A SEED SAVING GUIDE

FOR GARDENERS AND FARMERS

Learn how to plant the best varieties, maintain your crop "genetics", cultivate, harvest, process and store seed. Plus a crop specific chart and resources for gaining more seed growing knowledge.

from ORGANIC SEED ALLIANCE

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Introduction to the Guide

Organic Seed Alliance supports the ethical development and stewardship of the genetic resources of agricultural seed. Teaching farmers and home gardeners to produce and save their own seed is an important component of that work. We teach seed saving skills in workshops around the country, and through publications such as this. In doing so, we aim to help preserve crop biodiversity, diversify farm income, and increase farmers and gardeners involvement and investment in regional seed systems.

This guide outlines most of the things you need to know to grow seed successfully. It covers the basics of seed growing from choosing appropriate varieties for seed saving to harvesting, processing, and storing seed. It assumes that you have basic knowledge of vegetable growing.

The information contained in this guide was gleaned from numerous print and web resources, as well as from conversations with many prominent seed experts. We have endeavored to provide you with the best and most reliable information, but this guide is in no way a rigid formula for seed growing perfection. As you gain seed growing experience, you will find that your own personal knowledge of "reality on the ground" is just as important as recommendations from experts. Only through experimentation can you learn which practices work best in your climate and farming system.

This publication was made possible through generous contributions to Organic Seed Alliance from private donors. We thank these individuals for their support of regional seed systems by preserving the art, history and science of seed saving.

So, without further ado, we welcome you to the wonderful world of seeds. May this guide help you on your way to many seasons of delight and discovery in your gardens and fields.

The research and education staff at Organic Seed Alliance

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Open Pollinated Varieties and Hybrid Varieties: *Know how to choose a variety that produces offspring like its parents.*

Open pollinated (OP) varieties produces offspring that closely resemble the parent. For example, if a gardener grows the OP bean variety "scarlet runner" and saves seed, she will find that when she grows out her seed next season, her scarlet runners will look very much like what she grew last year. Open-pollinated varieties result from the combination of parents that are genetically similar and share specific traits that distinguish the variety.

Hybrid varieties result from the controlled crossing of genetically distinct parents. They produce offspring very different than their parents. For example, if a gardener grows the hybrid tomato variety "early girl" and saves seed, she will find that when she grows out her seed next season, there will be very few plants that closely resemble "early girl." In general, unless you are interested in a long term breeding project, avoid saving seeds of hybrids.

Annuals and Biennials: *Know how long it takes for your crop to produce seed, and how to manage crops that take two growing seasons to set seed.*

An *annual* crop requires only one growing season to produce seed and complete its lifecycle. Examples of annual seed crops include corn, beans, squash, tomatoes, and broccoli.

A *biennial* crop requires 2 growing seasons to produce seed and complete its lifecycle. Examples of biennial crops include carrots, beets, chard, rutabaga, and cabbage. In the first season, a biennial grows into the plant that we normally eat. If the following three criteria are met, a biennial will flower and set seed in the second season.

First, over winter, the plant must go through an important period of *vernalization* (exposure to cold) before it will flower. The specific amount of time that biennial crops need to become vernalized varies by crop and variety. But exposure to temperatures below 45F (7C) for at least 8 to 12 weeks is adequate for all common biennial vegetable crops.

Second, by the fall of the first season, the plant must be appropriately sized. Plants that are too small in the fall may not reach full size before flowering, resulting in lower seed yields. In other cases, too-small plants may not respond to vernalization; never flowering and setting seed. Plants that are too large may not be hardy enough to survive in the field over the winter. For crop specific information on appropriate sizing of some biennials and other overwintering tips, see *Crop Specific Seed Saving Tips* in this guide.

Third, the plant must survive the winter. Successful overwintering mainly depends on cool (but not too cold) temperatures. In areas where winter temperatures *do not* regularly drop below 14F (-10C), most biennial crops may remain in the field over the winter. In this case, it is especially important that the plants be small (i.e. hardy) enough to withstand cold temperatures. Where temperatures *do* regularly drop below 14F (-10C) the crop must be lifted and stored in a cool (but not freezing) location. Digging up the crop for storage offers an opportunity to discard any plants that show undesirable characteristics in root shape, flavor, size and texture, and to check for insect or disease infestations. Storing your crop over the winter may also provide better protection from pests and disease. Replant your stored roots in the spring.

Storing biennial crops over winter

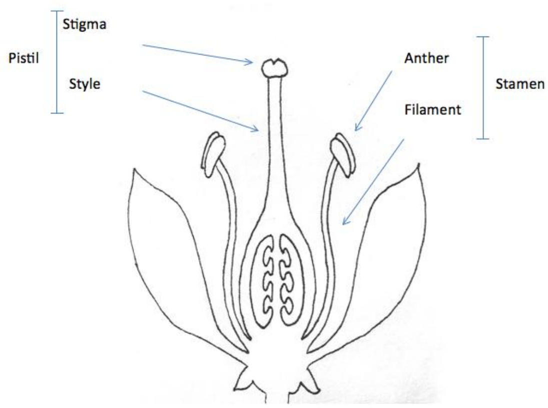
Biennial plants are commonly trimmed in some manner prior to storing over winter. Trimming is done to reduce the rate of transpiration and reduce the amount of vegetative material subject to rotting. For biennial root crops (also called stecklings) the tops are commonly trimmed to ½-1in. Once prepared for storage your biennial should ideally be stored at between 35-38F (1.5-3C) and at 90-95% relative humidity. For this, you can use an electric cooler with a humidity control. In the cooler, place wooden totes packed with clean, sound stecklings. The totes should have slotted planks that allow air and humidity to flow freely around the roots. Under high humidity conditions, standing water can accumulate on the surface of the uppermost layer of roots. Covering the totes with a two to three inch layer of *clean* wood shavings (not sawdust!) will help absorb this extra moisture and reduce rot problems. We recommend cedar wood shavings, if available, as cedar is reported to have a higher level of anti-microbial factors than most other types of wood.

You can also store stecklings in traditional root cellars, which benefit from cold temperatures and high humidity. In root cellars, carrot stecklings are traditionally stored in moist, clean sand or clean, undecayed deciduous leaves (in New England growers sometimes use maple leaves). The roots are laid carefully between layers of this material so as not to touch each other.

Days to harvest

Whether a crop is an annual or a biennial, it is also important to consider how many days of warm weather it needs before it will produce harvestable seed. Some crops like cilantro can require only 100 days to produce seed. Other crops like dry beans can require 4-5 months or more to complete maturity. If you live in a region with a cool and/or short growing season, you will need to experiment to see which crops can produce good yields of seed in your climate. Starting plants early in a greenhouse will help give your crops a head start.

Botany Vocabulary:
Know some basic botanical terms



Bisexual flower: A flower that contains both sets of reproductive organs, i.e. both stamens and pistils. Also called "perfect"

Unisexual flower: A flower that has only one set of reproductive organs, i.e. either stamens or pistils. Also called "imperfect"

Monecious: In monecious crops, every plant will house both sets of reproductive structures. They can have either perfect or imperfect flowers. Monecious means "one house" in Latin.

Dioecious: In dioecious crops, some plants will house only stamens, while others will house only pistils. Dioecious crops always have imperfect flowers. Dioecious means "two houses" in Latin.

Pollination: Pollination is the process by which pollen is transferred in plants, thereby enabling fertilization and reproduction. Pollination is complete when pollen lands on the stigma of a receptive flower.

Pollen tube: The pollen tube acts as a conduit to transport sperm cells from the pollen grain on the stigma to the ovules.

Fertilization: Fertilization is the process by which a sperm reaches the ovule. In plants, once the pollen lands on the stigma of a receptive flower, it germinates and starts growing a pollen tube. Sperm are discharged through the tube into the ovary. Fertilization is complete when the sperm fuses with the ovule.

The *stamen.* The stamen is the male reproductive structure of a flower. It is made up of: The *anther,* which produces *pollen.* Pollen contains the plant's *sperm*. The *filament* which supports the anther.

The *pistil*. The pistil is the female reproductive structure of a flower. It is made up of: The *stigma* which receives pollen. The *style*, which connects the stigma to the ovary. The *ovary*, which holds the *ovules.* Ovules that fuse with sperm become seeds.

Inbreeding and Outbreeding:
Know your crop's mating system.

The way that a plant mates can be described as falling along a spectrum between "strongly inbreeding" and "strongly outbreeding." A plant's place on this spectrum has several implications for its management as a seed crop, which we will discuss later.

In plants, *inbreeding* (also called self-fertilization or selfing) occurs when the sperm of an individual plant fertilizes an ovule of the same plant. Essentially, the plant mates with itself. A plant's inbred offspring receive all of their genes from their one and only parent, thus they are very similar to their parent. With one exception, any monecious plant can inbreed. The exception to this rule is when a plant has *self-incompatibility* (i.e. it has a mechanism that does not allow an individual plant's sperm to travel to or fuse with any of its own ovules, thus preventing any viable seed from developing).

Two important advantages of inbreeding include:
a) In plants that have evolved to become extremely well adapted to their environment, inbreeding offers a way to ensure that a plant's offspring will be just as well adapted as its parents. In other words, it is a way of replicating success.
b) Inbreeding helps to ensure reproduction in varying circumstances, as it does not require the presence of wind, insects, or animals to transfer pollen from one plant to another.

