Supporting the ethical development and stewardship of seed

On-farm Variety Trials: A Guide for Organic Vegetable, Herb, and Flower Producers

This publication was made possible through funds from the Risk Management Agency.

Table of Contents

Special thanks to the USDA Risk Management Agency (RMA), who has provided support for the publication of this guide and associated series of educational workshops. For more information on other risk management education publications and programs visit www.rma.usda.gov

Introduction

Farming can feel like one gamble after another, but the most successful farmers know that good risk management strategies can make all the difference in increasing farm stability and profitability. Since the advent of agriculture farmers have engaged in trials. They have experimented with new cultivation techniques and inputs, explored alternative and diversified markets, and initiated innovative pest and disease management practices. The complexity of operating a farm and the demands of the market can appear overwhelming, but engaging in on-farm trials can help refine production practices, keep innovation alive, and foster the sense of wonder that draws many to farming in the first place. Variety trials are an important, although often overlooked, tool for managing risk. Choosing the right crops and varieties for the local climate, field conditions, and market can significantly minimize loss and increase agricultural success while avoiding the expense of investing in poorly adapted or poorly performing varieties. Conducting on-farm variety trials helps identify varieties that can:

- Minimizing crop loss due to pests
- Maximize yields
- Fill key market and production niches
- Identify the best organic seed sources

Following basic scientific methods when conducting on-farm variety trials brings a level of assurance to results whereas simply trying a new variety without a good experimental design can give misleading and even invalid information. This guide provides training in basic, on-farm experimental design, as well as tools to efficiently and effectively manage on-farm trials and utilize trial results. Using this guide you can learn how to:

- Minimize efforts and improve results by efficiently integrating trials into standard farming practices
- Source varieties for trials
- Assess field conditions and layout variety trials
- Manage data collection and assessment

The target audience of this publication is organic vegetable, herb, and flower producers. The primary goal is to teach this group of producers how to conduct on-farm variety trials and use the results of trials to direct their variety selection and seed purchasing choices in a manner that minimizes farm risk. The funding for this publication was provided by the USDA Risk Management Agency (RMA). RMA supports risk management education for producers of specialty crops (such as organic growers) that do not qualify for federal crop insurance. This guide may also be very useful for additional audiences including conventional producers, seed producers, plant breeders, gardeners and producers of grain and commodity crops, but the content is directed toward the target audience.

Benefits of On-farm Variety Trials for Organic Growers

While all producers can benefit from conducting on-farm variety trials, organic producers have system-specific needs that make trials all the more valuable. For example, organic producers have fewer allowable inputs for mitigating crop pests than their conventional counterparts, and as such, appropriate crop genetics are all the more crucial for success. Organic producers are also faced with a lack of genetic research and educational information, as the vast majority of seed industry and public variety trial programs are conducted and managed in non-organic systems. Additionally the traits or issues important to an organic producer may be different than the traits prioritized in a conventionally managed trial. For example, pest issues, fertility requirements, and market demands may differ between the two systems.

Even a variety trial with results that indicate there is no suitable organic alternative to a given non-organic variety or source are valuable in that it demonstrates that the farmer is acting in good faith to follow the organic regulations guidelines. It also provides good information on alternative varieties in case a farmer’s standard variety is dropped from availability, which happens all too often. Additionally, if on-farm variety trial information is shared, it has the potential to improve future availability of appropriate organic seed sources by providing plant breeders with information that can help them set priorities for future breeding efforts for organic growers, and by providing seed companies with information about the needs of organic farmers.

Organic seed and the National Organic Program regulations

In addition to farm management benefits, on-farm variety trials are a useful tool for organic producers to minimize risk by evaluating and adopting varieties of available organic seed. Not only is there the potential that organic seed may be better suited to organic growing conditions, but organic growers are required to use organic seed sources when commercially available. On-farm trials can aid in organic seed adoption and compliance with organic seed regulations.

Organic producers who gross more than $5,000/year from organic crops must be certified by a USDA-accredited certification agency. Those earning less than $5,000/year can market crops as organic without being certified, but are still subject to the National Organic Program (NOP) standards. A list of accredited agencies and the organic regulations are available on the USDA NOP website: www.ams.usda.gov/NOP

The NOP organic seed standard states:

§ 205.204 Seeds and planting stock practice standard

> (a) The producer must use organically grown seeds, annual seedlings, and planting stock: *Except*, that:
>
> (1) 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*, *except*, that organically produced seed must be used for the production of edible sprouts;
>
> (2) Nonorganically produced seeds and planting stock that have been treated with a substance included on the National List of synthetic substances allowed for use in organic crop production may be used to produce an organic crop when an equivalent organically produced or untreated variety is not commercially available.

The term "commercially available" is defined in the regulations as:

> the ability to obtain a production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan.

Note that price is not mentioned and therefore not considered a component of commercial availability, which reinforces the importance of on-farm variety trials for demonstrating quality and form of organic and non-organic seeds found on the market.

Seed trials as an organic compliance issue:
As the organic marketplace matures, greater attention is being paid to the more subtle, less-defined, and often decidedly vague aspects of the regulation. The use or non-use of organic seeds and claims of commercial availability or equivalent varieties are an important example of this situation. Presently, the consensus among most certifiers is to require documentation that shows that *reasonable* attempts have been made on the part of the farmer to source organic seed. For the most part this has meant showing that the varieties used by the farmer are not available in organic form.

In some crops there may be cases where only one variety will meet market demands and suit conditions on a given farm. However in many cases more than one variety can be suitable. Variety trials can help organic farmers evaluate newly available organic varieties, adopt suitable organic seed sources and demonstrate compliance with the regulation.

It is widely understood and accepted that varietal characteristics such as timing of maturity, cold or heat tolerance, pest resistance, water requirements, color, size, appearance, and so on, are critical to the success of organic farmers. As such, certifiers do not generally second-guess farmers' decisions about variety selection. However, trials of organic varieties are currently accepted by some certifiers to evaluate new organic varieties as they become available, and to demonstrate commercial unavailability if available organic varieties are not suitable to the operation. With an ever-increasing list of seed varieties available in organic form, it is suggested that in the future organic producers may be required to use organic seeds on the market rather than the non-organic varieties they are accustomed to.

One aspect of the organic standards that differentiates organic production from non-organic production is the requirement to have cultural practices in place to justify the use of any off-farm inputs to manage fertility, weeds, and pests. There are also limits to the availability of allowed materials to use on organic farms to deal with weeds and pests. For example, manual, mechanical, and cultural practices are used to control weeds in an organic system, while most conventional systems rely on herbicides. Some of the most common cultural practices used are the use of cover crops, crop rotation, and the *use of resistant varieties*.

