment at all. Say you want to know if garlic dust repels insects

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on cabbage plants. An experiment to answer that question requires at least two treatments: cabbage plants dusted with garlic dust and cabbage plants not dusted (fig. 1).

Only by comparing pest numbers on plants with and without garlic dust can you decide if dusting worked. Suppose you had dusted every plant with garlic and later saw that pest numbers declined. The decrease wouldn't necessarily mean that garlic dust repelled pests. Maybe the real reason was stormy weather that killed the pests or natural insect migration from the garden.

To know if treatments cause an effect, there can be only one difference between check and treatment plants. In this case, it is the presence or absence of garlic dust. All other conditions, all other gardening practices, must be exactly the same on both the check and treatment plants. If you give the checks more fertilizer or water them on a different schedule or otherwise manage them differently from the treatment plants, the results you observe might be due to differences in management practices and not to the treatment.

For some experiments, the check treatment will be the standard practice you normally use. For example, if you were testing different tomato varieties for fruit yield, the check would be the variety you usually plant.

Replication—repeating the treatments

Another necessary part of every experiment is replication—repeating each treatment several times. Just as the best team doesn't win every game, the best treatment doesn't always produce superior results. In the same way that averaging performance across many games helps you pick the best team, averaging effects from several repetitions of each treatment helps you pick the best one.

Consider two alternative setups for the garlic research (fig. 2): dusting one cabbage plant and comparing it with a single check plant or dusting four cabbage plants and comparing them with four check plants. In the first design, by chance you might select an unusual or abnormal plant that inhibits or magnifies any repellent action. If garlic dust really repels insects, the more chances you give it, the more likely you'll see a repellent effect. Repetition lets you be more confident about your results.

Replication is a way of dealing with variation—normal differences in soil types, watering practices, planting techniques, fertility, and other factors besides the treatment that influence your results. A common type of variation is the edge effect. Edge effect means that plants on the outside or edge rows of the garden often respond

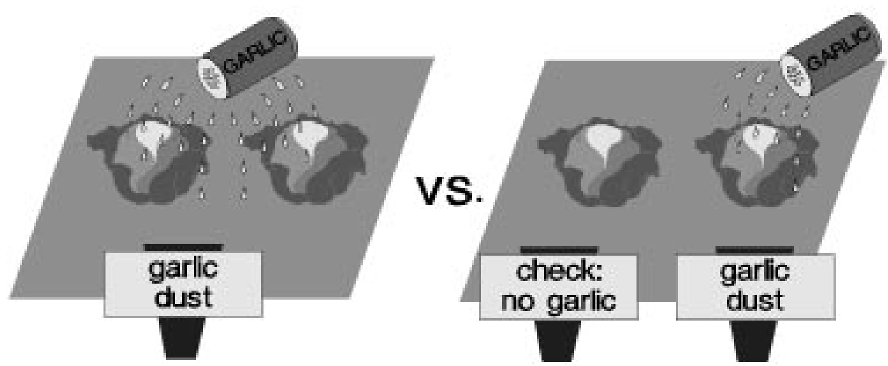


Figure 1. Every experiment must include a check treatment.