The plants that we call "*strong inbreeders*" rely almost completely on self-fertilization to reproduce. The flowers of these plants have ways of excluding pollen from any other flower. For example, in the flowers of most modern tomato varieties, the anthers form a cone around the pistil, effectively sealing off the flower's stigma from any pollen besides its own. In peas, the petals of the flower are typically closed when the stigma first becomes receptive to pollen, giving pollen from its own anthers exclusive access. When the pea flower opens, it is already fertilized. Other examples of strongly inbreeding plants include common beans, wheat, and oats.

Even a strong inbreeder, however, will occasionally cross with another plant of the same species. For example, bees can eat through or tear open a strong inbreeder's flower and deposit pollen from a different plant. Also, under certain climatic conditions, an inbreeder's flower will open earlier than usual, and the stigma will receive pollen from another plant before it has been fertilized by its own anthers. And, of course, a human with the intention of creating a new cross can transfer pollen from one strongly inbreeding plant to another.

In plants, *outbreeding* occurs when the sperm of one plant fertilizes an ovule of a different plant of the same species (also called cross-fertilization or outcrossing). In other words, a plant mates with another plant of the same species. When plants outbreed, they produce offspring that are genetically different than both parents. In general, all plants have the potential to outbreed, because every plant can be fertilized by another plant of the same species.

The central advantage of outbreeding is that it facilitates a plant species' ability to adapt to changing environments. Plant species that constantly mix their genes into new combinations increase the likelihood that at least a few individuals within the species will have the right combination of genes to withstand new environmental challenges.

Strong Outbreeders. The plants that we call "strong outbreeders" rely completely or almost completely on cross-fertilization to reproduce. Dioceous plants and plants that are self-incompatible have eliminated any chance of self-fertilization; they exclusively outbreed. Strong outbreeders that are not dioceous or self-incompatible have ways of discouraging (but not completely eliminating) self-fertilization. For example, in corn, which is monecious and has unisexual flowers, the male flowers mature and release the majority of their pollen before the female flowers open. In addition, corn's male and female flowers are situated on different parts of the plant. These strategies help to ensure that little self-fertilization occurs in corn. Other examples of strong outbreeders include beets, broccoli, and spinach.

As stated above, strong outbreeders that are not diocious or self-incompatible will self-fertilize. The likelihood of self-fertilization increases as the opportunity to receive pollen from other plants of the same species decreases. For example, if a corn plant is isolated from other corn plants, all of its offspring will be inbred.

The Plants In-Between

Between the "strong inbreeder" side of the mating spectrum and the "strong outbreeder" side of the mating spectrum are plants that will self-fertilize some of the time and cross-fertilize some of the time. For example, in an average field of fava beans, it is likely that about 50-75% of the flowers will be self-fertilized and 25-50% of the flowers will be cross-fertilized, thanks mainly to bees.

Classifications in the Crop Specific Chart

In the *Crop Specific Chart* of this guide we have classified many major crops into the following five categories: Strongly inbreeding; Generally inbreeding; Both inbreeding and outbreeding; Generally outbreeding; and Strongly outbreeding. In reality, the place of many plant species in one of these categories is mutable, as many species' level of selfing or outcrossing varies greatly depending on environmental conditions. Nevertheless, these classifications are a good way to help you get familiar with the tendencies of your seed crop.

Pollination and Fertilization:
Know how to promote a good seed set

If your crops are not fertilized, they will not produce viable seed. Your plants must overcome two hurdles for fertilization to occur: First, pollen must land on the stigma (pollination), second, the plant's sperm must travel to and fuse with the ovule (fertilization).

Pollination needs for strong inbreeders: While the journey of the pollen of a strong inbreeder is undoubtedly short (usually from an anther to a stigma within the same flower) good pollen coverage of the stigma often requires some external movement. The movement caused by wind, and in some cases insect visitation (even when the insect is unable to open the flower) can substantially increase pollination and promote a good seed set.

Make sure you address the need for external movement of your strongly inbreeding crop. If your crop is being grown in a location with no wind and few insects (such as a greenhouse), you may need to use a fan or manually shake the plants. You may also need to encourage a diversity of insects in your garden or farm so that more of them will jostle your crop's flowers.

Pollination needs for plants that depend to some degree on outbreeding: The more a crop relies on outbreeding for reproduction, the more important are the following three elements in ensuring a good seed set: 1) a sufficiently large population of the crop flowering in unison, 2) adequate insect populations visiting the crop or adequate wind/airflow, and 3) environmental conditions that allow pollen to remain viable from the time it leaves an anther until it reaches a stigma (if it is too hot or too dry, pollen may lose viability before reaching a receptive stigma).

Study the specific pollination needs for your outbreeding crop and make sure to address all three requirements for good pollination. Depending on your situation, you may need to grow more plants than originally planned, encourage a diversity of pollinating insects, discontinue overhead watering during flower (insects don't fly well when the sprinklers are on), use a fan to introduce wind, change your planting date to assure better environmental conditions during flower, and/or pollinate by hand. In some cases, you may find that your climate is not conducive for pollination of a certain crop, and you will need to choose a different crop from which to save seed.

Fertilization needs for all crops: Regardless of mating system, once pollen has reached the stigma, requirements for fertilization are the same for all crops: Environmental conditions must be right for the pollen to germinate and grow the pollen tube, and for the sperm to remain viable as it makes its journey to the ovule. If it is too hot, too cold, or too dry, the sperm will not reach the ovule. For instance, a heat loving crop like tomatoes will produce fewer fruit and low seed yields when it is exposed to cold night time temperatures during flowering. This is because it was too cold for the sperm of the tomato to complete its journey from stigma to ovule. In general, the climatic needs of your crop for fertilization are similar to the climatic needs of your crop for vegetable production. If your climate is not conducive for fertilization of this crop, you may need to choose a different crop from which to save seed.

Isolation, Population Size and Roguing: *Know how to maintain your crop's genetics*

Isolation from contaminating pollen

Isolation involves protecting your seed crop from the pollen of plants that you did not intend it to cross with. In other words, isolation keeps contamination of your crop's genetics to a minimum. First we will discuss how you can identify the plants that will cross with your crop, then we will discuss the isolation methods you can use to protect your crop from receiving pollen from those plants.

Plants that can cross your crop
To know which plants' pollen might potentially contaminate your crop, you must learn the *scientific name* of your crop and find out which plants share that scientific name. The scientific name of a species is formed by the combination of two terms: the first term is the plant's *genus*, the second is its *specific epithet.*

Plants that share your crop's scientific name (both its genus and specific epithet) are the same species as your crop. For example, cabbage, some kales, broccoli, Brussels sprouts, and cauliflower are all the same species--- they share the scientific name *Brassica oleracea.* Therefore, if you wanted to grow cabbage seed, you would need to isolate it from kale, broccoli, Brussels sprouts, and cauliflower. Domesticated carrots and wild carrots (Queen Anne's Lace) are both *Daucus carota*, hence carrot seed crops must be isolated from Queen Anne's Lace. The scientific name of most common vegetable crops can be found in the *Crop Specific Chart* in this guide.

Look for potentially contaminating plants among these three groups: 1) wild plants in your area that are the same species, 2) other varieties of the same species that you may be growing, and 3) other varieties of the same species that others in your area may be growing.

Isolation Methods

Isolating with time
To isolate two varieties of the same species by time, plant one variety earlier than the other. The first variety must be planted early enough that it has set seed before the second variety begins to flower. Some examples of crops that can easily be isolated using timing include corn, sunflowers, and basil.

Isolating with physical barriers
You can isolate your crops using physical barriers such as paper or cloth bags, cages of very fine mesh, rows of thickly planted flowers, shrubs or trees, buildings, etc. Thick plantings of vegetation and buildings can at least partially block foreign pollen-bearing wind and insects. Bags and cages can virtually eliminate any contamination from foreign pollen, but they have two drawbacks: First, they often require involved pollination techniques. For example, seed growers who use cages to isolate carrots must release fly larvae inside the cages to allow for pollination. Second, using bags and cages makes maintaining an adequately sized population more difficult, as these strategies require a larger per-plant investment of time and materials. For more information on using bags and constructing and using isolation cages see *Seed to Seed* by Suzanne Ashworth.

Isolating with distance
You can use distance to isolate your crops by planting them sufficiently far away from sources of contaminating pollen. The distance required for effective isolation varies from species to species. A general guideline, however, is that plants that mostly inbreed require less isolation, while plants that mostly outbreed require more isolation. For plants that tend to outbreed, those that are primarily insect-pollinated require less isolation than those that are primarily wind-pollinated. Ideal isolation distances are not absolute. They vary with environmental conditions and expert recommendations for the same crop vary widely.

We have provided two sets of recommendations on isolation distances for most commonly grown vegetable species in the *Crop Specific Chart* in this guide. Our recommendations for home use are based on the assumption that your seed saving goal is to maintain a pure variety and to manage your crop with a fair degree of assurance that you won't have crossing with a nearby variety of the same species. For species that tend to outbreed, we have recommended distances for home use that are far enough to mostly avoid cross pollination, but still short enough to scout and manage potential sources of contaminating pollen within the recommended radius. For species that tend to inbreed, we have recommended distances for home use that are adequate both to mostly avoid cross pollination and to help prevent accidental mixing of seeds during harvest. Our recommendations for commercial production are based on the assumption that you require a greater degree of certainty that no crossing will occur.

In some cases you may be able to get away with a shorter distance than we have recommended. Shorter distances may be adequate if you have the following conditions: 1) prominent barriers between varieties such as rows of trees; 2) the closest variety is of the same crop type so a little crossing will not significantly alter the appearance of your variety (for example two red beets are grown in proximity); 3) the population of a nearby variety is small so the amount of potentially contaminating pollen is minimal.