Expanding market potential and attracting new customers

A classic mistake that farmers may make in variety selection is to look over the fence of the best grower in the area and grow whatever he or she is growing. However, as progressive farmers know, if you can stay innovative, offer alternative varieties, and choose crops that attract customers, then it will be your fence the neighbors peer over. Producing the first tomatoes of the season or the last fall lettuce for Thanksgiving salads requires careful variety selection. On-farm variety trials allow you to identify the varieties that fit a market niche, produce optimally in a given planting window, extend your production and sales seasons, and provide increased security in your farm plan.

On-farm variety trials can increase economic security of a farm and expand market potential by identifying:

- Varieties that meet local climatic challenges
- Varieties that fit different production windows, allowing continuous availability over time and extending the season
- Novel crops to fit market niches
- Varieties with good market qualities like flavor or visual appearance

<u>Climatic challenges and extended seasons</u>: Agricultural markets have traditionally followed the cycle of the seasons. However, today the produce seasons are blurred as world-wide distribution allows year-round tomatoes and availability of off-season produce including asparagus, zucchini, and spinach. While this international market grows, there are an increasing number of customers who are devoted to local food, recognizing that fresh, seasonal produce nearly always has the best flavor, tends to follow seasonal cravings, supports local economies, and reduces environmental impacts.

Farmers who cater to local markets and build a reputation for quality know that local, seasonal produce can compete well with imported goods. However, local climatic constraints may challenge less-adapted crops. Many varieties have been developed specifically for the conditions of the major areas of production such as celery and artichokes for cool, maritime climates and tomatoes for hot, Central California valleys.

Genetic diversity allows crops to be adapted to regions far from their centers of origin. For example, chile peppers, originally from Central and South America, are now part of the Hungarian and Thai diet and corn from Mexico fed the Native tribes of the Northern Plains of the US. This diversity means that some varieties will perform better than others under climatic and environmental challenges. There are tomatoes that will set fruit sooner than others after a cool spring and some kales will survive or even continue to produce through cold winter temperatures. Identifying varieties with such qualities offers an ability to expand offerings and extend the season to fill early and late production windows.

Sequential sowings:
By planting a variety trial you can identify optimum varieties for each specific planting period. For example, some lettuce varieties resist bolting and form heads under hot summer conditions while others offer frost tolerance for late-season sowing. By sowing your lettuce trial repeatedly throughout the season you can identify the best variety for each production window, creating a strategy for sequentially planting the optimum variety for each sowing date.

> "Part of why I am interested in placing our existing varieties within the trial plots is that I haven't ever done a scientific trial of them. We have not yet been able to compile useful data, and would like to know what part of the season an old favorite like Waldmanns, for instance, actually performs best. None of them perform perfectly all season. I have a strong hunch that each variety within a type has its favorite part of the season." River Bean, Arctic Organics, Palmer, AK, lettuce grower

New crops and varieties:
Experimentation is one of the joys of farming – trying something unusual, whether it is a piece of equipment or a different planting rotation. Identifying novel, interesting crops or varieties of a crop you already produce can be a way to differentiate yourself in the marketplace and attract new customers. Farmers market customers, chefs, and specialty distributors are intrigued by unusual or exceptional varieties, varieties with a story, superior flavor, or intriguing color. Eventually these more obscure crops find their way into the supermarket, but they tend to get their start from local sales by innovative growers. The heirloom tomato craze of the last decade was a prime example of this market phenomenon.

Colored carrots (non-orange) are a current example of a 'new' crop appearing at farmers markets and in bags of mixed frozen vegetables. Many obscure varieties of common crops have not been bred for commercial production or may even, as in the case of colored carrots, have evolved in climates very different than those found in production areas of the United States. Many colored carrots, particularly the red ones, evolved in warmer climates and require little chilling (vernalization) to induce bolting, therefore when planted under cool spring conditions they bolt readily.

Conducting an on-farm variety trial prior to expanding production of new, unknown varieties prevents the difficult lesson of losing a crop. For smaller markets, such as restaurants and farmers markets, sharing samples from the trials with your customers not only garners consumer feedback, but also builds demand from the "sneak preview" of what new, interesting crops will come in the following year.

Addressing crop stresses
Individual plants and crop varieties vary in their response to crop stresses. This genetic breadth offers an opportunity to enhance crop growth

under environmental, pest, pathogen, and climatic constraints by identifying varieties least affected by the stress conditions.

Individual plants and crop varieties vary in the following:

- Pest tolerance and resistance
- Drought tolerance
- Nutrient utilization
- Heat and cold tolerance
- Pollution tolerance
- Timing of maturation
- Day length requirements

There is an axiom in plant breeding that states, “Always breed under the conditions of intended use”. The same rings true for conducting variety trials, “Always trial under the conditions of intended use.” If the crop stresses are not present in the trial, then the genetics for resistance or tolerance will not be expressed or apparent in the evaluations. As such, the trial must be established under the right conditions and timing to ensure the varieties are exposed to the intended crop challenges. For example, if your spinach crop is subject to downy mildew early season but not in the fall, and your goal is to find a good downy mildew resistant variety, then obviously the trial must be planted early spring. Similarly, if you want to identify a good bolt-resistant spinach variety then it should be planted to ensure it is exposed to the long-day bolting conditions of late spring and early summer. It is also important to remember that organic conditions are often very different from conventional and as such, relying on conventional trial data as your sole source of information is a risky venture.

It is important to keep in mind that many of the above-mentioned crop challenges may occur in patterns across the field. For example, aphids often move into a field from the direction of prevailing winds, cold pockets form in low areas of the field, and soilborne diseases and symphylans often occur in patches of the field. Replication in the trial is a tool to account for this variability in conditions. However, blocks should also be set up to increase uniformity of conditions as much as possible (see Trial Layout).

Planning the Trial

Identifying trial goals

It is important to articulate trial goals in order to ensure that the seed sourcing, trial planning, and experimental design will result in the desired information. Variety trials require time and attention. The trial goals determine the optimum timing of planting, how the crop should be managed, how large the plot size should be, when to evaluate the trial, and how to interpret trial results.

Prioritizing crops

Since trials of every crop are not usually practical you will have to decide how to prioritize efforts. On a diversified farm it can sometimes be difficult to do this. Clearly efforts would be well spent to optimize production of the largest farm crop or one that brings the greatest economic return. At the same time, this crop may routinely receive priority and production practices and variety selection have likely already been refined. Perhaps it is the new and less familiar crops that should receive emphasis. Integrating annual trials into your long-term farm plan will provide guidance in making these decisions.

Choosing trial varieties and acquiring seed

Seed acquired for your variety trial should reflect the goals of the trial and reflect your farm management approach. If you are only interested in using readily available seed that your favorite seed company carries then it makes sense to simply approach your seed company representative for suggestions of varieties. If you are interested in identifying the best variety in existence regardless of the source, then your search should have a broader reach. If the best variety is not commercially available, perhaps you would consider producing your own seed stock or approaching your seed company representative and asking if they would consider carrying it.