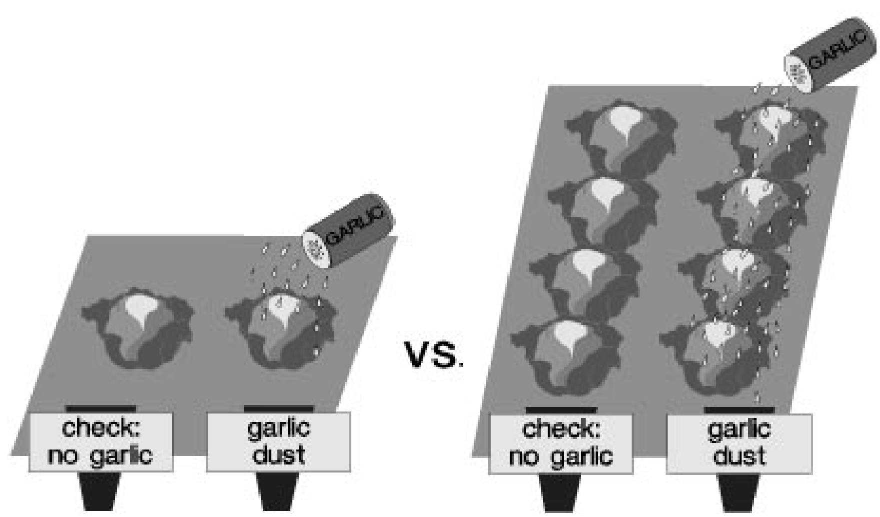
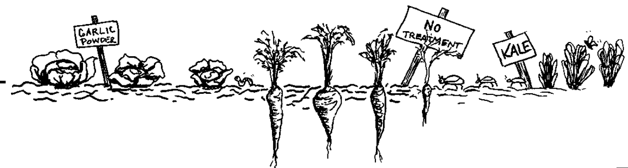


Figure 2. Comparing more than two plants gives you greater confidence in your results.



differently to treatments than plants in the middle of the garden.

Edge effects happen because of differences in plant-to-plant shading and crowding, wind intensity, pest migration, and other factors. In the cabbage experiment, you would avoid using edge plants and instead would select plants from middle rows surrounded by other cabbage plants.

Although reliability increases when you increase replications, space and time put practical limits on the number of replications you can handle. At a minimum, repeat (i.e., replicate) every treatment three or four times. If you do not have much room, increase the number of replications and decrease the number of treatments or the number of plants in each replication.

Decide before you begin how many replications you will use. Deciding ahead avoids the temptation to repeat treatments until they give the results you expect or want to see. In addition to repeating treatments at the same time and place, consider repeating the same experiment several years. Data from more than one season help adjust for year-to-year differences in growing conditions.

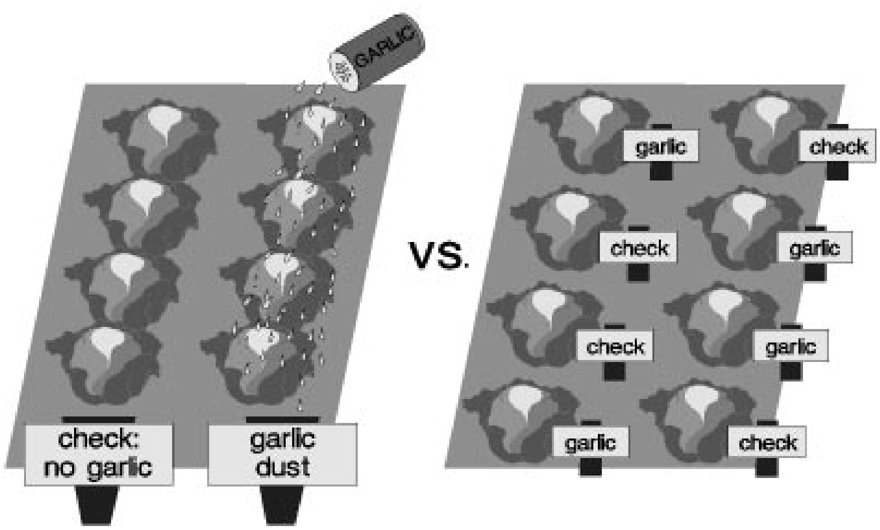


Figure 3. Deliberately selecting rows for the garlic dust and check treatments (left) is improper randomization. In proper randomization (right) plants to be dusted were selected by flipping a coin (heads = dust; tails = no dust).

Randomization—design by flip of a coin

The final consideration is the physical layout of your experiment—deciding which plants or which plots (area within your yard or garden) get which treatment. Each treatment must have the same chance to perform as well as it can so you can make fair comparisons among them. One way to arrange treatments is to flip a coin, assigning treatments to plants or plots completely at random.