In other cases you may need a greater distance to avoid contamination. You may need to expand the recommended isolation distance if you have any of the following conditions: 1) open landscape and/or high winds; 2) extremely different types of varieties in the same species (such as delicate squash and pumpkins); 3) proximity to GMO variety of the same species; 4) extremely high levels of pollinator activity; or 4) you are growing a special or rare variety that you want to ensure remains pure.

In the event of accidental crosses, you may be able to work your way back to a pure variety by removing off-type plants in following generations. The number of generations required to remove an unwanted cross will depend on the degree of crossing and whether your crop is predominantly a self-or cross-pollinated species. Ultimately, isolation distances are a risk management tool and only you can assess what level of risk is acceptable for the seed you are saving.

Population Size

Why population size matters
Maintaining an adequately sized population entails saving seed from enough plants to retain your variety's *genetic variability*. Genetic variability refers to genetic differences among plants in the same variety. For instance, one plant of the Red Russian Kale variety may differ from another of the same variety in flavor, vigor, resistance to insects and disease, tolerance to drought, or other important traits. There are two reasons that maintaining genetic variability is important:

Adaptability. Genetic variability allows a variety to adapt to changing conditions. For example, imagine two different populations of a lettuce variety, one large (100 plants), and one small (10 plants). Now imagine that the disease downy mildew attacks both populations. In the large population, despite the disease, 5 plants survive to produce seed, and in the small population, no plants survive. Why? The odds are better that in the larger population, a few plants will happen to have a gene that gives them resistance to downy mildew. In our example, as luck would have it, 5 plants in the large population had a gene that gave them resistance to downy mildew. If downy mildew strikes again next season, plants grown from the survivors' seed will be more likely to survive the outbreak. In the small population, the odds that a few plants will have the gene for resistance to downy mildew are not as good; indeed, in our example, none of them had the gene, so none survived. There was not enough *genetic variability* within the smaller population to contend with the disease. So, in larger populations, there is greater genetic variability, and it is more likely that, just by chance, some plants within the population will have a gene that can help them contend with new challenges.

Inbreeding depression. Genetic variability also prevents inbreeding depression in susceptible varieties. Inbreeding depression is a loss of vigor due to the crossing of genetically similar plants. Plants suffering from inbreeding depression germinate poorly, yield poorly, and will succumb more quickly to environmental stress. In general, plants on the strong outbreeder side of the mating spectrum are most susceptible to inbreeding depression, while those on the strong inbreeder side of the mating spectrum are least susceptible. One exception to this rule is the Cucurbitaceae (melon, squash, and cucumber family): members of this family generally outbreed, but are not as susceptible to inbreeding depression.

The right population size
We have provided recommendations of minimum population sizes for most common vegetable crops in the *Crop Specific Chart* in the appendix of this guide. Using the population sizes we recommend ensures good maintenance of the genetic base of your crop. Some of our population recommendations, however, may seem prohibitively large. Keep in mind, then, that the right population size for your system depends on the level of importance you place on being able to maintain genetic variability. It also depends on space restrictions in your garden or farm. If you cannot grow as many plants as we recommend, try growing as many plants as possible in the space you have available and see what happens. Stay vigilant for signs of inbreeding depression such as reduced reproductive capacity (lowered seed yield or fewer flowers), and reduced vigor and. If you notice signs of inbreeding depression, you can try introducing seed from an outside source to reinvigorate your variety.

The right number of seeds to plant
Please note that the recommendations in our *Crop Specific Chart* are for the final number of plants from which you should harvest seed, *not* the initial number that you plant in the spring. The decision of how many plants to start with in spring is a judgment call that you will make based on these two factors:

Environmental conditions. You may lose plants due to bad weather, pests, poor winter storage conditions (for biennials), accidents, etc.

Condition of the variety. Some plant varieties produce a crop in which almost all of the plants perform as desired. This variety can be considered to be in good condition. Other varieties produce a crop in which *some* plants perform as desired, but many others perform poorly. This variety can be considered to be in poor condition. To properly maintain your crop's genetics, you should not save seed from poorly performing plants. Therefore, if your variety is in poor condition, you will need to begin with more plants than you would if your variety was in good condition.

Roguing: Removing off-types or underperforming plants

To "rogue" is to remove inferior or atypical plants. Essentially, roguing involves walking through your planting and pulling out the plants that you don't want to reproduce. Roguing helps eliminate the ill effects of accidental crosses that may have occurred in a previous generation, accidental mixing of home-saved seeds, or genetic mutations. If you do not rogue, your variety will deteriorate; showing more and more undesirable traits season after season. Some helpful guidelines for roguing include:

Rogue more than once. It is often best to rogue varieties at more than one point in the season. For example, with a population of lettuce, at the beginning of the season, you may remove the plants that were the slowest to germinate. Later on in the season, you may remove (and eat) plants that have off-type foliage. Still later, you may remove plants that appear to be the most affected by disease.

Rogue before flower. Roguing of outbreeders should be done before flowering if possible. This way, both the rogue plants' pollen and seed is eliminated from the next generation.

Consider variable conditions. Consider variable growing conditions in the field. Plants that are in a poorer part of your field may perform poorly in comparison to their neighbors not due to inferior genetics but because they have had proportionately less sun, water, soil nutrients, etc. Conversely, plants that are in the best part of your field, or that are on the edge of an otherwise uniform field, may perform better not due to their superior genetics, but because they have had the advantage of more sun, space, soil nutrients, etc.

Maintain population size. When considering how many plants to rogue, be careful to maintain genetic variability in your population. Do not remove so many plants that you no longer have an adequate number of plants from which to harvest seed.

Soil and Cultivation:
Know the In-Field Needs of Your Crop

The needs of your seed crop as it grows in the field are very similar to its needs as a vegetable crop. We will focus mainly on the in-field needs of seed crops as they differ from those of vegetable crops. The basic in-field elements to consider in regards to seed production include: soil preparation, spacing, staking and trellising, managing disease, and managing weeds.

Soil Preparation

Seed crops, like most vegetable crops, benefit from fertile, nutritionally balanced soil with good drainage, high organic matter, and a friable (crumbly) texture. Since seed crops are often in the ground longer than vegetable crops, make sure that you provide your plants with a slow release source of fertility that can nourish them through their entire life cycle. Also be sure to provide an adequate source of Phosphorous, as it crucial for good flowering and seed set.

Striking the right balance in Nitrogen availability is especially important for seed crops. Too little Nitrogen will result in stunted plants and lower seed yields. Too much Nitrogen encourages plants to produce vegetative growth rather than flowers and seeds; can make plants more susceptible to lodging (falling over); and can make plants more susceptible to attack by insect and disease pests; all resulting in lower seed yields. In general, if you provide about the same amount of Nitrogen as is commonly recommended for your crop as a vegetable, you will probably strike the right balance between too much and too little Nitrogen.

Spacing

In general, plants that have fruits or seed that we eat (such as tomatoes, beans, melons, sunflowers, etc) don't need any more space than you would normally provide for them as a vegetable crop. Plants that we normally never see the fruit of (such as broccoli, spinach, carrots, and beets) often greatly surpass their size as a vegetable crop as they reach full maturity, commonly reaching 3 feet in diameter. These crops will require extra space. You will need to experiment to determine the right spacing for your seed crops. One popular spacing strategy is to space your crops closely together initially and gradually thin (harvest and eat) them as the plants increase in size leaving a final population adequately spaced for seed production.

Staking and Trellising

If your crop is going to get a lot bigger than it normally gets as a vegetable crop, it may need staking or trellising to help increase airflow and to keep it from falling over. Staking plants helps prevent disease, aids in the drying of the mature seed crop, and can make it easier to get into the field for late season weed management if needed. In particular, species in the Brassicacea (broccoli family), Apiaceae (carrot family), Chenopodiacea (beet family), and Alliacea (onion family) benefit from staking.

Managing Disease

Disease impacts seed crops by:

- Reducing seed yields.
- Reducing seed viability.
- Transferring disease to the next generation of plants. In cases where the crop is infected with a seed-borne disease (a disease that can live for extended periods of time on the seed itself), the plants grown from that seed will also be infected.

The strategies you can use to protect seed crops from disease are generally the same as those that you would use for crops being grown as vegetables. There are, however, a few additional considerations for managing disease in seed crops:

a. In most cases your plants will be in the ground longer than they would be if they were being grown as vegetable crops. This means you'll need to protect them from disease longer.

b. You may need to stake or trellis crops that become dense and crowded and/or top heavy (and likely to fall over) to reduce disease risk.

c. For plants that we normally don't see the flowers/fruit/seed of, you may confront a new set of flower/fruit/seed specific disease pathogens that you have not previously encountered.

d. Once your seed is harvested and cleaned, if you suspect your seed crop may have been infected with a seed-borne disease you may have a few options for control, two of which we will describe here:

First, you may be able to simply wait the disease out by storing the seed for an extended period of time; some diseases will die in storage before the seed loses viability. An example is soft rot (*Erwinia carotovora*) on celery seeds which dies after two years of seed storage. Little research has been done on this method of disease management.

Second, you can treat the diseased seed with hot water. The purpose of hot water treatment is to submerse seed in water hot enough to kill the pathogen without seriously damaging the seed. When properly done, hot water treatments are effective, but they can be risky. Too high of a temperature or too long of a treatment time can kill the seed or reduce its viability.