Ralph’s Greenhouse, a 100-acre farm in Mount Vernon, Washington, is located near Osborne Seed Company. Tim, the farm’s production manager, wants to start producing Brussels sprouts and cauliflower, two new crops for the farm. Since Osborne Seed representatives are familiar with the farm location and climatic conditions and they have a good working relationship, he asked them for recommendations for his trial. Tim is also interested in identifying good organic seed sources for his Brussels sprouts and cauliflower, so he sourced additional organic seed varieties from other companies to include with Osborne's organic and non-organic recommendations.

Before seeking out varieties it is helpful to create as complete a description as possible of ideal crop characteristics, or desired traits. This will help you articulate what you are looking for when sourcing seed and guide your variety selection process. The list of desired traits will also serve later as your criteria for evaluating the trial. For example, your description might include quality criteria along with basic plant growth parameters like days to maturity and height. You may want to be the first grower with tomatoes at the farmers market, but you also want a variety that fits your market and production system. So your description might be a red, flavorful, salad-size tomato that is determinate (to minimize trellising) and is less than 75 days to maturity.

Appendix A includes a list of resources for finding organic seed sources, public variety trial information, and other useful seed resources. Following are general sourcing considerations and recommendations.

<u>Seed companies</u>:
Seed companies are a good place to start looking for recommendations, but remember that they are in the business of selling seeds, so don't simply be swayed by the pretty pictures and gushing descriptions. Many seed companies have regional sales representatives who specialize in recommending varieties for local conditions and markets. Seed companies that conduct their own field variety trials will also tend to have more specific variety recommendations. Some seed companies even offer free seed or other compensation in exchange for conducting on-farm variety trials on cooperating farms.

<u>Public trials</u>:
Traditionally, public variety trials were a typical service of county Extension assisting growers in identification of regionally-specific, locally-adapted varieties. A decline in federal and state funding has reduced this service in many areas. Today, though not available in every county, there are a few programs in the Pacific Northwest that conduct vegetable variety trials on university research farms and cooperating growers' farms. Their results are very useful for gaining information about variety traits and regional performance. However, it is valuable to consider that some public trials can be limited in range of varieties and locations evaluated and in some cases are not conducted in organic production systems. (See **Appendix B** for information on public vegetable variety trial programs in the Pacific Northwest.)

<u>Networking – seed and information exchanges</u>:
Networking with other growers through regional conferences, farmers markets, or seed exchanges is a fun way to find interesting varieties while gleaning information from other growers or even sharing on-farm variety trial results. Local grower groups may even be interested in planning local on-farm variety trials strategizing evaluations of different crops on different farms to maximize the gain of trial efforts. Check with local farmer/gardener groups for opportunities or even start a seed and trial information exchange in your area.

Including a check variety

Always include your farm's standard variety in your trial, also called a check or benchmark variety. Your check or standard variety is a familiar point of reference to compare all other varieties in the trial. Including a check variety is important to:

1. *Compare the conditions of the season to "normal" conditions* – If you know your standard variety does not usually get disease, but it did this year, then you

would be able to recognize that the disease pressure is higher than normal and may be influencing other varieties in the trial more than it would under a low disease-pressure season.

2. *Compare the performance of the trial varieties to your standard variety* – This helps answer whether you should switch your standard variety to a new one.
3. *Communicate results to others* – If the standard variety is well known then you will be able to use it as a point of reference for explaining results of the trial to others such as co-workers, seed company representatives, or researchers. For example, "This tomato produced ripe fruit three weeks earlier than Early Girl!"

Doing the Trial

A variety trial is a scientific experiment in which the hypothesis is that some of the varieties have more desirable characteristics or genetic traits than the others. The goal of the experiment is to identify the best varieties for the location, market or production system. As with any scientific experiment, following a rigorous experimental design increases the likelihood that the results measured will truly be due to the treatment (in this case the variety) rather than from an external influence. The experimental design provides a statistical basis for measuring the likelihood that your results are accurate.

When varieties are grown and evaluated in one plot each on the farm, this is considered to be an 'observational' trial. When varieties are planted in multiple plots on the farm following a replicated experimental design, this is considered to be a 'replicated' trial. Replicated trials require more attention and effort, but provide greater assurance that the results are accurate.

<u>**Plot**</u>**:** The plot is the fundamental experimental unit. The term plot refers to a single location of the field planted with one variety. Each plot usually includes several plants of the variety. Each **block** includes a plot of each variety.

Observational trials

Observational trials can be very useful, especially if variability is minimized (see <u>Field effect</u> and <u>Consistent treatment</u>), but their limitations should be kept in mind. Because conditions such as soil type, sun exposure, or irrigation may vary across the field there is a risk that differences in performance of varieties are due to variable field conditions rather than genetic or seed quality differences. We have all seen uneven irrigation or changing soil types resulting in variable plant growth across a field. Replicating helps account for this sort of variability. Two of the benefits of observational trials over replicated trials are an ability to evaluate a larger diversity of material and a greater ease and simplicity in planting. If the same varieties are included in trials repeated over seasons then confidence in results may increase. For example, if a variety shows consistent performance over two or three years, then it is likely to continue to perform well.

Some crops are best evaluated inside as well as outside, such as the core sizes of these cabbages

Observational trials are useful for:

- An initial screening to evaluate whether a variety merits consideration for a replicated variety trial.
- Evaluating the overall composition, or uniformity, of a strain of a variety in an adequately large population.
- Checking for trueness-of-type or other seed quality concerns.

- Identifying variety traits, or potential strengths or weaknesses of a variety, with consideration of potential field variability. This sort of information gains strength when replicated over time, over multiple locations, or is followed up with a replicated trial.

Experimental design - replicated variety trials

The experimental design refers to how the experiment, in this case the variety trial, is set up or arranged in the field. The most common and appropriate design for variety trials is called a Randomized Complete Block Design (RCBD). It allows for testing as many varieties as desired, but must include two or more. (Three or more replications are recommended and required to conduct statistics). Each variety is grown in a plot in each block; and in each block, plots (varieties) are arranged in a randomized order. Blocks should ideally be located where there is as little variation in conditions within and between blocks as possible. Where variability exists, blocking is a tool to account for field variability; and where variability exists, blocks should be arranged so that the variability in conditions within the blocks is less than between blocks. In this manner all varieties are evaluated under each condition (block), giving each variety an equal opportunity to perform. (See Trial layout for a diagram of an RCBD.) Replication and randomization are the essential elements of the experimental design that help separate out the treatment effects (variety performance) from the field effects (variation in the environment).

Genetics by environment interaction:

There is a scientific premise called ‘genetics by environment interaction’, or GxE. What this means is that both the genetics and the environment (climate, soil, pest conditions etc.) affect plant growth. The goal of the on-farm variety trial is to identify the optimum combination, i.e. the genetics that result in optimum crop performance under the local environmental conditions. Take care to minimize environmental variability across plots within the trial to ensure that the genetic component is truly measured. Some seed company and public trials are conducted across multiple locations with the goal of identifying the genetics that perform in a variety of environmental conditions and therefore serve multiple markets. There is no exact industry standard for number of trials, but breeders usually want to see data from at least nine year-locations (some combination of years and trial sites) before deciding to release a variety.

