Planning and Conducting an Organic Vegetable Variety Trial at any Scale

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By Caleb Poppe

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Introduction

At the bare roots, variety trials allow for the observation of how a single variety performs within the context of a specific location, and by adding numerous varieties of a specific crop to the trial, we allow for comparisons to be made between the progenies. Yet, while the concept is somewhat simple, the significance of variety trials may be vast, and the potential of a single trial comes down to what questions the individual grower is attempting to answer. When properly planned out and introduced into growing operations, variety trials can introduce diversity to a crop plan while allowing for the grower to better understand the vast differences that can exist between varieties of the same vegetable crop.

The importance of a well-performing crop variety in any climate or region has, at some level, always been recognized (and often cherished) by the farmers and gardeners of that region. Even when looking back to the dawn of agriculture, as the growers tended to their desired food crops and collected seeds from the plants that performed the best and exhibited the grower's desired traits, it seems that plant breeding and seed collection was being done on an instinctual level. Now, in more modern agricultural settings, the majority of farmers have shifted to relying on seed companies and plant breeders to do the time consuming, but

important job of producing and distributing organic seeds collected from crop varieties that are known to perform well and meet the farmer's needs. While there are many pros and cons to this shift, it has undoubtedly put an added burden on growers when they begin choosing the specific varieties to trust and rely on to meet their needs; implementing variety trials into growing operations may assist growers in garnering trust of the varieties they include in their plans. This guide will attempt to highlight the importance, aid in the planning and implementation of, and give some suggestions towards efficiently incorporating variety trials in into growing operations. The order in which this guide is laid out is the order that the author follows when conducting variety trials of their own, and as other growers gain more experience, they may find an order of operations that makes more sense than the one presented here.

Why do we do variety trials?

There are many reasons growers implement variety trials within their operations. Perhaps a grower wants to compare a few of the newer varieties that are just coming into the market in relation to their tried-and-true varieties that have been working for them for years. Doing a trial with these different varieties may show that some of the new varieties outperform the grower's go-to, maybe the new varieties add some unique color or flavor but isn't as vigorous as the trusted variety, or maybe the new varieties just can't compete with what the grower has trusted for years; no matter what the outcome is, each scenario has the potential to offer clarity and confidence to the grower.

Organic plant breeders conduct trials for similar reasons, but they are often working with varieties that are novel and may never make it to a seed catalog, and in this setting, variety trials are an integral part of the breeding operation. The process of breeding organic, open-pollinated varieties is a slow process that never really ends as this world and its environment is everchanging, which means humans must remain adaptable and observant. It is common in organic breeding operations for large fields of certain varieties to be grown out, and for seeds to be collected year after year in a process called *Mass Selection*, which is the process of collecting seed from plants that displayed the desired traits of the breeders. The seeds that are collected from the mass selection are then mixed and grown out yet again, repeating the process over and over until the variety shows consistency. While this is a very large-scale and specialized example of a 'variety trial', the process of planning is not that far from that of smaller scale operations.

The importance of holding variety trials only grows when considering the deepening discrepancies and insecurities that climate change has added to the world. With the longer lasting and more dramatic weather events and the increase of unprecedented seasonal changes, having varieties that are suited to a grower's climate becomes critical. By selecting for hearty and resistant plants, farmers are given a leg up in preparing for and adapting to the unpredictable growing conditions.

In the face of these changes, it seems that biodynamic/organic agriculture has been gaining attention and reverence among farmers and agricultural researchers, some may even

call it a ‘renaissance’. As more growers shift from conventional agriculture, there has come a demand for organic or heirloom varieties that have been bred to thrive in an organic system instead of relying on excessive amounts of synthetic inputs to grow the crops. It has been presented that by continuing to maximize the potential of organic varieties through intensive organic breeding programs, and in conjunction with regenerative farming practices, organic systems may begin to match the yields of conventional agriculture, further shifting modern agriculture in an arguably more sustainable direction.