Step-by-step instructions for conducting your own hot water treatments can be found in a publication from Ohio State University entitled: Hot water and chlorine treatment of vegetable seed crops for eradication of bacterial pathogens (accessed at: http://ohioline.osu.edu/hyg-fact/3000/3085.html on 2/1/10). See the Resources section for a reference to this publication online. To follow the Ohio State methods, the basic materials you'll need are a hot water bath, a woven cloth bag, a thermometer, and a screen for drying seed. You can purchase hot water baths online, but they can be expensive. As a substitute for a hot water bath, we have had success using a turkey roaster with a temperature control. Others substitute with a pot of water and a stove, but beware that it can be difficult to maintain a consistent a temperature using this method and seed should not be allowed to touch the bottom of the pan which is in contact with the burner and therefore a much higher temperature.

See the Organic Seed Resource Guide, published online at eXtension.org for more information on disease management in organic seed production.

Managing Weeds

Weeds impact seed crops by:

- Reducing seed yields.
- Reducing seed viability.
- Increasing disease risk.
- Contaminating harvested crop seeds with weed seed.
- The strategies you can use to manage weeds in seed crops from are generally the same as those that you would use for crops being grown as vegetables. There are, however, a few additional considerations for managing weeds in seed crops.

Additional considerations for managing weeds:

- Some seed crops will be in the ground much longer than they would if they were being grown as a vegetable. This means that there is more time for multiple generations of weed seeds to germinate, and there is more time for weeds to mature and set seed.
- Some seed crops remain for long periods of time at a height at which they can't be easily mechanically cultivated.
- If weed seed is in your harvested seed lot, you will need to remove it during processing.
- See the *Organic Seed Resource Guide*, published online at eXtension.org for more information on weed management in organic seed production.

Harvesting and Processing:
Know about wet seeded and dry seeded crop methods of harvesting and processing

A *wet seeded crop* has seeds that are embedded in the damp flesh of fruits. There are only two vegetable plant families with wet-seeded fruits: the Solanaceae (includes tomatoes, peppers), and the Cucurbitaceae (includes melons, squashes, cucumbers). A *dry seeded crop* has seeds enclosed in pods or husks that are usually dried in place on the plant. Numerous vegetable plant families have dry-seeded fruits, a few of which are: the Poaceae (includes corn, rice, wheat), Fabaceae (includes beans, peas, lentils), and Brassicaceae (includes cabbage, mustard, kale). Certain peppers can be treated as dry or wet seeded crops, as they can be either processed when they are fleshy, or after they have dried.

Dry seeded crops and wet seeded crops require very different methods to get from harvest ready plant to storage ready seed. We will discuss the basics of harvesting and processing of dry and wet seeded crops in turn. You can find crop specific harvesting information in *Crop Specific Seed Saving Tips*.

Dry Seeded Crops: Harvesting and Processing

Depending on your scale and personal interests, getting from harvest ready dry seeded crop to storage ready seed can be as simple as going out to the garden every day and cracking open a few pods as they dry, stripping out the seeds and sticking them in your pocket, then bringing them back in the house to finish drying. It can also be a much more intensive process involving harvesting, drying, threshing, and repeated cycles of winnowing, screening, and further drying. In either case, you will need to know when your crop is ready for harvest, which we will discuss next.

When to harvest
In deciding when to harvest your dry seeded crop, you will need to ask yourself the following questions:

Do I have mature seed?
The elements that typically indicate dry seeded crop maturity:

- Color of seed and/or seed pod. Depending on the crop, the color that indicates maturity may be beige, yellow, brown, black, or some color in between.
- Dryness of seed and/or seed pod. Adequate dryness of some seeds, such as spinach seed, is determined by cutting the seed open and seeing if the inside is starchy instead of milky. Adequate dryness of seed pods is often determined by seeing if they will easily shatter when rolled between one's fingers. If they become *too* dry, some seed pods will pop open or shatter and drop their seeds.
- Ease of detachment of seed and/or seed pod from stalk. Adequate ease of detachment of seed in some crops, such as cilantro, is determined by seeing whether the seed will come off the stalk easily when rubbed vigorously.

How much of my seed is mature?
The seeds in a planting do not mature all at once, and for many dry seeded crops, the span between the first ripe seed and the last ripe seed can be as long as 4-8 weeks. If you have time, you will get the most high quality seed by doing multiple harvests; collecting the early maturing seed when it is ripe, and coming back as many times as is practical to harvest later maturing seed. Alternately you may be able to position a drop cloth in a manner that catches falling seed. Remay or geotextile fabric, discussed below under harvesting, make good drop cloths for catching seed.

If your situation does not allow for multiple seed harvests, you will need to strike a balance between waiting for later maturing seed to ripen and harvesting earlier maturing seed before too much of it has either fallen off the plant or become too brittle to harvest or process. A general guideline is to harvest when 60-80% of your seeds are ripe.

How will rain and animals affect my ripening seed crop?
Weather and animal competitors can force you to harvest at a time other than peak maturity. Rains (or overhead watering) can damage seed quality once the seed begins to dry, so you may need to harvest before a rain, even if you were hoping to let your seed ripen longer. Alternatively, you may need to wait to harvest your crop until it has thoroughly dried after a rain, at which point it may be somewhat over-ripe. Organic Seed Alliance has a useful publication on this topic title: Weather Related Risk Reduction Guidelines for Dry-seeded Specialty Crops. It is available on the Organic Seed Alliance website at: http://www.seedalliance.org/uploads/pdf/weatherrelatedriskguidelines.pdf. Also, as your seed matures, birds, squirrels, and other animals may begin to use your crop as a food source. When hungry animals are after your seed, you may need to harvest it early and dry it in a place where the animals won't find it.

How to harvest
To harvest is to sever the seed's connection to the ground. Harvest methods vary according to scale of harvest and type of crop, but some popular methods are listed below:

Smaller scale harvests:

- Strip seeds off into a bucket.
- Clip individual pods into a bucket.
- Clip seed heads into a bucket.
- Cut or uproot whole plants and place in buckets.

Medium scale harvests:

- Cut or uproot whole plants and make long rows on dirt in aisle.
- Cut or uproot whole plants and make long rows on tarps in aisle.

Large scale harvest:

- Use a mechanical swather or a combine.

How to prepare your crop for processing:
Due to threatening weather, hungry animals, and concerns about loss of seed through older seed pods popping open or shattering, dry-seeded crops are usually harvested before all their seed is sufficiently dry and mature. The crops usually need additional curing time before they are ready for processing. The seed must be dry and hard enough to withstand processing, and the plant material it's attached to must be brittle enough to easily shatter and break away from

the seed. This time also gives seed that was still immature at harvest additional time to ripen.

Be sure to allow for enough air flow as the crop cures. Depending on your scale and type of crop, this may entail such things as placing your seed pods in a shallow container and stirring them daily, hanging plants or seed heads upside down from the ceiling, or making sure the piles of plants in the field are no more than a foot or two deep and turning the piles regularly to expose buried plants to the air. For medium to larger scale harvests plants are commonly laid in rows in the field (refered to as **windrows**) for drying. Plants in widrows can be laid on tarps, remay, or geotextile fabric to catch dropping seed. Facing the heads of your plants toward the center and roots toward the edge of the fabric is best. This allows for catching the seed while keeping roots off the drop cloth to avoid contaminating your seed with soil. **Geotextile fabric**, commonly used in landscaping as a weed barrier, is an ideal material because it allows water to pass through and wicks moisture away from the plant material. Remay also allows water to pass, but can easily tear. Tarps are sturdy, but moisture will pool, even from morning dew, on a tarp. Geotextile fabric can also be placed over a widrow to shed light rains if precipitation is expected. Plants in a windrow should be turned frequently to ensure even drying through the pile. Refer to the three elements that indicate dry seeded crop maturity to help you gauge when your seed is sufficiently dry for processing.

How to process seed

When your crop is dry enough, you can separate the seed from the non-seed material that it's mixed with. This non-seed material may include leaves, stems, and pods from the seed crop, called *chaff*, as well as dirt, stones, and weed seeds. The first step in this process is to *thresh* the crop. Next, depending on how important it is that there is no non-seed material mixed with the seed, the crop is usually *cleaned* through cycles of *winnowing* and *screening*. Often, between threshing and cleaning, or between cycles of winnowing and screening, the seed is given time to dry further.

Threshing

To thresh is to break up the material that is attached to the seed. This step facilitates the subsequent separation of the seed from non-seed material in seed cleaning. There are many different threshing techniques, and the technique that is best for you will depend on your crop and your scale. Some popular methods of threshing include:

Rubbing by hand: Rub seed pods between your gloved hands to break them open or rub the seed and chaff over a rough surface.

Stomping or "dancing" on top of the seed and chaff: Lay the seed and chaff on a tarp or in a large bucket. Wiggle your feet from side to side on top of the seeds, allowing the ball of your foot to swivel from left to right, as if you were squishing a bug. This works best wearing smooth soled boots so the seed does not stick to the tread on your sole or fall into your shoe at your ankle. To protect your seed from damage, make sure to always have several inches of seeds and chaff between your foot and the bottom of the bucket or the ground while crushing.

Driving a vehicle over the seed and chaff: Lay the seed and what it's attached to on a tarp. Place another tarp on top of the seed, and secure it in place. Now drive back and forth and side to side on the tarp.

Using a variety of machines: Larger-scale seed growers often use commercial threshing machines (belt threshers or combines), or mulching equipment adapted into threshing machines.

Most of the threshing methods listed above subject the seed to a significant amount of pressure, and each crop varies in sensitivity to pressure. Some delicate seed crops, such as broccoli, peas and cilantro, will be damaged if stomped on or driven over. Others, such as beets, radish, and spinach, can easily withstand such pressure. In addition, while seed needs to be sufficiently dry before threshing, seed that is too dry is more subject to crack under pressure. To be safe, try any threshing method on a small lot of seed before attempting it on your entire seed lot. Sometimes you can reduce the chances of damaging seed by threshing it on a softer surface or for a shorter amount of time. While threshing, check seeds often to see if they have received sufficient pressure to break free from the material they were attached to or if they are cracking from too much pressure.