> The term **genetics** describes the genetic composition or combination of genes that gives a crop variety a unique set of heritable traits. Breeders use the term **genotype** (genetic patterns) to describe the genetic contribution and **phenotype** (observed traits) to describe the combined environmental and genetic forces acting on a variety. Here we use the term genetics to describe the genotype.

Field effect:

The “field effect” refers to the influence that variable field conditions have on the performance of the plants in the field. For example, if the field is on a slope and the soil is richer on the downhill side, then plants planted on the downhill side may grow larger because they grew in better soil conditions, not because they had superior genetics. Likewise, plants grown on the southwest side of a field may grow larger because they receive more afternoon sun, or smaller if they are sun-sensitive and their roots are dried out by the afternoon sun. Patterns often exist in the field which affect crop growth including soil quality, soil texture, soil pH, soil fertility, drainage, pest pressures (insect, weed, disease, and animals), sun exposure, irrigation variability, temperature variation (cold pockets), and pollution. Some sources of environmental variation are relatively fixed, like soil type and production practices, while others are more random, like weather and climate. Pests (diseases, insects, and weeds) may be either fixed or random depending on the organism. The soil insects called symphylans are usually found in the same spot year after year and would be regarded as a fixed effect, whereas aphids blown into the plots from another region would be a random effect. Fixed sources of variability can be compensated for by the use of randomization whereas random sources of variability require testing over locations and/or seasons ("seasons" as used here may be different times of year or different years; the objective is to obtain data in a number of different growing environments). The goal of the experimental design is to minimize the effects of environmental variability on trial results by blocking replications so that field variation is minimized within blocks. In essence, you replicate in the trial to account for fixed effects and repeat the experiment over time to compensate for random effects.

Consistent treatment:
All management practices should be consistent across all trial plots including irrigation, soil fertilization, pest management, cultivation and weeding, staking, or any other horticultural aspect of crop production. If practices are not consistent, differences in performance may be the result of unequal treatments as opposed to genetic differences in varieties. For example, if half the field was cultivated and the other half left uncultivated, then the plots in the uncultivated section would have an unfair disadvantage as they were subject to greater weed competition. Conduct plot management operations by block to minimize variation within each block. For example, complete the cultivation of an entire block before stopping for the day so that all plots in that block received consistent treatment (cultivation).

This small-scale vacuum seeder allows establishing trial plots using the same techniques as in regular production.

Randomization:
Randomizing plots within each block helps increase the assurance that the results of the evaluation are due to genetic difference between varieties rather than due to variation in the environment (field effects). The more replications you include the greater the assurance that measurements will reflect differences in the varieties rather than variation in the field. Randomizing is also important to minimize the influence that varieties have on one another. For example if each variety was planted in the same order in each block then one variety planted next to another very tall, vigorous variety might be unfairly affected by the competition for light and nutrients.

The order of plots may be randomized by any basic randomization tool such as drawing numbers from a hat. An easy method is to mark all of the plant stakes for each block and then mix them up and walk the block inserting whichever stake comes to hand first to mark the first plot and continue down the row marking plots in this manner.

One exception to randomization is that the first block may be planted in the numbered order of the stakes while the next blocks must be randomized. This is acceptable because randomizing the successive blocks ensures that varieties in each block are in a different order. You may want to have your varieties in a particular order in the first replicate if you plan to use your variety trial as a demonstration plot.

Population and plot size:
The size of plots in the trial should be large enough that the resulting number of plants provides a good representation of the whole population. The greater the plot size and population size, the more representative the population will be. However, the larger the plot the more difficult it may be to manage, especially if there is a large number of varieties and three or more replications. In general, when evaluating open-pollinated varieties of self-pollinated crops fewer plants are necessary to get a representative sampling than in cross-pollinated crops due to the

generally greater inherent genetic variability in cross-pollinated populations.

Recommended minimum number plants per plot in a replicated variety trial to evaluate population	
Crop	**Min. # of plants**
Corn	30
Brassicas	30
Carrots	50
Radishes	50
Tomatoes/Peppers	10
Squash/Cucumbers	10
Beans (bush varieties)	30
Beans (pole varieties)	10
Lettuce (heading varieties)	10
Lettuce (leaf varieties)	25
Spinach	25
Peas	30

Ideally plots should be large enough that the practices used represent your normal farming practices. For example if you normally plant your cabbage on 36-inch centers and field cultivate with a tractor then a small garden trial with 24-inch spacing and hand hoeing may result in some varieties performing differently than they would under "normal" conditions. Similarly if you usually apply drip irrigation, then overhead irrigation may skew results. For best results, include your variety trial within your production field of that crop so that all production practices are the same as for commercial production. Plots may need to be a certain size in order to use normal planting and management practices. For example, a minimum amount of seed may be required to plant with a seed drill or vacuum planter and the planting equipment may need to run a certain distance in order to function properly. Similarly mechanical harvesting equipment may require a certain size scale in order to operate appropriately.

Another variable to consider in determining plot size is number of rows to include per plot. Single row plots allow you to place more varieties in your trial, but may give more variable results because of fewer plants per plot and potential competition between varieties in adjacent plots. With three or four row plots, the center one or two rows can be evaluated. While this approach takes more space, it does minimize inter-plot competition and produces more accurate data. As with plot length, minimum number of rows may be determined by equipment. For example, your planter may only plant six rows at a time.

Border rows around your experimental plots will minimize the edge effect whereby plots without borders will tend to be more productive because they lack competing plants around them. As such, data from un-bordered plots around the outside of the trial will be biased towards greater productivity than in the center of the field. Border rows should be planted not only on the sides of the trial, but at the top and bottom of the field as well.

Trial layout:

Before laying out the trial it is useful to create a map of the field, diagramming any sources of variability. Aerial photographs, if available, are also useful to view field variability.

From an aerial view, it is easy to see variability in soil type, vegetation, and field edge effects – important considerations in deciding where to establish your trial.

Mark on your map or aerial photo any differences in soil type, irrigation type, disease or pest pockets that you are aware of, wind and sun direction, and temperature gradients such as cold air drainages on a hill slope. The map is a tool for you to decide where to place each trial block. Blocks may be adjacent (RCBD) or in different areas of the farm (replication by location), but blocks should be placed in a manner that minimizes variability within the blocks. Variability should also be minimized between the blocks as much as possible, but providing uniform conditions within the blocks achieves the intent of blocking. In the following example note how blocks are placed to minimize variability of soil texture within the blocks.

Clay soil	Clay-loam	Loam soil
Block 1	**Block 2**	**Block 3**

Decreasing amounts of clay in soil --------->

Case study of an experimental design:
Jamie Kitzrow of Springhill Farm is conducting a fennel variety trial. He has been planting the variety Orion, but he wants to see if there are any other varieties available that perform better on his farm.