It matters not what setting and scale a grower operates within, the potential benefits of conducting variety trials are expansive, and if nothing more, it offers an opportunity to grow a novel vegetable variety with an interesting background that will inevitably bare food that will make it to someone’s dinner plate.

Data Collection and Documentation

Variety trials take time, and with the passing of time comes the opportunity for details to be lost or forgotten. Potentially the most important aspect of any research project (variety trials included) is a comprehensive plan for data collection and documentation. There are many ways to go about this, and it often changes from one person to the next, but it can help to have a single location that records, observations, notes, maps, etc. are kept. Field notebooks are perhaps the most common medium for data collection, and smartphones are becoming more and more capable as well, but no matter the medium, some form of plan for data collection and documentation should be put in place before getting to far into the trial planning process.

Now that there is a data collection plan, there ought to be a plan for what specific data will be collected and what research questions will be posed. There is no limit on the questions and observations that may be considered at the beginning, only the reality of realistically being capable of collecting all the wanted data. Biting off more than can be chewed can affect the project as a whole so it is suggested to be precise with the questions and remain adaptable along the way.

Every crop has its own unique set of traits that play a major role in the growth of a plant and every grower has their own concerns and desires for their crops, so it is difficult to express potential examples of what kind of data could be collected. It can help the process of choosing what data to collect by coming at it from the perspective of which traits does the grower want to see in a specific crop. In tomatoes, for instance, direct sunlight can damage the exterior of a tomato and so it may be wise to collect data on the % leaf cover that each variety offers its tomatoes. Another potential example may be that a grower wants to know the total number of days that pass from the point of transplant to the first setting of fruit for different pepper varieties. Regardless, any questions that the grower finds intriguing are worth attempting to answer, and the more variety trials that a person does, the easier this gets.

An interesting suggestion for documenting the progression of plants in a trial is to try and take a photo of one specific plant from each varietal block at equal intervals throughout the extent of its life cycle. Having a weekly photo of the same plant from every varietal block

can be strung into a very compelling, visual tale of the plant's life within a specific trial. While it is not wholly necessary, coming up with creative and unique ways to document plant progress only adds more perspective to the trial and makes for interesting contemplation when it comes time to analyze the results. Frequent note taking and documentation allows for clear and concise recollection during the trial, and even months or years after the trial has ended! The goal should be to make the whole process as fluid and streamlined as possible, and clear record keeping and concise data collection are a great start to being successful in this.

Complying with Organic Standards:

When a variety trial is being conducted on certified organic land, there are some added aspects that need to be considered throughout the planning period. The National Organic Program's organic seed rule states: "The producer must use organically grown seeds, annual seedlings, and planting stock: Except, that: Nonorganically produced, untreated seeds and planting stock may be used to produce an organic crop when an equivalent organically produced variety is not commercially available." In other words, if the trials are to be held in a certified organic space, organic seeds need to be acquired, and when that isn't possible, proof will need to be shown that there is no organic equivalent to the desired non-organic variety that is offered by distributors.

In addition to the seed origin, good records should be kept of all amendments and or treatments that are applied to the field during the trial, in addition to the records of the management of the land. When making decisions on potential amendments and treatments, they should be approved as acceptable for certified organic use. This is another good reason for having clear and concise documentation and record keeping.

Getting started, choosing a seed origin

Before a seed order is ever placed, there is some planning to be done and questions to be answered. A safe place to start the planning of a variety trial is put together one or more big picture questions that you are hoping to answer, questions such as: '*How does variety A compare to variety B in its resistance to a particular pest?*' or '*Is there a difference in harvest yields between varieties?'.* Variety trials are a pertinent way to compare differences and similarities in varieties, so choosing which crops and varieties you want to compare should also be at the top of the list of the planning stage. Growers often choose varieties that they want to know more about and are interested in and doing this adds personal interest and intrigue to the whole process, making it easy to integrate the varieties that perform well into their crop rotation. Using local seed companies or breeders to source your seeds from also increases the likelihood of finding successful varieties because these entities usually specialize in regionally adapted crops that are known to perform in the climate they operate in. It never hurts to make a few phone calls and talk with seed distributors about varieties that they find exciting or may be new to the market and could use some private grower's feedback. In the end, the varieties

that are chosen should have some interest to the grower and have the potential to fill a niche within their operation.