Depending on the relative quantity and type of material that the seed is mixed with, some garden-scale seed growers may find that they need go no further after they have threshed their crop. They may have no problems using seed that is mixed with chaff. In most cases, however, seed growers will want to separate the seed from the sticks, leaves, dirt, stones, and weed seeds that it may be mixed with. If so, the next step is cleaning.

Cleaning

Cleaning is generally accomplished using a combination of two methods: winnowing (separation based on weight) and screening (separation based on size).

Winnowing

To winnow is to use an air current to separate seed from non-seed material based on weight. In winnowing, seed and non-seed materials are dropped before a wind source (either natural wind or a fan). The heavier materials fall closer to the wind source while lighter materials are carried further from the wind source.

One typical winnowing setup includes two plastic bins arranged in front of a box fan. The fan and bins are on a tarp to catch any stray seed. When the seed and non-seed materials are poured in front of the fan, the heaviest seed will land in the first bin and lighter seed will land in the second bin. Much (but not all) of the non-seed material will be lighter than the lightest seed, and will land somewhere past the second bin. It takes practice to determine the correct fan speed, the distance the bins should be from the fan, and the speed with which to pour the seed in front of the fan. See photo below:

Another typical winnowing setup includes standing on a tarp and pouring seed from one stainless steel bowl to another. Light chaff will float away from the bowl receiving the seed. Some use a wind source like a fan or a hair dryer (with no heat) to further encourage chaff to float away as seed falls from bowl to bowl. It takes practice to determine the correct amount of seed to put in the bowl and the best distance of the wind source from the bowl. For winnowing large seed lots, farmers and seed professionals often use machines called gravity tables. It is best to use a dust mask when winnowing to keep chaff out of your lungs.

Screening. To screen is to use metal with holes to separate seed from non-seed material based on size. One basic screening technique involves the use of two stacked screens. The top screen should have holes slightly larger than the seed and the bottom screen should have holes slightly smaller than the seed. Pour seed and chaff in a thin layer on the screen with the larger holes. Shake and/or gently rub until the seed and any smaller materials have passed through. All the materials that are larger than the seed will remain on top and can now be discarded. Next shake and/or gently rub the remaining seed and chaff on the screen with the smaller holes until all materials that are smaller than the seed have passed through. The majority of what remains on top of this screen will be seed.

You can buy screens specifically designed for seed cleaning or you can make them yourself. The screens specifically designed for seed cleaning are categorized (by width of holes) in increments of 64ths of an inch. For example, a #6 screen has openings that are 6/64" in width. Most screens have round holes, but some screens made for particular crops have holes of different shapes. For example, there are screens with oblong holes that permit lettuce seed to pass through while retaining larger and differently shaped materials on top. The most commonly available seed screens are nestable and are mounted on 12" square wooden frames. You can buy seed cleaning screens through *Hoffman and Seedburo (see Resources section).* Seed of different varieties of the same crop and seed of the same variety grown in different years or locations will vary in size. Following are estimates of screen sizes for common vegetable seeds of varied sizes.

Screen Sizes for various crops

Seed Size	**Crops**	**Range of Commonly used Screen Sizes**
tiny	basil, mint, amaranth, many herbs	1/20th to 1/16th (no. 4)
small	Brassicas (broccoli family), celery, chicory	5/64th to 7/64th
medium	beets, chard, carrot, parsnip, filet beans	7/64th to 12/64th
large	cucumber and squash family, common beans and pole beans	12/64th to 20/64th (pill shape x ¾ long for beans)

Due to the relative expense of commercial seed screens, you may decide to make your own screens using materials such as hardware cloth, window screens, and wire mesh.
¼", ½" and 3/8" hardware cloth are useful for screening medium to large seeds and for removing large pieces of chaff. 1/8" hardware cloth is useful for medium seeds and some smaller seeds. You may find pieces of old kitchen or electronics equipment at scrap yards and thrift stores that have perfectly sized screens for your seeds.

For screening large seed lots, farmers and seed professionals most commonly use machines called Clippers from Crippen Manufacturing Company.

How to dry seed at ambient conditions
Dry your seed in thin layers (around ¼ inch thick) on plywood, window screen, sheet pans, or any hard, non-stick surface. Stirring seed helps ensure even drying. Placing fans near seeds will also facilitate drying.

Seeds can become damaged when their temperature rises above 95 degrees, but even at temperatures of around 85 degrees, dark colored seeds in the sun can become overheated. Therefore, take care to dry your seed in a location that is warm, but not too warm, and dry them out of the sun if necessary.

Wet Seeded Crops: Harvesting and Processing

Fewer generalizations can be made about when or how to harvest and process wet seeded crops. See *Crop Specific Seed Saving Tips* for guidelines on eight major wet-seeded crops. There are, however, a few generalizations that can be made, and this is what we will cover next.

When to harvest and when to extract seed
In general, let your wet seeded crop mature on the vine as long as possible before harvest; the seeds will continue to increase in size and quality for days to months after the fruit first reaches edibility. But to protect against damage and disease, you may need to harvest the crop before all of its seeds are fully mature and let them continue to ripen in storage before extracting them from the fruit.

How to process seed
For every wet seeded crop, there are a number of viable options for seed extraction and processing. Most of the options involve one or more of the following methods: *soaking, fermentation, rinsing, and decanting.* The right option for you will depend on your scale, the equipment you have on hand, your time constraints, and your desired level of seed quality. See the appendix for crop-specific seed extraction and processing suggestions and experiment to see which option works best for you.

Soaking
Soaking can make seed cleaning easier by loosening the pulpy residue clinging to the seed. Place seeds and pulp in a container full of water. Allow seeds to soak until the pulp seems easier to separate from the seed, no longer than 8-12 hours.

Fermentation
Fermentation also makes seed cleaning easier by loosening the pulpy residue clinging to the seed. In addition, it removes a germination-inhibiting gel from the seed and destroys some diseases. There is much disagreement among seed experts on which seeds need to be fermented and which seeds are damaged by fermentation. The only two crops that virtually all experts generally agree should be fermented are tomatoes and cucumbers. Therefore, we recommend fermentation only for these crops. To ferment**:**
1. Place seeds and pulp in a container. Add water to the seed/pulp mixture only if the mash is too thick to stir.
2. Place container in a warm location, ideally between 70-85F. Depending on temperature and seed variety, the fermentation process can take anywhere from 48 to 72 hours.
3. Stir the fermenting mixture two or three times a day to aerate it and facilitate even fermentation. A small amount of white mold may appear on top of the mash; it is not harmful and can be stirred back in.
4. Closely monitor the seed for sprouting. Although damage may begin earlier, sprouting is a sure sign that the seed has soaked too long, and that damage has occurred. Experts disagree on the best method to determine when fermentation is complete. Some consider the process finished when the mixture stops bubbling. Others stop when a thick layer of white mold completely covers the surface of the mixture. Still others test for doneness by regularly removing a sample of the fermenting seeds, rinsing them in a strainer, and feeling them. If the gel around the seeds is completely gone, they consider the process finished. People have had success using all of these methods. Experiment to find the method that works best for you.
5. When fermentation is complete, decant and rinse.

Rinsing
The process of rinsing separates pulp from seed. The basic elements necessary for screening are 1) a piece of metal with small holes in it, such as a colander, strainer, or screen 2) pressurized water 3) hands for rubbing. Rinsing setups can vary according to your scale and how thorough of a rinse is necessary. Below are two common methods:

1. Place seeds and pulp in a strainer. Put the strainer under running water. Rub and rinse until the seeds are clean.
2. Use two framed screens, one on top of the other. The top screen should have holes just large enough to allow the seeds to fall through while retaining large pieces of pulp on top. The screen below should have holes just small enough to retain the seeds on top while allowing small pieces of pulp to fall through. Place seed and what the seed is attached to on the top screen and break up the material by rubbing it and spraying it with water. Once the majority of the seeds have fallen through the first screen, remove this screen and spray and rub the material on the bottom screen until only seed remains.

One drawback to relying solely on rinsing for cleaning your seed is that it does not remove lightweight, non-viable seed. To do that, you will need to use a decanting process.

Decanting
The process of decanting separates pulp and lightweight, less-viable seed from good heavy seed. To decant:

1. Place seeds and pulp in a container that can hold at least 10 times the volume of your seeds and pulp. If necessary, break up the seed/pulp mixture by crushing and stirring.
2. Add water to your seeds and pulp. A good general guideline is to have about 1 part seeds and pulp to 4 parts water. If necessary, agitate until the seed is loosened from the pulp.
3. Wait a few minutes for the good, heavy seed to settle on the bottom. With some crops, good seed can become stuck to air bubbles and remain floating on top. In these cases, gently push the seeds down with your hands.
4. Pour the top layer of pulp, debris, and lighter, less viable seed off the top. Repeat steps 2 through 4 about 3 to 6 times until the water is fairly clear.
5. Pour seed into a strainer or onto a screen and rinse.

Note: For some crops, some seed growers do a quick rinse, then decant their seeds. In some cases, rinsing first can remove much of the pulp before decanting, requiring fewer repetitions of the decanting process.

Large scale wet seeded crop processing
Large scale growers often harvest and process wet seeded crops in one mechanical operation where fruit is picked from the row, conveyed to a crushing mechanism, and the pulp is removed from the seed by washing with water in a rotating drum.