Figure 3 shows how you could randomize the garlic experiment using two treatments (with and without garlic dust) replicated four times using a total of eight cabbage plants. Don't deliberately match one row of dusted plants with an adjacent row of undusted cabbage plants. Instead, flip a coin. Heads, the plant is dusted; tails, the plant isn't dusted, until each treatment is repeated four times.

Dusting plants at random keeps you from subconsciously giving an unfair advantage to one treatment, such as never dusting the biggest plants or dusting only the weakest plants. Even by flipping a coin, you might end up with a design like that at left in figure 3, but don't rerandomize. The idea is to remove any personal choice from the arrangement of your treatments.

For experiments with more than two treatments, randomly assign treatments by drawing names out of a hat. You might expand the garlic experiment by testing several different concentrations of dust: no dust (check), low concentration of dust, medium concentration, high concentration. Write each treatment name on a slip of paper, then without looking choose a slip. The name you choose is the treatment you apply to the first plant. Randomly assign treatments to plants 2, 3 and 4 by drawing slips without replacing those already chosen. Then start over with all four slips for each additional block or replication of four plants. Figure 4 illustrates the experimental design, which is called “randomized block.”

Getting started

Step 1.

Decide on the question you want to answer

What new gardening practice are you testing? Write it down. Stating your research question in a sentence helps identify the treatments needed, especially the check treatment. In the example, the question is this: Does garlic dust repel insects from cabbage plants? This also is a good time to check your local library for reference books to see if anyone else already has done similar research.

Step 2.

Determine what data you need to answer the question

Unless you identify at the very beginning the information you need to answer the research question, you may waste the entire season collecting the wrong data. For vegetable crops, you probably will want to measure produce yield or quality. For landscape plants, you might record plant height, flower color, or presence/absence of blemishes. In the garlic dust example, you would observe and record pest infestation levels to determine if there was any repellent action. You also would measure and record cabbage head weights at the end of the season.

Step 3.

Select a research site

Do your experiment in a uniform part of your garden or yard that is big enough for three or four replications of each treatment. Avoid areas with different types of soil, low spots and high spots, or any other variation. This keeps treatment effects from getting mixed up with factors that are not part of the experiment. For the dust-no dust garlic experiment with four replications, pick eight identical cabbage plants from one part of the garden where all growing conditions are the same. Avoid possible edge effects by planting enough cabbages so that these eight plants are surrounded by other identical cabbage plants.

Step 4.

Draw a map of your research area

A map can help you see and eliminate variation before you begin. This lets you best position your experiment so growing conditions are similar across the entire area. Use maps to decide the size of each replication (such as how many plants, or square feet, or row-feet). Make replications big enough to accurately measure yield, quality, and any other data you need.

Step 5.

Lay out your experiment

A common way to arrange your experiment is called a randomized complete block. A block is an area that contains one complete set of treatments. A block could be one raised bed, a length of row, or some arbitrarily sized part of your garden or yard. In the expanded garlic dust experiment, one block would contain four cabbage plants, one plant for each treatment (the three rates of dust plus an undusted check treatment).

With a randomized complete block, every block is a replication. If you wanted five replications in the expanded garlic dust experi-