To do this, he sources five fennel varieties, four new varieties plus his standard variety, Orion. Jamie first numbers each variety for the trial, 1=Zefa fino, 2=Perfection, 3=Fino, 4=Orbit, and 5=Orion. He then starts one flat of each variety (172 cell plug tray) planning on planting fifty plants per plot. In order to collect useful data from his trial, Jamie wants to plant three blocks or replications and has prepared three beds for the trial, one bed per replication. He will plant each variety (fifty plants per plot) into each block (bed), randomizing the order of varieties in each block.

5	4	3
4	1	5
3	2	4
2	5	1
1	3	2
1	2	3

3 blocks (replications)

Note: Blocks can also be in different sections of the same row, but separate rows makes it easy to track where one block ends and another begins.

Each square in the diagram in the left column represents fifty plants of that variety. It is helpful when marking tags in the field to label them with the variety number and replication number to keep track of blocks. For example: variety #1 in the first block would be labeled 1-1, variety #2 in the first block would be 2-1, variety #4 in the third block would be 4-3 etc. The order of varieties in the first block does not need to be randomized, but the order must be randomized in the second and third blocks. (See Randomization.)

Wooden survey stakes are useful for marking a trial, and a long tape measure is handy for evenly spacing plots, as above. It is best to establish the trial in the middle of the field under uniform conditions to avoid edge effects.

Marking and mapping the trial

Once block areas are identified you are ready to layout and mark the trial. You must decide on your plot size and then mark each plot in the field ensuring there is enough room for equal sized plots of each variety in each block. Tags or stakes are necessary to mark plots and to identify where to plant each variety and recall the location of each plot for future evaluations. Ideally you should conduct what is called a blind trial. In a blind trial a letter or number is assigned to each variety rather than listing the variety name on each stake. This helps eliminate bias when evaluating varieties. It is crucial however to not loose the code for which variety each letter or number represents or else the entire trial value will be lost.

Common farm materials may be used as plot markers including irrigation flags or survey stakes. Wooden stakes or even paint stirring sticks make good markers, are relatively low cost, and are biodegradable in case one gets demolished in the field. Permanent marking pens work on the wood, but may fade in bright sun. So if marking with permanent pens, either rewrite mid season or use your map to confirm markings at the end of the season. Irrigation flags (plastic squares on thin wire commonly used to mark irrigation in the field) are also low cost and available at most farm stores. Permanent pens will also write on the plastic flags. The benefit of the flags is they usually survive being run over by a tractor, but they are not biodegradable and over time can result in lots of metal wire and plastic flags in the field. Labels can also be printed on weatherproof label paper and placed on small plastic stakes.

Once the stakes are placed in the field, it is critical to create a field map. Stakes are easily lost, stepped on, run over by a tractor, or fade in the sun. Your plot map will be critical when you return to evaluate the trial. A simple piece of notebook paper or graph paper will suffice, but be sure to make at least two copies and file one in a safe location.

Evaluating the trial

Sample data collection and evaluation sheets are available in **Appendix E** and online at www.seedalliance.org These sheets are useful for collecting data in the field. Excel is a helpful program for inputting and analyzing data collected. A formatted Excel file for data input and analysis is available at www.seedalliance.org

The trial evaluation should be a combination of data collection and notes. Collecting data, including measurements and scored traits, is a useful tool for developing a clear picture of individual traits and provides a record for later reference. It is also helpful in comparing differences between replications to assess the field effects vs. treatment effects. Field notes allow a complete assessment of the variety integrating overall impressions and capturing finer notes on details that may get missed in the data. Both elements should be used in concert in the final analysis and decision making process about future variety selection or trial plans.

Evaluation criteria can be extensive or focused depending on the intent of the trial and amount of time available. Because farmers are very busy, we recommend narrowing the list of evaluation criteria to those that are most important (five or six at most). These key traits should be identified in the trial planning and variety selection process (see *Choosing trial varieties and acquiring seed*). You can also walk the field and take notes to capture any missed details. At the end of the evaluation, it is also helpful to give each variety an overall score.

Variety evaluation can occur throughout the season to capture important traits at different stages of growth. Most importantly, each variety should be evaluated at harvest maturity. Often all of the varieties in the trial will be mature at the same time allowing evaluation of the entire trial on a given date. However, in some cases varieties may differ in maturity dates and the trial will require multiple evaluations. It may be useful to evaluate some crops at multiple growth stages if each stage may be harvested for a different market. For example, lettuce may be harvested as baby salad mix, baby heads, or full-head size. Vigor is a useful trait to evaluate at an early seedling stage (2-4 leaf stage). Seedling vigor is a trait particularly important in organic production as it is related to improved competition against weeds, efficient nutrient utilization, and even resistance to certain seedling-stage diseases like damping off.

> ***Efficiency Tip*:** If evaluating the trial throughout the season is too time-consuming to plan, then just monitor the trial for full maturity and set aside time to capture key evaluation criteria at harvest time. The quality of data is more important than quantity of data.

Quantitative vs. qualitative traits

Quantitative traits are those that can be measured on a continuous scale such as height, yield, or fruit size. Qualitative traits are descriptive, such as color, flavor, and uniformity. Quantitative data can be measured directly if time permits and equipment is available. A data collection tool that may be used for either quantitative or qualitative traits is to assign a score, commonly on a scale of 1-9, that reflects the trait. For example, if yield is the trait evaluated then a 1 would be the lowest yielding plot and a 9 would be the highest yielding plot. All numbers should reflect a comparison of the plots of varieties in the field on the day of the evaluation, so a 9 would be the highest yielding in the trial, rather than the highest yielding variety you have ever seen. A useful scale developed by the International Center for Tropical Agriculture uses nine points and is easy to translate into a verbal rating system. Rating is as follows: 1=poor, 3=fair, 5=average, 7=good, and 9=excellent. The even numbers in the scale can be used to achieve finer differentiation. It is important to use at least this range of numbers (1-9) in order to differentiate between varieties. If you use a smaller scale, ratings often fall in the middle (2 on a scale of 1-3 for example) and it is not possible to say if one variety was better than another. This rating scale can be applied to diseases and pests as well as performance traits.

> ***Efficiency Tip:*** Score traits rather than measuring or counting to save time. (See *Qualitative vs. quantitative traits* above.)

Evaluation traits to consider

The evaluation traits should reflect the goals of the trial and the desires of the grower, which may vary from crop to crop. Some traits such as seedling vigor and pest resistance may be particularly important to organic growers. Evaluation traits may address market demands such as flavor and uniformity as well as production constraints such as yield and storage capacity.