How to dry seeds at ambient conditions
To reduce the risk of seeds becoming diseased, dry your seeds as quickly as possible. To do this, maximize airflow. Spread the seed out in a very thin layer (about ¼ inch thick) onto screen, plywood, sheet pans, or any hard, non-stick surface. Avoid using paper towels, newspaper, cardboard, or cloth because wet seeds will tend to stick to the surface, making them difficult to remove. If seed is very wet, repeated stirring (every fifteen minutes for the first few hours, less often thereafter) of the seed will encourage quick drying and further reduce any chances of sticking. Air conditioning (especially in hot, humid environments), and fans can also be useful. Remember that seeds should not reach temperatures over 95F (35C).

Seed Storage:
Know how to protect your seed harvest and keep it viable

To maximize the life of your seed, keep it cool and dry, and protect it from insects and rodents. Seed needs to be kept cool and dry because inside every seed is a plant embryo living on the seed's food stores; when the embryo uses up all of its food, it dies and the seed will not germinate. To prolong the life of a seed, then, you must slow down the rate at which the embryo goes through its food. You can do this by keeping the seed cool and dry. Another reason to keep your seed cool and dry is that cool, dry seed is less vulnerable to attack from bacteria, fungi, and some insects.

Seed can be an excellent source of nourishment for rodents and many insects. Therefore, where insects and rodents are a concern, you will need to protect your seeds by storing them in thick plastic, glass, or metal. But before you can safely store your seed in plastic, glass, or metal, you will need to make sure that your seed is "very dry," which we will describe next.

Determining if your seed is "very dry"
An important principle in seed storage is that the more a storage container or location restricts the release of moisture, the drier your seeds will need to be. To be on the safe side, we recommend drying seed to a level that we call **"very dry"** before storing in any container that restricts the release of moisture. Seed is "very dry" when it passes one or more of the following three tests:

Brittleness test
Test small, oblong seeds, or thin ones (such as squash) by bending them. If they are "very dry," they will snap instead of just bending. With bigger seeds such as corn, beans, or peas; put seeds on a hard surface and hit them with a hammer. If they are "very dry," they will shatter like glass when hit. If seeds are inadequately dry, they will smash or mush instead of shattering.

Envelope test
Put an envelope (or some other paper item) in your lot of seed overnight. The next morning, compare the envelope left with the seed to an envelope that was not with the seed. Does it seem moister than the envelope not left with the seed? Is it more malleable, or is it as crisp as the other envelope? If the envelope left with the seed seems dry as or drier than the envelope left at ambient conditions, then you can consider the seed to be "very dry." This test works best where paper tends to stay crisp and dry at ambient conditions.

Test of percent moisture
The most accurate test for dryness is to determine the percent moisture content of your seed. To determine the percent moisture content, record the weight of a sample of your seed. Next, place this sample of seed in an oven or toaster oven and dry it slowly on low heat (taking care not to burn it) until all moisture is removed. Weigh the seed several times during drying to determine if all moisture has been removed and the weight has come to equilibrium. Record the weight of your completely dry seed, then use the following formula:

$$\text{Seed moisture content (\%)} = \frac{\text{fresh seed weight} - \text{dry seed weight}}{\text{Dry seed weight}} \times 100$$

A general guideline is that small seeds are "very dry" and ready to be stored in containers that restrict moisture release at approximately 5% seed moisture. Large seeds are ready at 7% seed moisture.

Getting your seed to "very dry"
With some exceptions for hot, dry climates, seed dried at ambient conditions usually will not be "very dry." If you discover that your seed dried at ambient conditions is still not "very dry," and you wish to store it in a container that restricts moisture release, there are a couple of options for further drying your seed:

Using silica gel
Determine the weight of the seed to be dried, including the packet that will hold the seed in the drying container. Measure out an equal weight of silica gel and place the packet of seed and silica gel in an airtight container. The container size should be small in relation to the volume of seeds being dried. Depending on the original moisture content and size of your seeds, they should remain in the drying container for 2-7 days. Use the tests described above to determine when the seed is "very dry." Check daily for dryness, because seed left with silica gel too long may lose too much moisture and become damaged or go dormant. Small seeds should not be dried below 3% moisture, and large seeds should not be dried below 5% moisture. When the seed is "very dry," remove the packet of seed from the drying container and transfer it to another airtight container.

Using a food dehydrator
Use a food dehydrator with temperature controls that go down to 85F (29C). Set the dehydrator at 85F (29C) and check your seed often to avoid over-drying. The amount of time it will take for your seed to dry will depend on your crop and your dehydrator, so experiment with small batches of seed before drying your entire seed lot.

Where to store your seeds
The right storage method for you will depend on the quantity of your seed, your intended length of storage, ambient conditions, and presence of pests. It will also depend on the type of seed you are storing. Some seeds like amaranth, which can retain good germination and vigor after 40 years in storage, are famously long lived. You have more leeway in choosing how to store long-lived seeds. Other seeds are famously short lived. The three major crops with very short-lived seeds are onions, leeks, and parsnips, which may retain good germination and vigor for only one to two years. It is especially important to keep short lived seeds very cool and dry.

For the bulk of major vegetable crops, if the seed is of good quality (not small or diseased), and storage conditions are good, you can expect that it will retain good germination and vigor for 3-5 years. So, with the exception of the short-lived seeds listed above, you can plan to store most of your seeds for 3-5 years before you grow them out again. In many cases, however, seed will still germinate and grow after more than 5 years in storage. In fact, it is not unheard of for high quality seed of some common vegetable crops to remain viable for more than 10 years. Seed stored for this long, however, will likely have a lower germination rate and lower vigor.

Storage containers and locations
Two basic elements to consider when choosing a storage container are the level of moisture release that it allows (and hence whether it requires you to get your seed "very dry"), and the level of protection from insects and rodents that it provides. Here is how four common seed storage containers compare on these two elements:

Paper or cloth - Allows for moisture release, so seeds don't have to be "very dry". Not protective against insects and rodents

Plastic bags - Somewhat restricts moisture release, so seed should be "very dry". Not protective against insects and rodents

Plastic tubs, bins, buckets - Somewhat restricts moisture release, so seed should be "very dry". Somewhat protective against insects and rodents

Glass jars, other air-tight containers - Greatly restricts moisture release, so seed must be "very dry". More protective against insects and rodents

On display - Storing your seeds in glass jars in a place of prominence in your house allows you to fully enjoy their beauty, but ambient conditions may not be ideal for seed longevity.

In coolest, driest place in house - Good for short to medium term storage of seeds.Not necessary to get seeds to "very dry." To determine whether a location is cool and dry enough to store seed, you can use this general guideline: The sum of the storage temperature (in degrees F), plus the relative humidity (in percent) should not exceed 100. The formula looks like this: Temperature F + Relative Humidity % = <100.

Refrigerator - Protects against insects and rodents.
Good for medium term storage of seeds. A refrigerator may not provide the ideal level of humidity, so seed should be in an air tight container, and must be "very dry." If seeds are taken from the refrigerator and transferred to room temperate, prevent condensation on the seeds by allowing them reach room temperature before opening the container.

Freezer - Protects against insects and rodents. Kills insects.
Good for long term storage of seeds. A freezer is so cold and dry that moist, unprotected seed will be damaged. Seed should

be in an air-tight container and must be "very dry." If seeds are taken from frozen storage and transferred to room temperate, prevent condensation on the seeds by allowing them reach room temperature before opening the container.

What to do when your seed lot is infested with insects
Insects such as mites, weevils, beetles, and moths can be present in your seed at harvest, and they can find your seed in storage. If you have cause to believe that your seed is infested, you can kill the pests by putting your seed in the freezer for a few days. Your seed must be "very dry" before you put it in the freezer, and it should be in an air-tight container. If you don't plan on leaving your seeds in the freezer after the insects are killed, remember that you will need to prevent condensation on the seeds by allowing them reach room temperature before opening the container.

Temperature and humidity fluctuations
Temperature and humidity fluctuation are detrimental to seed longevity, so to maximize the life of your seed, store it at a constant temperature and humidity. If you are storing your seed in the refrigerator or freezer, minimize the number of times that you remove the seed from these locations.

Labeling
Make sure to label your seed. Include on your label the type of plant, the variety name, the name of the seed's original source, and the year the seeds were last grown. You can also include information gathered about the crop throughout the growing season such as days to maturity (number of days from sowing to mature seed); plant height and habit; fruit size, color, and shape; productivity; disease resistances or susceptibilities; flavor; and storage qualities. To be on the safe side, many seed savers put labels both on the inside and the outside of their storage containers.

Saving seed back
Make sure to save some seed back whenever you plant. That way, in case of a crop failure, you will still have some seed in storage to try again next year.

Germination:
Know your seeds germination rate.

If you have old seeds or are curious about the quality of seeds that you grew and saved, you can use one of the following tests to determine the germination rate of your seed.

In soil germination test
The best way to test the germination rate of your seed lot is to sow a selection of seeds in a flat of soil as you would if you were starting them in a greenhouse. The only major difference between sowing seeds for starts and sowing seeds for a germination test is that you may sow seeds for a germination test more closely together (around ½ inch apart is fine). Adapt the directions below for germination testing done in paper rolls to your in-soil germination test.

Paper roll test
If you find that it is not practical to test your seeds in soil, use the paper roll test.