Once the varieties have been chosen, it is time to begin thinking about the field that the varieties will be grown in, as well as how this will be done. Knowing how many plants of each variety should be grown, and how much space is needed to accommodate this are questions that ought to be answered before seeds are purchased so that the grower can purchase the correct number of seeds. Next, we will talk about field layout and how to make decisions about space, plant volume, and what materials may be needed to manage and care for these crops.

Field layout and experiment Design (layout, planting amounts, maps)

It is common to for growers to already have a location within their garden or farm in mind as they begin to conceptualize the variety trial in their heads. While the amount of available space is a critical aspect, variety trials can be beneficial at any scale with the success usually depending on the grower's ability to accommodate the total scale of growth that they decide to attempt. To simplify, a grower tending to 4 plants of 3 different head lettuce varieties in there back yard may find just as much value in their trial as a university breeder trialing 50 plants for 13 different varieties, and the processes of conducting these two trials are fairly similar.

No matter the scale, it is necessary to know the amount of space that can be dedicated to the trial, once the field dimensions are known, it is possible to start mapping out the field to equally contain the varieties chosen. Depending on the crops that are to be grown, there will be different spatial requirements that need to be met. For example, a trial of peppers will have a different set up than a trial of carrots because they both require different planting spacings and management practices. Knowing the dimensions of the planting beds, how many rows per bed are common for a specific crop, whether the plants will be transplanted or directly seeded, and the plant spacing are all factors in planning out the layout of the field.

Another thing to consider is whether there will be multiple replications within the trial, meaning that there may be multiple plots that each contain a different, random arrangement of the same varieties. For instance, say there is a shady spot and a sunny spot in a grower's field and the grower wants to know if the varieties perform differently in those two setting, multiple replications can allow for a richer and more powerful result. If numerous replications are to be included, this will undoubtedly need to be included in the planning process. To put the planning of the field layout into context, below is a real-world example of a radicchio trial, and how the field may be laid out.

<u>Example of Necessary Information for Field Design:</u>

- Total number of varieties of the specific crop ----- 6 varieties of Radicchio
- Field(s) Dimensions ----- 36ft x 7ft
- Bed Length and Width ------ 36ft x 36in

- Number of desired replications ------ 2 Replications
- Planting rows per bed ------- 2 planting rows per bed
- Recommended plant spacing for the specific crop. ------ 12 inch, offset

Once all this information has been collected, the experiment design can begin taking place.

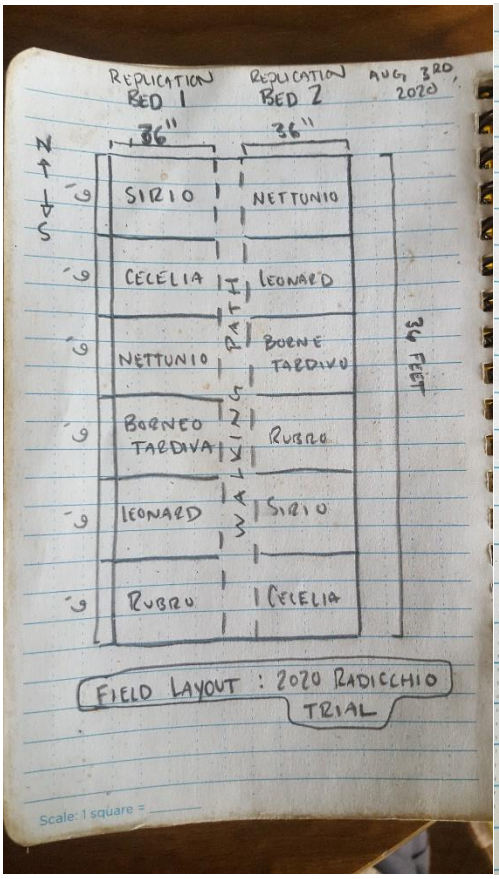

Image 1 : Example of a Randomized Block Design of 2 separate replications from a radicchio trial containing 6 radicchio varieties.