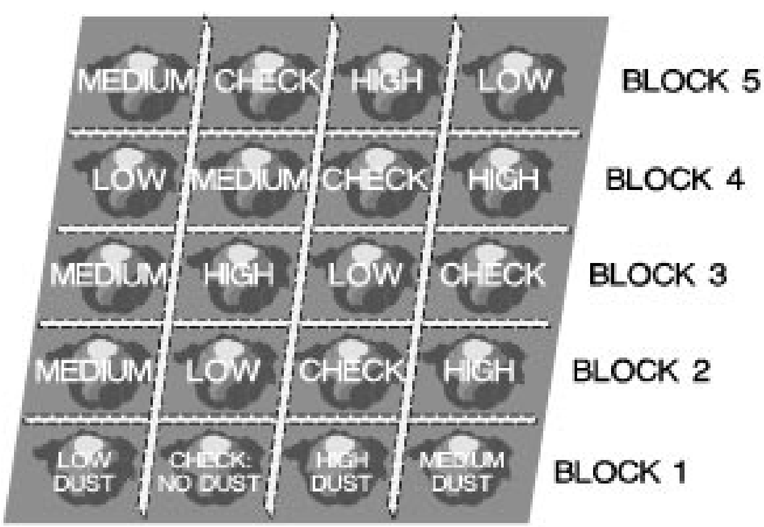


Figure 4. Randomized block design: Each of four treatments is found in each block.

ment, you would need five blocks, each with four plants (one plant per treatment).

Figure 4 shows how you can use your map to arrange your treatments. Begin by dividing the map into boxes for the number of treatments multiplied by the number of replications. In this example, the map would have 20 boxes (4 treatments x 5 replications = 20 boxes). They would be arranged as five blocks of four cabbage plants each. Now fill in the map. Assign treatment locations within each block by drawing names from a hat. You have just created a randomized block design.

When laying out blocks, you may not be able to find a completely uniform area in which to place them. When this happens, you have two options. One is to put each block within its own uniform area. The second is to position blocks perpendicular to the gradient. Suppose your garden has two different types of soil. Figures 5 and 6 show the two alternative ways you could arrange your plots to deal with variation in soil patterns.

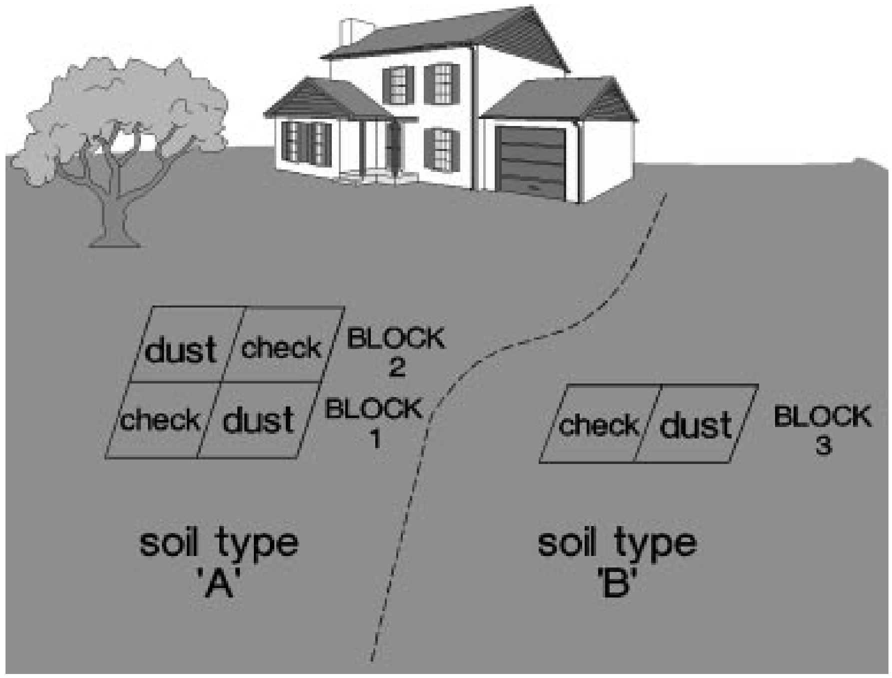


Figure 5. One way to lay out experiments in nonuniform areas is to place each block within its own uniform area.

Step 6.
Collect the data

The key point in gathering data is consistency: measure yield, quality, and other treatment effects the same way in every replication and for every treatment. This makes it easier to detect differences in results among treatments.

Always measure and record data from each replication of every treatment separately. For instance, you would NOT harvest and weigh all the cabbage plants from one treatment at the same time. Instead, weigh and record each head individually, replication by replication.