Materials needed:
1. Germination paper or paper towels. If possible we recommend using germination paper because it is acid-free; acid in paper towels can affect germination. It is also an ideal texture to retain moisture without becoming soggy or waterlogging. Germination paper is not easy to come by in small quantities so you may want to go in on a supply with your gardening friends. Larger quantities may be purchased from Hoffman Manufacturing (see Resources section).
2. Plastic bags or dinner plates
3. Permanent marker
4. Notebook for recording information

Procedure:
1. Moisten germination paper. The paper should be wet but not dripping. You can use a spray bottle to moisten the paper, or you can quickly dip the paper into a tray of clean water. If water beads up around your fingertip when you press on the paper, it is too wet.
2. Choose a random selection of seeds from the seed lot you are testing. Do not select all the best (or worst) looking seeds or your results will be skewed. Additionally, the more seeds that you can spare to do the test, the more accurate your results will be. Ten seeds is an absolute minimum. Testing 50 – 100 seeds will give you more dependable results.
3. Place seeds to be tested somewhat equidistant from each other, usually not closer than ½", on the damp paper. If seeds fit easily on half of the paper, then fold the other half of the paper over the seeds. If the seeds take up the whole paper, put another damp paper on top of the seeds. Roll the paper up somewhat tightly to keep the seeds from shifting position or falling out.
4. Seeds need both air and moisture to germinate. You need to strike a balance between keeping moisture in and allowing the seeds to breathe. There are four ways to do this; you can place the seed roll a) between two diner plates closed together, b) in a plastic bag that is sealed all the way, but has some air in it, c) in a plastic bag that is sealed all the way but has holes in it, d) in a plastic bag that is closed only partially.
5. Using the permanent marker, write the variety name of the seed, the date you started the test, and the number of seeds onto the bag (or tape the info to the plate). Also write this information into your notebook.
6. Try to approximate the conditions that your seed prefers for germination. Some seeds, like spinach, celery, and peas geminate best at lower temperatures (60-70F (15-21C), while eggplants, melons, and peppers prefer more warmth (70-80F (21-26C). Most vegetable seeds are indifferent to the amount of light they receive during germination, but some (such as

lettuce and celery) prefer light, while others, (such as onions and chives), prefer darkness. You can learn your crop's preferred conditions for germination in seed starting books, or in some gardening books and seed catalogs.

7. After 3 days, start checking the seeds daily. The fresh air that wafts in when you check on the seeds will do them good, and you can add moisture if the paper is drying out. Most importantly, check the progress of your germinating seeds. If a seed molds or looks rotten, count it as dead and remove it. If it looks like a seed's first root has fully emerged, count it as germinated and remove it. Removing dead and germinated seeds from the paper roll keeps things from getting moldy. In your notebook, keep a running count (with dates) of the dead and germinated seeds.

8. Continue to check your seeds daily until a) all of your seeds have germinated, or b) the maximum predicted germination time for your seed has passed. Some seeds take no more than 2 days to germinate, while others take as long as 20 days. A good general rule is to continue the test for at least 21 days. Then, from your running count, find the total number of good seeds. If all of the seeds germinated, then you have a perfect germination rate - 100%. If it was less than perfect, divide the number of seeds that germinated by the number you started with to determine the germination rate. For example, it you started with ten seeds and only nine germinated, then 9/10 = 0.9 or 90%.

How to use the results of your germination test

First, the germination rate helps you to know how much seed to sow. For example, if the germination rate is 50%, sow twice as much seed to get a full stand.

Second, the germination rate tells you about the fitness of your seeds. In general, as the germination rate goes down, so does your seed lot's general vigor and vitality. Low germination rates are a warning that the energy reserves stored in your seed are running very low, and that they may produce plants that under perform in the field.

A note about dormancy

Most seeds of wild plants go through a period of dormancy, which is a mechanism for delaying germination until the seed is dispersed and exposed to favorable growing conditions. In general, as our food crops became domesticated, their seed dormancy characteristics were lessened or eliminated. Nevertheless, the seeds of some of our common crops still exhibit some dormancy. For example, spinach, lettuce, and peppers, may not germinate well, or at all, shortly after harvest.

A period of dry storage is usually all that is required before dormant seeds will germinate. In some cases, such as with a number of herbs, the seed coat must be scratched, notched, or otherwise worn down before the seed can germinate.

In general, since dormancy is usually broken by time in storage, and seed usually sits in storage over the winter, you may never need to think about the seed dormancy characteristics of your crop. If, however, you wanted to test the germination rate of a lot of freshly harvested seed, do not be surprised to discover that the tested seed doesn't germinate. Rather than assuming that your seed is dead and needs to be discarded, let the seed sit in storage for a few months, then try testing it again.

Specific Crops:
Seed Saving Tips for common vegetable crops

Beets (Chenopodiacea) *Beta vulgaris*

Growing tips: Beets are a cool season crop and are best grown in areas with mild temperatures (below 75-80F (23-26C) during flowering. Beets are a biennial and require vernalization to flower. The ideal size for overwintering (in terms of cold hardiness) is 1-1.5in diameter. The flower stalk is extremely large; up to 5ft tall.

Harvest and processing tips: Beet seed crops from second year roots mature in approximately 140 – 160 days depending on variety, climate, and planting date. Beet seed formation usually starts anywhere from six to ten weeks after flower stalk initiation. As the flowering habit is indeterminate, flowering and subsequent seed maturation will continue until harvest or frost. Because beet seed matures sequentially the percentage of beet seed reaching full maturity at the time of harvest will usually not exceed 75% of the total seed crop. The earliest seed to set will often mature several weeks before the bulk of the seed on any given plant has matured. This first seed set is usually of a high quality and has a high germination rate, but it may readily shatter as the bulk of the crop is maturing. The seed grower must determine when the maximum overall maturation has occurred, without losing a significant amount of the earliest maturing seed. Cool, wet weather can often occur during the late season, seed maturation period for beets in the Pacific Northwest making it even more important for growers to closely monitor the seed maturity and not harvest too early or too late. Early harvest may result in a percentage of seed that is not fully mature. Harvesting seed past the optimum time period may result in reduced yield and seed quality due to seed shattering and an increased incidence of seed borne diseases.

A standard method used to judge maturity of the beet seed crop is a visual assessment of the color of the seed ball (a multiple-seeded fruit resulting from the fused dry corky bracts of two or more flowers that occur at the same node). Harvest should occur when between 60 and 80% of the seed balls on at least 90% of the plants in the field have turned a tannish-brown shade, typical of mature beet seed. Unfortunately this method may sometimes be inaccurate due to the potential effects of the environment or the genetic variation of the particular beet variety being produced. In a number of environments the beet seed balls will turn a darker shade of brown, sometimes before they reach full maturity. This often occurs with higher than usual levels of precipitation during the final weeks of seed maturation. This darkening may be due to saprophytic bacterial or fungal growth on the corky bract tissue of the seed balls. Depending on the pathogen it may not be harmful to the seed, but it seriously impedes visual assessment of beet seed maturity. There is also considerable variation between varieties for the degree of browning of the seed that occurs during the maturation process. Some beet varieties may retain greener hues than others, even when fully mature.

In order to make a more accurate assessment of the maturity of the seed it is best to check the relative maturity of the endosperm of the seed. The endosperm, which grows concurrently with the embryo, must be fully developed to produce viable, fully mature seed that will grow vigorously and maintain a high germination percentage through its expected storage life. The starchy endosperm can be monitored through the maturation process by cracking open any one of the several seeds that occur within each beet seed ball. The best way to determine the maturity is to squeeze a small amount of the endosperm out of the cracked seed and visually inspect it. If the endosperm is viscous and appears translucent or milky, it is not close to maturity and will require at least 3 to 4 weeks to mature. Sometime after this the endosperm will start to appear grayish and waxy, what is often called “flinty,” but it is still not close to maturity. When the endosperm becomes “starchy” with a true solid white color and has a firm texture then the seed is very close to maturity. A majority of the seed, at least 70 to 75% of the seeds on a given plant, must be at this advanced starchy stage before considering harvest.

Broccoli/Cauliflower (Brassicaceae) *Brassica oleracea*:
Growing tips: Broccoli is commonly grown as an annual for seed as it does not require vernalization, though its ancestors followed a biennial cycle. Cauliflower is a true biennial and requires vernalization. Both broccoli and cauliflower benefit from staking in the field.

Harvest and processing tips: Harvest and processing for broccoli and cauliflower should follow steps outlined in the cabbage description.

Cabbage (Brassicaceae) *Brassica oleracea*:
Growing tips: Cabbage is a biennial and requires vernalization to induce flowering. The ideal size for overwintering (in terms of cold hardiness) is a fully grown, but loosely formed head, before the head firms up. Cabbage plants will generally overwinter in areas that don’t drop below 20F (-7C) in the winter. In colder winter climates, cabbage plants must be dug up and stored over the winter. Choose the firmest heads and trim off loose leaves. Dig up the entire plant and clip the roots to 12 inches, leaving some lateral roots. The cabbage heads should be covered with damp sawdust. Heads may also be wrapped in damp newspaper and stored for 2-4 months at a temperature of 32-40F (0-4C) and 80-90% relative humidity.

In the spring of the second year, after re-planting or overwintering in the field, it may help to cut a shallow X on the top of the cabbage head to promote the seed stalk to emerge. The seed stalk will grow 3-4 feet tall and produce seedpods.

Harvest and processing tips: In Year 2 pods will start to dry and turn brown as they mature. If the seed pods are allowed to dry completely in the field, you run the risk of them shattering. It is best to harvest the mature plants and allow them to dry completely on tarps. Cut plants at base and windrow (onto tarps) for 3 - 5 days during dry weather. Dry plants need to be threshed before cleaning. Thresh plants by stripping pods and rubbing gently to crush pods and release seeds. Brassica seeds can be crushed or damaged by too vigorous of rubbing. Threshed pods can be cleaned by winnowing and/or cleaning with screens. When cleaning seed with screens two screens are commonly used, a top screen to scalp off large debris and a smaller bottom screen to retain seed and allow small debris to pass. A size 7 or 8 screen should allow seed to pass through and retain larger debris. A size 3 screen or a small slotted screen or wire mesh may be used to retain seed and allow smaller debris to pass through.