Suggested evaluation traits include:

- Flavor
- Yield
- Length of productivity (i.e. first and final harvest dates)
- Seedling vigor
- Plant vigor
- Uniformity
- Rate of pest infection
- Bolting sensitivity
- Holding and storage qualities

Seedling vigor is an important variety trait

Data collection

*See **Appendices** for sample evaluation sheets and a trial planning worksheet.*

Data collection steps:

1. Begin the evaluation process by first walking the trial to observe the plots, gaining a feeling for the breadth of traits within the field.
2. Every plot should be individually evaluated. Do not pool the three replicated plots for the evaluation or the intent of replicating will be lost.
3. Start with the list of all the traits to be measured or scored. Walk the field and evaluate each plot for a single trait. Then starting back with the first plot repeat the process for each trait, one trait at a time. So, for example, all plots are evaluated for uniformity, then all plots are evaluated for vigor, then all plots are evaluated for color, etc., proceeding until evaluation of all the desired traits are recorded.
4. Take notes on each plot individually. Notes might include an overall assessment or notable details that were not captured in the data collection or even comparisons of one plot to the next (i.e. variety #3 is much more productive than variety #4).
5. Before leaving the field it is sometimes useful to rank each variety overall to capture impressions after going through the evaluation process. You may want to rank them from top to bottom in order of performance or it may be useful to assign a number according to future use such as, 1 = grow next year, 2 = continue to evaluate, or 3 = drop from consideration. Note that the exercise of collecting data, plot by plot, and taking detailed notes helps you notice more detail and gain an overall Gestalt or holistic impression of each variety by the end of the evaluation process.
6. Evaluate all of the plants in a plot as a whole rather than just assessing the best or worst individuals in the population. This applies to both assigning a score and measuring a trait. When measuring, it is best to assess all of the plants in the plot and compute an average or, if the plot is too large to measure the whole population, then randomly select a sub-sample to measure and compute an average for that plot.

Making Sense of the Data

Once data are collected the task remains of assessing the results. The first step is to review your trial goals. Was the goal to identify a single variety that out-yielded your current standard variety or the most disease resistant variety available? Or was the goal to identify several new and interesting varieties to expand your offerings? Depending on your goals the data assessment may be approached from different angles.

Much can be learned from simply looking over the data without using statistical methods. Statistics are an additional tool which can be used to assess the effects of natural variability between plots and the likelihood that the differences measured are due to the genetic differences between varieties.

Post-harvest storage quality is a key evaluation trait for many crops

Viewing the data

Entering the collected data into an Excel spreadsheet makes it easy to look at and calculate averages. It will also facilitate entering data into statistical formulas if you choose. Each plot should be entered separately into a chart of the traits evaluated, the varieties and replication (see table below). Each trait evaluated should be considered separately and then compared to identify the best varieties overall. Let's consider the following example:

	Yield (scale of 1-9)			
Variety	**Rep 1**	**Rep 2**	**Rep 3**	**Average**
Var A	7	6	7	6.67
Var B	8	9	2	6.33
Var C	3	4	3	3.33

We can learn a lot by looking at all three replications along with the average scores. From an assessment of the averages we would conclude that variety A was the highest yielding variety, but by comparing individual replications we can see that variety B actually scored higher in two out of three replications. We might consider what happened to variety B in the third replication. Did it not receive irrigation? Or was the soil compacted in that plot? We can most confidently conclude that variety C was the lowest yielding, but we might consider other traits for A and B before deciding which performed best. As you can see if the trial had not been replicated and Variety B had only been planted in the location of the third replication then you might have dropped it from the trial based on poor performance in that location. This is the purpose of replicating.

After looking over all of the traits evaluated you should begin to get a feeling for which varieties performed the best overall. As Dr. John Navazio, OSA Director of Research says, "The cream always rises to the top".

Identifying the winners

It is useful to create an overall rating scale to sort out the varieties and make decisions about how to proceed in the future. If the goal is to pick the top variety then you might consider ranking all of the varieties in order of overall performance based on your identified priority traits. So, number 1 would be the best variety (in this case variety A in the chart above), and you might decide to grow it next year. If the top varieties are close you might decide to drop all but the top two or three and trial them again the following year to compare a second season.

If the goal of the trial is to identify multiple good varieties, potentially for different production or market niches, then it may be more useful to create an overall ranking that separates the varieties into classes of performance. For example, 1 = best performing, ready for production; 2 = medium performing, continue to evaluate; 3 = poorly performing, drop from the trial. In this case each variety would be assigned and overall score of 1, 2, or 3 which would indicate how to proceed the following year. This type of scoring is also useful in the event that the top variety is dropped from availability. Then you may return to your trial data and choose among the other varieties that ranked # 1 overall.

Ranking scales are a decision-making tool. Again, the type of ranking you choose to create should reflect your trial goals and make sense for use in your decision making process. The goal of most variety trials is to decide whether to replace your standard variety with a better variety. Therefore it is useful to consider how each variety compares with the standard. For multiple year trials consider performance of a variety over time in comparison to the standard, check variety. For example, variety A out-performed the standard check in seven out of ten years or 70% of the trials. In a single year or over multiple years consider how the performance of each variety offered an advantage or disadvantage over your standard variety. For example, variety A had a 10% yield increase over the standard variety. Alternatively if the average yield of the standard variety is considered 100% then variety A had a 110% yield advantage. This sort of comparison helps put into perspective the potential benefit of replacing the standard variety with a better performing variety.

Seed cost:
Although cost is not a trait that is evaluated in the field it may be an important factor in deciding which variety to grow. Once the data is analyzed and overall scores are assigned it may be useful to evaluate the relative cost of each variety. For example, if one variety out-yielded another by 10%, but the seed cost twice as much it may not be worth the yield increase.

Statistics
Statistics are an additional tool to assess the data. Statistical analysis of the RCBD is computed using an analysis of variance, called ANOVA for short. An ANOVA may be calculated for each trait individually or for the overall score assigned to each plot. The ANOVA provides an estimate of the experimental error or variation among the replications. It also provides a way to test the significance of the differences measured between varieties – or the likelihood that the differences measured are truly due to difference between varieties rather than differences in the environmental conditions. Local Extension agents may be available for help with conducting an ANOVA and analyzing the data.

Statistical terms:
Least significant difference (LSD) – the minimum difference between treatment averages that is required to be considered a real difference rather a difference due to chance.

P-value – the probability that difference between treatments that were considered significant could occur by chance. For example a p-value of 95% means that there is only a 5% chance that the differences were actually due to chance rather than real differences in the treatments (in this case varieties).