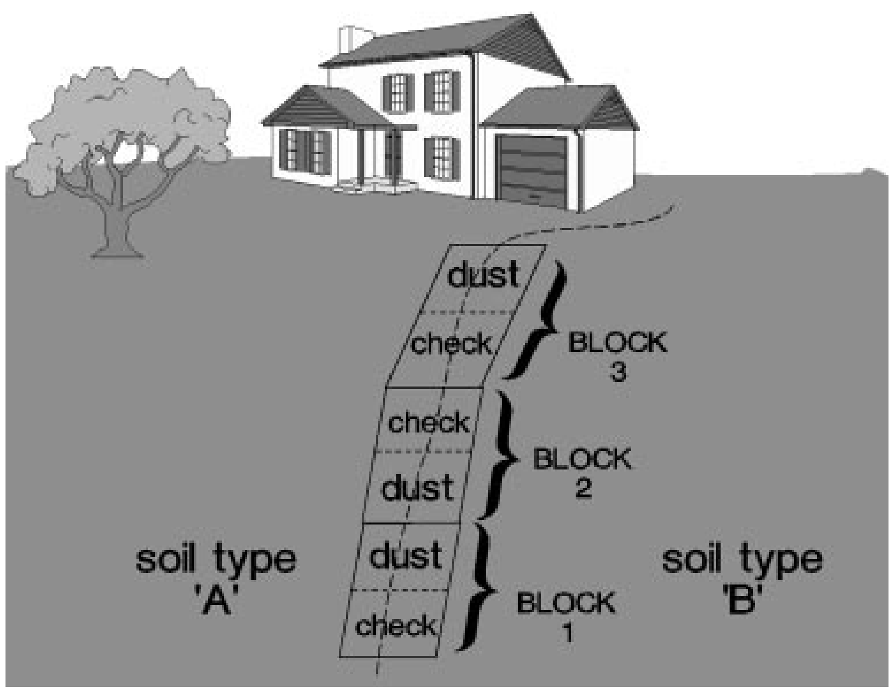


Figure 6. Another way to lay out experiments in nonuniform areas is to position blocks perpendicular to the gradient.

Finish one replication before starting another, planning ahead so you can complete your observations on the same day, one replication after another. If you must take a break or if an interruption prevents you from taking all your measurements on the same day, do not stop in the middle of a replication. Take your break after finishing one replication and before beginning another. This reduces variation by insuring all treatments within the same replication are examined under the same conditions.

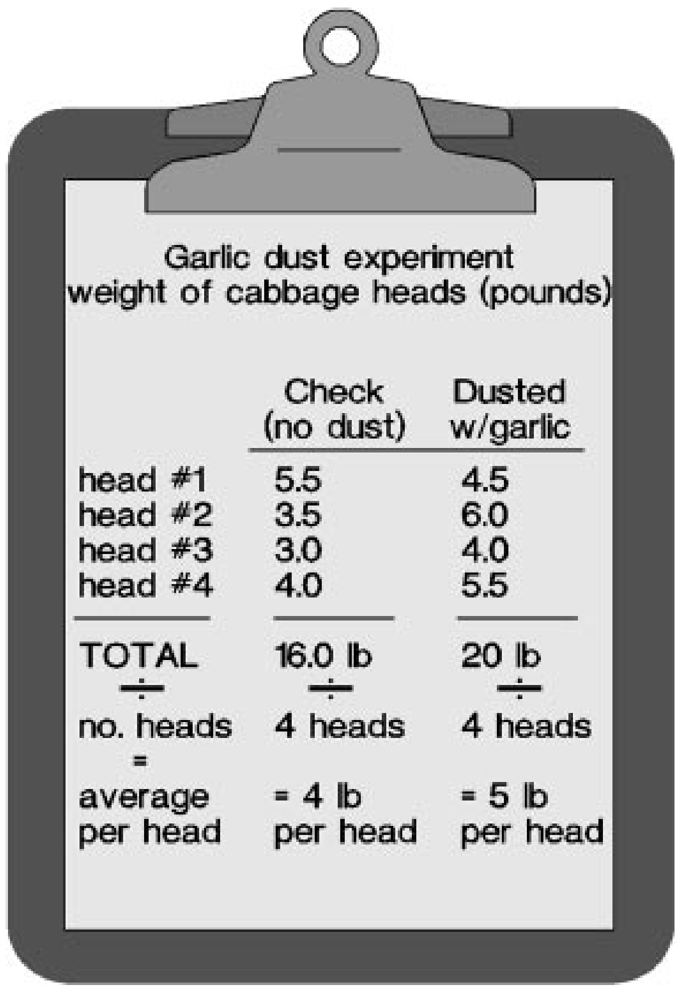
Ideally, your replications will be big enough that you will not have to completely harvest each replication. You especially can decrease variation due to edge effects by harvesting only the middle part of each replication, such as the two center rows of a four-row plot or the middle 3 feet of a 6-foot row. If you have enough space, it would be better to expand the replication in the cabbage garlic dusting experiment from one plant to several plants per replicate.