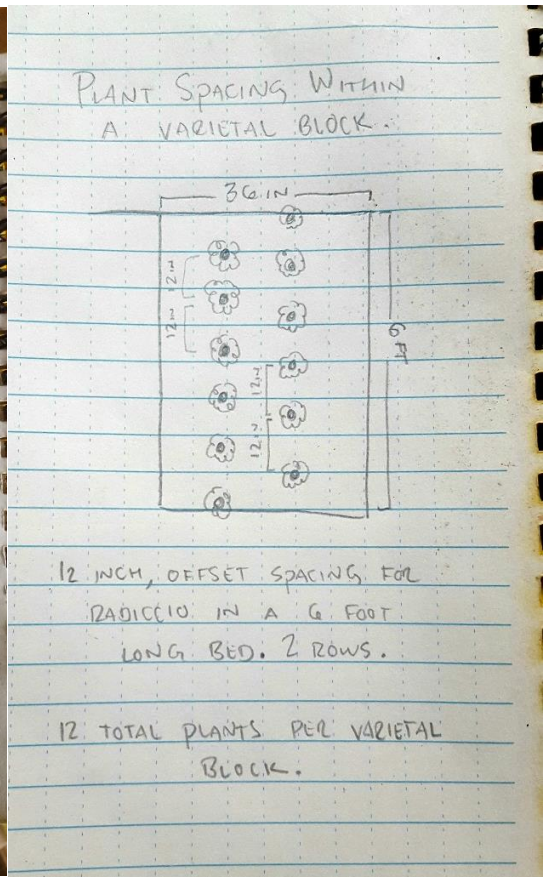

Image 2 : Example of a single 6ftX36in varietal block containing 12 radicchio plants spaced 12in apart.

There are many correct ways to design a variety trial but there are a few factors that should remain constant throughout the planning. No matter how many varieties end up getting trialed, the blocks that will each contain an individual variety (often called varietal blocks) should be the same size and contain the same number of plants. Image 1 above shows an example of a plot design in which 6 different varieties of radicchio are being trialed in two separate replications, side by side. In this design, both replications contain identically sized beds, each varietal block has the same dimensions, and both replications contain the same six varieties of radicchio arranged in different orders. When this arrangement is done randomly, to not give any bias

towards any one variety, it is referred to as a Randomized Block Design (RBD); if all replications had the varieties arranged in the same order, there would no way to know for certain whether the varieties only performed the way they did because of the influence of the adjacent varieties. An example of this may be: one variety that is known to grow quite tall may begin shading out its neighbor, and if there was the exact same arrangement of varieties across all replications, then it would be difficult to know whether the smaller neighbor only grew small because it was shaded out, or if short growth can be considered the 'norm' for that particular variety. This example is also a good piece of evidence towards why it is good to try and have at least 3 replications in a trial, if not more, but there isn't sufficient space for that, it shouldn't stop the grower from doing the variety trial.

Referring back to the example above, the planting field was laid out with two beds that were 36 feet long and 36 inches wide with a 1-foot-wide walking path in between the beds. Knowing that the trial would be planting 6 different varieties conveniently allowed for each bed to be broken into 6 identical varietal blocks that would each be 6ftx36in. Now that the plot has been clearly and equally laid out and the varietal blocks have been delineated, the varieties can be randomly placed within each replication. There are equations that exist that aid in the Randomized Block Design, but it is this author's belief that in the context of *most* variety trials, pulling names out of a hat is an acceptable method as long as there isn't too much similarity between the replications.