A free statistics program designed for farmers called AGSTATS02 is available from Oregon State University, Washington State University, and University of Idaho. AGSTATS02 was designed for on-farm trials and is available at http://pnwsteep.wsu.edu/agstatsweb/index.html

Appendix A
Organic seed availability

Agriculture Technology Transfer for Rural Areas (ATTRA):
ATTRA provides a list of organic seed suppliers, databases of organic seed, background on the organic certification regulations, and additional organic grower resources.
http://attra.ncat.org/attra-pub/altseed_search.php

ATTRA also provides a list of regional sources of bin-run organic grain seed for organic grain producers. http://attra.ncat.org/attra-pub/summaries/marketingorganicgrains.html

Organic Materials Review Institute (OMRI):
OMRI is a non-profit organization that provides organic certifiers, growers, manufacturers, and suppliers an independent review of products intended for use in certified organic production, handling, and processing. OMRI has established a database of organic seed suppliers and varieties available with the goal of allowing growers and suppliers a single place to find organic supplies of organic seed. All listed seed sources are verified by OMRI for the validity of their organic certification. http://seeds.omri.org

Saving Our Seed project of the Carolina Farm Stewardship Association:
Saving our Seed, a non-profit organization, provides an organic seed sourcing service in which growers may contact their organization with “wish list” requests and Saving our Seed will search their database providing lists of organic seed sources and suggestions of alternative cultivars in the case that requested varieties are not available.
http://www.organicseedsourcing.com

Pennsylvania Certified Organic (PCO):
PCO is an organic certification organization that provides a list of organic seed suppliers and a guide to organic regulations regarding organic seed and plant materials.
http://www.paorganic.org/pdf/2007%20ORG%20SEED%20SUPPLIERS%20O.pdf

Washington State University Center for Sustainable Agriculture and Natural Resources (CSANR):
The mission of CSANR is to develop and foster agriculture and natural resource management approaches that are economically viable, environmentally sound, and socially acceptable. Rather than duplicate ongoing efforts, the center strives to facilitate interdisciplinary linkages and coalitions between WSU, growers, industry, environmental groups, agencies, and the people of Washington. Their website provides resources for organic producers including a list of sources selling organic seed.
http://csanr.wsu.edu/Organic/OrganicSeed.htm#sources

Appendix B
Public vegetable variety trials in the Pacific Northwest

Oregon State University Vegetable Variety Trials:
Each year the OSU Department of Horticulture vegetable breeding program in Corvallis, Oregon grows and evaluates a diversity of vegetable varieties. Although the trials are not replicated and are not grown on organically certified ground they offer a valuable screening of variety traits and performance in the Willamette Valley region. Each year they release evaluation results for the public, and in combination with trials from other regions of Oregon they publish a list of recommendations by region. Recommendations are available at
http://www.extension.org/news/156
Evaluation results are available from Dr. Jim Myers and Deborah Kean, (541) 737-3083
http://extension.oregonstate.edu/catalog/details.php?sortnum=0624&name=Vegetables&num_results1=31&s=12&num_pages=3&sort=snumbera

Washington State University Vegetable Extension Program:
Within the Vegetable Extension Program variety trials are conducted on cooperating growers' farms and at WSU research stations. Many of the trials are on-farm, most are organic, and all are replicated. Variety trial results of watermelon, dry beans, fresh shell beans, edamame, baby corn, winter lettuces, and asparagus are available at http://vegetables.wsu.edu or by contacting Dr. Carol Miles at (360) 848-6150 or milesc@wsu.edu

Appendix C
Additional seed and variety information resources

National Plant Germplasm System:
The USDA National Plant Germplasm System (NPGS) curates crop varieties at about a dozen locations around the U.S. and territories. The collections house both wild and cultivated species. Plant accessions are cataloged in the GRIN (Germplasm Resource Information Network) available as a searchable database at
http://www.ars.usda.gov/Services/Services.htm
Small quantities of seed can be requested for research purposes. While some crop collections are quite extensive (there are over 12,000 accessions of *Phaseolus* beans for example), many accessions are unadapted to North American climates. In particular, many tropical varieties flower and fruit under short days, but are inhibited by the long days found during our normal growing season. As such, these varieties will not begin to flower until September, when there is insufficient growing season to produce a mature crop. Seed quantities from NPGS are typically small and you are expected to maintain the variety once you receive it. When using this resource, it is important to use all information available and choose varieties carefully.

Public Seed Initiative (PSI) and Farmers Cooperative Genome Project (FCGP) trialed a number of vegetable accessions from NPGS from 2002-2004. They found that varieties from similar latitudes as North America had the best adaptation, and they were able to identify a few heirloom and landrace varieties of merit. Information on this project can be found at http://www.plbr.cornell.edu/psi

Organic Seed Partnership (OSP):
The OSP program evolved out of the PSI as a means of giving organic growers wider access to varieties and breeding lines in the public domain. Begun in 2005, it is coordinated by Cornell University, with four hubs across the U.S. involved in trialing and breeding for organic systems. Hubs in turn work with growers interested in trialing materials available from the OSP list. The program ends in 2008, but recommendations from trials should remain available.
www.plbr.cornell.edu/PSI/OSPrelated.htm

Seed Savers Exchange:
Seed Savers Exchange is a non-profit organization of gardeners who save and exchange heirloom seeds. They also have a seed catalog business. They additionally publish a garden seed inventory and are a good place to research and source small quantities of seed that may not be commercially available. www.seedsavers.org

Appendix D

Variety trial planning case study

Greentree Naturals Farm – Sugar snap pea variety trial

Envisioning the Trial:

Diane and Thom of Greentree Naturals in Sandpoint, Idaho have been saving their own pea seed of a variety they like on their farm for several years. Peas fill an important niche for the farm as they are a good early spring crop during a time of year when little produce is available at the market. However, they regularly experience hot, dry spells during June at which time their pea production drops off. They want to conduct a variety trial to see if there are any other sugar snap peas that tolerate the climatic conditions better than the one they currently use but also possess the good eating quality of their current variety. As an organic farm, identifying good organic seed sources is also of interest to Diane and Thom. However, since they plan to save their own seed which will then be organic, this is not the top priority.

Trial crop:
Sugar snap peas

Trial goals:
To identify varieties of sugar snap peas that produce well, have desirable traits and tolerate the dependably warm, dry spells that occur in mid-June.

Desired variety traits: *listed in order of importance*
Productivity (quantity and length of time), lack of stringiness, large pod size, good flavor

Trial varieties:
Seven new varieties total + one check variety = eight trial varieties
Each variety will be assigned a number 1-8. This information will be recorded for reference after the evaluation, but the numbers will be used in the trial to avoid biases in the evaluation process.
From organic sources: Sugar Daddy, Cascadia, and Sugar Ann
From non-organic sources: Sugar Snap, Super Sugar Snap, Sugar Sprint, and Sugar Star

Check variety:
Greentree Naturals farm-saved pea seed

Planning the Trial:

Ideal planting date:
Normal planting time of early-mid April as soon as the soil is workable and warm enough to plant.

Number of replications:
Three replications

Plot size:
Ten row-feet per plot
Peas are a self-pollinated crop. In general, varieties of self-pollinated crops don't tend to have as much genetic variability in the population

as cross-pollinated crops. Therefore smaller plot sizes are needed to get a good evaluation of the population. Diane and Thom prepared three rows for the trial so that each replication could be in a separate row. This arrangement blocks for row to row variability in conditions. Each row is 100 feet long so with eight trial varieties they can make each plot about ten-feet long and have extra space to skip the beginning and end of each row avoiding edge effects. They can also leave one to two feet between each plot making it easier to keep the peas in each plot separated for evaluations.