For treatment effects that cannot be measured directly (such as the visual appearance of plants), make up a rating scale. In the garlic dust experiment, you might decide on the following 0 to 5 scale to estimate the severity of insect feeding: 0 = a plant without any feeding holes, 1 = a plant with a few small holes, and so on to 5, a plant with only leaf veins remaining.

Take general notes about soil type and planting history and about how you planted, watered, and fertilized. Also record plant growth and development through the season. These data can help explain the why of your experimental results. Note unusual weather conditions or disease, weed, or insect infestations.

Especially note if problems occur in a single treatment, in all treatments within one area of the garden, or just around the edges. These data may indicate edge effects or differences in susceptibility among plants. Together these observations provide the information that you and other gardeners will need to repeat the research. They also help others evaluate your research.

The garden research record form at the back of this publication will help you record your general observations as well as specific yield and quality measurements. Before you start your experiment, duplicate as many forms as you think you will need.



Garlic dust experiment
weight of cabbage heads (pounds)

	Check (no dust)	Dusted w/garlic
head #1	5.5	4.5
head #2	3.5	6.0
head #3	3.0	4.0
head #4	4.0	5.5
TOTAL	16.0 lb	20 lb
÷	÷	÷
no. heads	4 heads	4 heads
=		
average per head	= 4 lb per head	= 5 lb per head

Figure 7. Determining average treatment effects of dusting with garlic powder and not dusting.

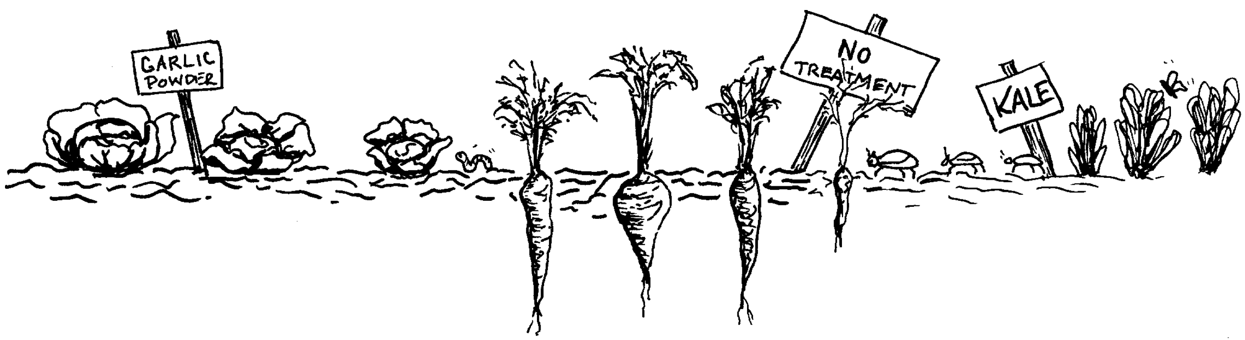
Step 7.