The final key to the field design is deciding how the plants will be arranged in each varietal block. In the example above, there is 6 bed-feet for each block, and it is common to have 2 rows of radicchio next to each other in a 36in wide bed; with a 12in, offset plant spacing, the maximum number of plants that could equally fit into that bed is 12. In other words, each varietal block could contain two rows of radicchio plants with 6 plants in each row spaced 12 inches apart, just like in Image 2. With 2 total replications, that would mean a total of 24 plants would be needed per variety, and it is often a wise choice to have a few back-up plants for each variety, so that the grower has a little room for error.

This process of experimental design is only slightly affected by trials in which the plants are to be directly seeded rather than transplanted. In the example above, the grower needed to know exactly how many plants were going to transplanted so that they could make a plan for starting the plants indoors. When seeds are to be directly seeded, the total number of plants is less important, and the seed spacing, and total number of seeds becomes the focus of the design. If it is known what the length of the varietal blocks are, the recommended seed spacing, and the total number of rows per bed, then an estimate for the total amount of seeds that will be needed can be determined using some simple arithmetic. [(block length ÷ seed spacing)*rows per bed]

If a seed order hasn't been placed by this point, it would be a good time to do so; with the knowledge of the total number of plants that will be needed per variety, a reasonable number of seeds can be purchased.

(Notice that the two example images are pictures taken from a field notebook, it is always wise to draw and catalogue the steps and decisions that are being made along the way. Notes from a field notebook can always be transposed or scanned to a more permanent setting such as a computer or tablet later on.)

Necessary materials i.e. irrigation, trellis, mulch, tools, etc.

Although the field layout has been set up and the urge to get seeds started is nearly unbearable, there are a few more steps that need to be done ahead of seeding.

As most growers are aware of, the care and management of plants through an entire life cycle often requires the use of various materials such as drip tape, seedling trays, trellises, mulch, etc. which all need to be acquired, and have their own associated costs. To remain prepared and ahead of the schedule, it is suggested to make a list of the exact amount and type of materials that the grower would like to use in the management of the trial. Budgeting for these materials ahead of time is also wise (and often necessary) no matter what scale the variety trial will be, knowing the costs that are associated with the trial ahead of time keeps the grower prepared and adaptable while putting into perspective how the total expense of a variety trial compares to the normal operating costs of the space.

Beginning now to think about the management plan of the specific crop is a good place to start when making the list of materials that will be used. More information about planning the management of the crops will be covered in the *Plant Management* section of this guide. Important questions to help with this may be: What materials and supplies already exist in excess that wouldn't need to be purchased? Will the plants need to be trellised? Will they have overhead irrigation, drip irrigation, or be hand watered? How many seedling trays and seeding mix will be necessary? And more!

All the necessary materials may not all be clear from the very beginning but starting the process of contemplation early maximizes the potential of having everything in order on time, and materials can always be added or removed from the list as the planning and preparation progresses.

Remember that documenting the field set-up is an important part of the trialing process and a record of any materials that will be added to the soil or used in the fields should be kept for posterity, and for organic certification purposes.

Field Preparation

As the time to get seeds into dirt draws nearer, the planting field awaits preparation.

If the plants of the trial are to be transplanted, seeds may be sown in their trays ahead of the actual field preparation as there will be time to prep the field as the plants get established; for direct seeding, the planting bed must obviously be prepared ahead of time so that the seeds can be placed and then left relatively undisturbed. Knowing that every grower has their own process of field preparation, it is common for this look different from one grower

to the next. It is suggested that the same practices that the grower uses in their normal operation (field prep, amendments, plant management, irrigation, etc.) be carried into the variety trial setting as this offers the most authentic results for how these varieties perform in that grower's context. Although the field layout should be recorded in the notes and maps created by the grower, it is highly recommended that the varietal blocks are clearly labeled in the field, with the varieties they contain, the replication #/name, and the dates that the trial was started.