Production methods:
The peas will be grown in the same manner that they always follow on their farm, single rows on a trellis with drip irrigation. All plots will be watered, weeded, and fertilized equally.

Field assessment:
Greentree Naturals Farm is a small, two-acre farm nestled in the valley between the Cabinet and Selkirk mountain ranges in Northern Idaho. The farm land is fairly flat but the soil texture varies from a sandy loam to loam across the farm. The weather and prevailing winds usually come from the north through the valley. Trees along one side of the farm shade some of the eastern side of the field in the morning. Because they use drip irrigation the watering is fairly consistent, but can sometimes be slightly heavier at the beginning of the row and lighter at the ends.

Trial layout:
The three rows for the trial will be placed in a flat area of the field where the soil type is consistent and away from barriers like trees to avoid shading part of the plot or blocking it from the wind.

7	6	3
6	4	4
5	1	7
4	7	5
3	2	1
2	5	6
1	3	2
1	2	3

replication

This ensures that all plots in the field will be similarly exposed to the sunny, hot, windy conditions of concern in June. The three rows are in an area with consistent soil conditions. (See diagram in left column.)

Plot layout:
Seven varieties, each is assigned a number
Three replications
Each number in the diagram at left represents a ten-foot plot of peas of that numbered variety. Each variety is in each replication or block in a random order.

<u>Trial evaluation</u>:

Evaluation criteria:

- *Seedling vigor* (scale of 1-9, 1 = least vigorous, 9 = most vigorous)
- *Yield* (pounds harvested will be recorded by plot on each harvest date and then added up after the last harvest date)
- *Length of productivity* (record first and last harvest dates to assess length of harvest window)
- *Lack of stringiness* (rated on scale of 1-9, 1 = most stringy, 9 = least stringy)
- *Overall eating quality* (rated on scale of 1-9, 1 = least favorite, 9 = best overall)

Evaluation timing:

- *Seedling vigor* (three weeks after planting)
- *Yield* and *length of productivity* (each harvest date)
- *Lack of stringiness* and *overall eating quality* (two dates, one early season when all varieties are being harvested and one late season when all varieties are still producing, but pods may become tough)

Appendix E
Sample evaluation sheet and *variety trial planning worksheet*

Please see manual inserts for a sample evaluation sheet and a variety trial planning worksheet. These documents are available online at www.seedalliance.org

References

Anderson, D. and M. Honyman. 2004. How to conduct research on your farm or ranch. Sustainable Agriculture Network, USDA-CREES.

Arnold, M.A., R.D. Lineberger, T.D. Davis, S.W. George, W.A. Mackay, G.D. Grant, J.M. Parsons, and L.A. Stein. 2001. Integrating Plant Trials into Teaching and Student Research Programs. Hort. Technology 11(3):385-388.

Drinkwater, L.E. 2002. Cropping Systems Research: Reconsidering Agricultural Experimental Approaches. Hort. Tech. 12(3): 355-361.

Exner, R. and R. Tompson. The Paired-Comparison: A Good Design for Farmer-Managed Trials. Practical Farmers of Iowa.

Green-McGrath, D., L.S. Lev, H. Murray, and R.D. Williams. 1993. Farmer/Scientist Focus Sessions: A How-To Guide. Oregon State University Extension. EM 8554.

Havlin, J.L., J.P. Shroyer, and D. Devlin. 1990. Establishing On-farm Demonstration and Research Plots. Kansas State University Cooperative Extension Services. Manhattan, Kansas.

Herwaarden, A.V., H.G. Macpherson, H.M. Rawson, J.A. Kirkegaard, K.J. Bligh, and W.K. Anderson. 2003. Explore On-farm: On-farm Trials for Adapting and Adopting Good Agricultural Practices. Food and Agriculture Organization, United Nations, Rome.

Hildebrand, P.E. and F. Poey. 1985. Site-Specific Trials. In: On-farm Agronomic Trials in Farming Systems Research and Extension. Lynne Reiner Publishers Inc. Boulder, Colorado. Pages: 45-56.

Janke, R., D. Thompson, C. Cramer, and K. McNamara. 1991. A Farmer's Guide to On-farm Research. Rodale Institute Research Center.

Johnson, D.H. 2006. The Many Faces of Replication. Crop Sci. 46:2486-2491.

Karow, R. Crop Science Report, Field Experimentation. Oregon State University.

Linker, M. 1991. Doin' Research. Stewardship News. 16(6)

Mutsaers, H.J.W., G.K. Weber, P. Walker, and N.M. Fischer. 1997. Design and Conduct of On-farm Trials. In: A Field Guide for On-Farm Experimentation. International Institute for Tropical Agriculture.

Nuland, D. 1988. Using Farm Strip Tests for Comparison. The Bean Bag.

Payne, R.W. 2006. New and Traditional Methods for the Analysis of Unreplicated Experiments. Crop Sci. 46:2476-2481.

Perrett, J.J. and J.J. Higgins. 2006. A Method for Analyzing Unreplicated Agricultural Experiments. Crop Sci. 46:2482-2485.

Peterson, R.G. 1994. Agricultural Field Experiments: Design and Analysis. Marcel Dekker, Inc. New York, New York.

Piper, E.L., K.J. Boote, and J.W. Jones. 1998. Evaluation and Improvement of Crop Models Using Regional Cultivar Trial Data. Applied Engineering in Agriculture 14(4): 435-446.

Ramsey, F.L. and D.W. Schafer, 1997. The Statistical Sleuth: A Course in Methods of Data Analysis. Wadsworth Publishing Company. Beltmont, California.

Sooby, J. 2000. On-farm Research Guide. Organic Farming Research Foundation.

Wuest, S., R. Karow, S. Guy, B. Miller, R. Veseth, and D. Wysocki. 1995. Using an On-farm Test for Variety Selection. Pacific Northwest Cooperative Extension Publication. PNW 486.

Authors

Completed June, 2007
Micaela R. Colley, Organic Seed Alliance
Dr. James R. Myers, Oregon State University

Organic Seed Alliance
PO Box 772, Port Townsend, WA, 98368
360/385-7192

Pictures courtesy of Micaela Colley (OSA) and Dr. John Luna, Oregon State University

Producer-Professional Reviewed
As an institutional standard, all OSA publications are reviewed by both scientific researchers and professional producers.

We thank the following for contributions and review of this publication:
John Foster, Oregon Tilth
Dr. Carol Miles, Washington State University
Nick Andrews, Oregon State University
Dr. Cinda Williams, University of Idaho
Dr. Roseanne Leiner, University of Alaska
Erin Mirrett, WSDA Organic Foods Program
Brian Andersen, Brian Andersen Farms
River & Sarah Bean, Arctic Organics
Anthony Boutard, Ayers Creek Farm
Diane Green, Greentree Naturals Farm
Jamie Kitzrow, Springhill Farm
Tim Terpstra, Ralph's Greenhouse

Educational Materials

For PDF versions of this and other seed publications, please visit us at www.seedalliance.org