Make your conclusions

Making sense of your research may be as simple as comparing yield data or plant quality among treatments. Drawing a graph or making a bar chart may help you more easily spot trends in your data. Regardless, make your conclusions only by comparing the average response of each treatment, using all your replications.

Do not selectively discard data that disagrees with what you expected to happen. Figure 7 is an example of how to compute average treatment effects in the two-treatment garlic dust experiment.

Sometimes one treatment clearly outperforms the rest and conclusions are straightforward. Other times, only slight differences in yield or quality separate treatments. When no treatment clearly outperforms the others, statistical analysis can help you understand your results. There are many different types of statistical analysis. You can do them by hand or with a calculator, but they are more easily and accurately done using personal computers. Check with the UI Cooperative Extension System office if your county to see if an extension educator can help you with statistical analysis.



Further reading

On-Farm Testing: A Grower's Guide, EB 1706, $1.00. Order from Washington State University Cooperative Extension Bulletin Office (509-335-2857).

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Garden research record form A

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Research Description

Your name ___________________________________ Date treatments applied ________________________

Location_____________________________________

Research question/objective ____

____

____

Treatments tested – be sure to include check treatment.

Treatment 1. ____________________________________ *Treatment 2.* __________________________________

Treatment 3. ____________________________________ *Treatment 4.* __________________________________

Treatment 5. ____________________________________ *Treatment 6.* __________________________________

Size of each replication: i.e., number of plants; number of rows and row length; length and width of plots

____ ____

____ ____

Draw your general experimental area, showing the arrangement, size (length x width), and placement of replications and treatments. For row crops, include numbers of rows in each replication, length of rows, and row spacing.
Show major variations in soil types, irrigation patterns, wind direction, and shading from nearby trees or buildings.

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Garden research record form B

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Garden Management

Keep separate records for each replicaton if there are major differences within your experimental area.

Previous year

What was grown in the experimental area last year? What pesticides and fertilizers did you apply there last year? ______________________________

____

____

Current season

Soil type ____________ Date planted ____________ Variety/cultivar ____________

Watering practices
- ❏ Drip irrigation
- ❏ Overhead sprinkler
- ❏ Other ____________

Frequency of watering ____________

Amount applied ____________

____

Fertilizer practices – type applied

N ____________

P ____________

K ____________

Other ____________

Dates/amounts applied ____________

____

Weather and pest observations

Describe unusual/extreme weather conditions and problems with diseases, insects, weeds, or other pests; list any management actions or control measures applied, especially pesticides.

Date of observation	**Plant growth stage**	**Situation/problem** Keep separate notes for each replication, and use extra sheets as needed.	**Action/control**

Garden research record form C

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Research Results

Fill in any of the tables needed to answer your research questions. Not every question will require data collection for every table.

Days to maturity from planting or transplanting

	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Replication 1						
Replication 2						
Replication 3						
Replication 4						
Replication 5						
Replication 6						
TOTAL						
Average result Total ÷ no. reps.						

Yield

You may choose to measure yield on one day or over the course of a season.

Date__________________ Units of measurement ___________________________ (lb, bushels, no. fruit, etc.)

	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Replication 1						
Replication 2						
Replication 3						
Replication 4						
Replication 5						
Replication 6						
TOTAL						
Average result Total ÷ no. reps.						

Garden research record form D

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Research Results

Quality

Rate plants or produce according to their appearance, color, firmness, size, shape, taste, or other characteristic by using the scale 1 = not acceptable, 2 = poor, 3 = fair, 4 = good, 5 = excellent.

Date ____________________ What was measured? __________________________

	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Replication 1						
Replication 2						
Replication 3						
Replication 4						
Replication 5						
Replication 6						
TOTAL						
Average result Total ÷ no. reps.						

Other measurements

Date ____________________ What was measured? __________________________

	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
Replication 1						
Replication 2						
Replication 3						
Replication 4						
Replication 5						
Replication 6						
TOTAL						
Average result Total ÷ no. reps.						

Garden research record form E

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Notes

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