Another consideration of field preparation has to do with the intention of the trial and the questions that are being posed by the grower. Perhaps they want to observe the plants in a more 'extreme' setting than normally exist in their field, they may reduce the frequency of irrigation to stress the plants or opt out of placing a replication in a covered tunnel to see how the plants perform when exposed to the elements of that region. All of this is perfectly acceptable, but it is important to be consistent across all varietal blocks, and to give each variety similar care to rule out any controllable variables that may affect plant growth.

Seeding & Seedling Care (direct seeding, transplant)

The next step of the planning process is to make a plan for the sowing and maintenance of the seedlings. In the *Field Layout and Experiment Design* section of this guide, the grower is asked to consider whether they plan to transplant the seedlings or directly seed the varieties into the beds. It is recommended that there is an intentional plan put in place for whichever method is to be used.

For trials where the plants will be transplanted, it is good to plan out:

- where the seedlings can be safely kept prior to transplanting
- how many total plants need to be started in the trays
- the seeding method for the trial crop (seed depth, seeds per cell, tray size, etc.)
- whether they will be repotted into bigger pots before being transplanted
- how long the seeds will remain in a greenhouse/indoor setting
- watering and maintenance plans
- data collection for germination rates
- where the plants will be hardened off before being transplanted.

With regards to the total number of plants that should be started indoors, this author recommends adding 20-30% more plants to the seeding than the total number that will be transplanted into the field. Doing this allows for some failures in germination and other accidents that may result in the killing of plants, and any excess seedlings can be planted elsewhere so that they don't go to waste. All other information for the list above can often be

found in the varietal descriptions done by the seed distributors or it may just be intuitive from past experiences.

For trials that will be directly seeded, it is good to plan out:

- seed spacing and seeding depth
- irrigation and seedling maintenance
- materials needed to aid in the seeding (hoes, seed drill, shovel, etc.)
- data collection for germination rates

Another thing to consider when planning out the seeding is what to do when there is a large amount of crop failure that might affect the trial results. What if a branch falls on one of the varietal blocks and kills half of the plants? It is hardly the variety's fault that it was planted underneath that branch and yet, this would undoubtedly have a dramatic effect on the data that is collected from that variety. As a rule of thumb, when there is any crop failure, it is good to thoroughly document what happened, and how it was addressed. Depending on the timing and the maturity of the plants, it is often acceptable to try and re-seed or re-transplant into the space where there are missing plants, and thus validating the suggestion to have a bit of excess seeds when possible. If re-seeding or re-transplanting is not an option, the loss can be accounted for when analyzing the results.

To minimize the amount of loss, the grower should have in place a schedule for the watering, weeding and maintenance of the wee little babies. The first 1-2 weeks of seedlings is a critical time where many things can go wrong, so being prepared and having contingency plans in place may save the day at some point. If there are no plants that make it maturity, then there is no variety trial.

Once these methods have been carefully thought out, the field has been mapped and prepped for the crops, and some sort of management plan is in place, seeds may finally be sown!

Plant Management (pruning, thinning, pest & disease management)

Once the plants have become established, the real fun may begin.

Each vegetable crop has a slightly different process of management and is often done differently from one grower to the next. For instance, carrots may have to be thinned, weeded occasionally, and then harvested; tomatoes, on the other hand, often call for pruning, trellising, mulch, weeding and continual harvests. One method isn't necessarily harder than the other, but they do require different amounts of work and a different timing of when that work has to be done. It is common for variety trial growers to follow whatever standard management is agreed upon for a certain crop, and this should be done consistently from one variety to the

next. To reiterate, if the varieties receive similar care across the whole trial, the efficacy of the trial will remain intact.

Another critical aspect of plant management is planning for potential pest and disease outbreaks in a field. Managing pests and diseases is usually high on a grower's list of things to tend to when they have been identified, but in variety trials, pests and diseases are not always an unwelcome discovery. These outbreaks in a trial are often quite exciting and can add a unique set of data to the results as a whole. When a pest or disease is first observed within the trial, the first thing that should be done is the immediate documentation of what varieties and how many plants have been affected. Once this has been done, the trial may require some more frequent observation to see at what rate the infestation is spreading, as well as how the plants are coping. Observing varieties that seem to be unaffected, even when they are within close proximity to infected plants, can be some compelling data pointing to that variety's pest and disease resistance. The grower must then make a choice as to whether they want to try and step in to slow or stop the spread, or if they are okay with the outbreak running its natural course; both options are acceptable as long as they are clearly documented.

Labor and help

Having people that are willing to help with a variety trial are usually greatly appreciated, offering some relief to the total amount of work, and adding another point of view and set of eyes to the trial. If there are multiple people tending to a variety trial, time should be taken to fill everyone in on the details and management plans so there is a smaller chance of misunderstandings and mistakes taking place. Knowing that different forms of data and observations will be gathered, it is also wise to ensure that everyone is using the same standard for collecting data and documenting observations. Keeping everyone in the loop with the plans and changes that are taking place will make for a streamlined trial, and when it comes time to analyze the data, there will be less confusion in interpreting the results.

End Use/Harvest

Up to this point of the guide, details and information have been given that ought to carry a grower up to the point in which the varieties are just becoming mature and harvests need to start taking place (if the goal is to harvest them at all). With every different crop type comes a different standard of harvesting, so growers should plan to accommodate whatever type of harvest is needed for the crop; this could be gathering harvest bins, getting scales and other measuring devices, or knowing where the harvested crops will be stored. To make things a bit more complicated, different varieties may begin to mature and different times, thus requiring some changes in the harvest plan such as making a schedule and/or deciding how long consecutive harvests will go on for. It may also be worth explicitly detailing what is going to be determined as ripe for harvest, and what is considered under-ripe so that each variety is being represented equally.

There are commonly 2 types of plant harvests: there are continual harvests in which the crops are returned to and harvested from over a period, and there are mass harvests in which the whole trial is harvested all at once. Tomatoes are a good example of a crop that is often continually harvested, and barley is a good example of a crop that is often mass harvested. As the ripe crops begin to get harvested, there should be a plan in place for what is going to be done with the harvested crop. What data is going to be collected from the harvests? What is going to be done with the crop once the data has been collected? Answering these questions may ensure that the harvested crops do not go to waste and that good, usable data is collected from them.

Data coalescence & Site Clean Up

It is always bitter-sweet seeing the variety trial field empty out as the harvests take place, so much time and energy has been put towards the gathering of this personal research, but it usually pays off in quite a bounty of knowledge and vegetables! Throughout the trial, data has likely been gathered from multiple different aspects of vegetable growth and it may seem a bit daunting to tackle the data analysis. Whether the grower's notes and data are scattered among various field journals or kept tidy in folders on a computer, it is a good idea to try and clean up all the data and put it into one simple format. Often, trial data is transposed from field notebooks into spreadsheets where it can be condensed, organized, and eventually analyzed. While this may be a time-consuming task, it can save endless amounts of time down the road when the grower attempts to answer the questions they have posed from the very beginning. Having the data in a spreadsheet also makes any potential statistical analysis and/or graph building clean and easily done. Throughout this process, it can be helpful to keep the research questions front and center in the mind as this usually helps keep the analysis in perspective and can give the grower clarity on how and where to move forward. The data analysis can take time, and shouldn't necessarily be rushed, unless there is an outside time limit that must be kept. Work smart, not hard through the coalescence of the data!

Regardless of the results, there still exists and entire field full of labels, management materials, and harvest supplies that are waiting to be cleaned up and organized. While most growers have a routine for site clean-up and flipping planting beds, it is still worth mentioning that this is a very important part of the whole process and often feels like the proper end to the full cycle of the trial.

At this point, a big sigh of relief and yet another deep breath may be in order, for this specific variety trial that has been carefully thought out and implemented has all but come to an end.

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