Carrot (Umbellifereae) *Daucus carota*
Growing tips: Carrots are a biennial and must acquire vernalization to flower. The ideal size for overwintering (in terms of cold hardiness) is slightly smaller than the size you would harvest for food. It should be about ¾-1in wide at the crown (see section on biennial crops). However this size is a little small for selection of roots for tip fill and overall shape. If grown for improvement then grow roots slightly larger size to select and overwinter, but if conditions are cold and overwintering is risky then grow for smaller size. Carrots benefit from staking in the field.

Harvest and processing tips: Carrot seed crops usually mature from mid-August to mid-September in the Western Region. The king or primary umbel is the first to ripen. The seed will turn from a dark green to brown and will actually begin to detach from the umbel, but because of the racemes, or little hooks that cover the seed, they often latch together and remain on the umbel surface. Much of this seed can still be lost to shattering. The secondary and tertiary umbels that form after the king umbel will ripen anywhere from a few days to a few weeks later. However, waiting until all of the late forming umbels ripen is seldom economically viable as this seed tends to be of lower quality and strong winds will begin to dislodge the seed from the king umbels which is generally the best seed.

Poor soil fertility, uneven soil water, excessive heat at flowering, inadequate pollination and Lygus bug damage can all effect the development of the embryo. Good quality carrot seed is generally plump and heavy. One way to check initial seed quality is to rub a small sample in the palm of your hand using a fair bit of pressure on the seed. Good seed will remain intact while poor seed will crush and break apart. When about 80% of the total seed has turned brown and detached from the umbel the crop is usually swathed and left to lie in the field for 2-5 days to allow the stems to dry so that the crop can easily be threshed. The crop is very vulnerable to shattering due to high winds and rain at this stage so timing and being mindful of the weather is important in timing this step.

Proper threshing takes an experienced operator. Because carrot seed is light in comparison to the stems and other trash created by threshing with combine, it's difficult to get a clean seed crop using a combine. Further seed cleaning with screens and forced air is necessary to get a clean seed crop. It's not uncommon for the total weight that comes out of the combine to be less than 50% good, clean seed. Research and trials show that early harvest of carrot seed before the seed is physiologically ripe results in lower seed quality.

Harvest beyond mid-September is dangerous as it exposes the crop to the vagaries of wind and rain damage. If the crop is small and cover is available, cut the crop at the proper stage and then move it onto paper or plastic under cover until it can be threshed. The stems will still have a fair bit of moisture so make sure to manually turn the crop to get it uniformly dry. Don't pile the crop any higher than 2-3ft (61-91cm) deep and try to keep the pile loose and fluffy to allow air flow through the crop. Supplementary air from fans may be necessary to keep mold from forming on the mature seed until threshing.

Common Bean (Leguminaceae) *Phseolus vulgaris*:
Growing tips: Bean seed crops may require a long season to mature (average 90-120 days) and must be planted early enough to mature and dry prior to frosts or rains. Dry, long growing seasons are key to minimizing disease pressure. Temperatures above 90F (32C) or below 50F (10C) during flowering may adversely affect pod set and seed yields. Most bean varieties germinate best when soil temperatures are at or above 65F (12C), but germination may be inhibited at temperatures above 95F (35C). There are however, instances when seed growers must plant with soil temperatures below optimum in order to fully mature a seed crop by the end of the season. Depending on your climate beans can be day-length sensitive, which means the flowers will not open until the days are shorter. Always test the variety before relying on a seed crop.

Harvest and processing tips: Each variety has its own specific harvest timing and while this makes overall recommendations for gauging cutting, curing and threshing difficult, there are basic signs that indicate maturity. Most bean varieties will be mature for harvesting when they first turn yellow, tan or mahogany. If the bean has turned too dark a brown, it is at risk for seed shattering during harvest. The crop should be cut when approximately 70 to 80% of the pods of the plant are the desired color and point of breaking.

Corn (Poaceae) *Zea mays*:
Growing tips: Corn is highly susceptible to inbreeding depression so maintaining a large enough population is essential (see *Crop Specific Chart*). A good seed set requires adequate application of pollen to the silks (pistils). For this reason corn benefits from planting in a block rather than long, narrow rows.

Harvest and processing tips: Corn husks are harvested when they have dried completely on the stalks. After the husk is dry you can rub two husks together to free the seed kernels from the husk. Other machinery can be used for larger productions. Winnow out any other debris from the seeds.

Cucumbers (Cucurbitaceae) *Cucumis sativus*:
Harvest and processing tips: The seeds of cucumbers are still very immature when the fruit is edible. Leave edible cucumbers on the vine for around 4-5 weeks. For harvest, the fruits will be very large and their color will be pale yellow to orangish brown, depending on the variety. The wall of a harvestable fruit will give slightly under gentle thumb pressure.

Good options for processing:

- Cut open, scrape out seeds and pulp, rinse or decant
- Cut open, scrape out seeds and pulp, soak for 8-12 hours, rinse or decant
- Cut open, scrape out seeds and pulp, ferment 48-72 hours, rinse or decant

Eggplant (Solanaceae) *Solanum melongena***:**
Harvest and processing tips: The seeds of eggplants are still very immature when the fruit is edible. Leave edible eggplant on the vine for an additional 2-3 weeks. For harvest, purple fruits will turn a dull brown and white eggplants will often turn yellow. To confirm harvest readiness, cut open one or two fruits and confirm that all of the seeds are dark.

Good options for processing:

- Blend lower (seed containing part) of the fruit with water in a food processor (use a thick plastic blade, or wrap tape around metal blades to avoid damaging seeds) then choose between rinsing, decanting, or rinsing and decanting.
- Grate lower (seed containing part) part of the fruit, Put gratings and any loose seed in a container that can hold at least twice the volume. Add water to within 2 inches of the rim, and squeeze by hand until very few

seeds are left in the flesh. Then choose between rinsing, decanting, or rinsing and decanting.

Kale/Collards (Brassicaceae) *Brassica oleracea*:
Growing tips: For the seed crop kale is usually seeded into flats from June 20 – July 15 and transplanted 3 to 4 weeks from emergence. These plants are overwintered in the field.
This crop is the traditional European style kale which should not be confused w the 'Red Russian' type which is *Brassica napus*, the same species as rutabaga. European kale (B. oleracea) **will not cross** with the 'Red Russian' types or Russo Siberian kales, but **will cross** readily with broccoli, Brussels sprouts, cabbage, cauliflower, collards and kohlrabi. Kale benefits from staking in the field.

Harvesting and processing tips: Harvest and processing for Kale should follow steps outlined in the cabbage description.

Lettuce (Asteraceae) *Lactuca sativa*:
Growing Tips: Lettuce is a long season annual crop. The seed matures between 12 and 21 days after flowering. On any given lettuce plant, the flowers do not mature all at once, instead maturing sequentially. The expansion of the pappus from the beak of the seed, called feathering, signals seed cluster maturation. Seed harvest may begin when 30 - 80% of seed clusters display feathering, depending on methods and conditions.

Harvesting and Processing Tips: For commercial seed production lettuce seed is normally harvested all at once, however on a small scale or with ample labor it may also be harvested multiple times in the field.

Good options for lettuce seed harvest:

Multiple harvests. Harvesting repeatedly is typically done by hand. The first harvest occurs when one-third of the seed heads have feathered. Each plant is shaken into a sack or bucket. A second harvest is repeated in 1 to 2 weeks, when significant new feathering is visible. Sometimes, 3rd and 4th harvests can be made, but the seed may be unacceptably poor quality. Multiple hand harvesting can result in more seed yield, and higher seed quality. However, it requires more labor.

Single harvest - mechanical. When approximately 50% of the flowers have feathered, the crop is swathed. After 3 or 4 days, the seed is harvested and threshed with a combine. Harvest should happen in the late morning, so that residual morning moisture can reduce losses due to shattering. The combine will either have pick-up guards on the header and a reel, or a belt pick-up without a reel. Because lettuce seed is small and delicate, the concave needs to be opened, the air needs to be set low, and the cylinder should be slow. Many growers find a 10 - 20% reduction in germination when lettuce is machine-harvested, both because immature seed is harvested and because mechanical threshers can damage the seed.

Single harvest – hand. An improved single harvest method has been developed by Gathering Together Farm in Philomath, Oregon. In their method, the lettuce plants are pulled and windrowed with the plant roots intact. Most of the plant, including the seed head, is placed onto geotextile landscape fabric to catch shattering seed. The plant roots are placed off of the fabric to avoid soil contamination in the gathered seed. The plants are harvested with the roots in order to continue providing energy to the maturing seedplants, which may continue to flower daily and mature seed for up to a week. The geotextile fabric wicks moisture away from the seed plants, but "breaths" and allows incidental rain to pass through, rather than puddle as it will with a tarp. The plants should be left to dry until the leaves are crisp. In the event of a forecast for prolonged precipitation, roots may be removed and plants rolled up into round "bales" that will shed rain for a few days of bad weather.

Melon (Cucurbitaceae) *Cucumis melo:*
Harvest and processing tips: At the point of edibility, you have some options for harvest: a) if getting to eat perfectly ripe melon is more important to you than extracting the maximum number of fully mature seeds, promptly harvest the melon, eat it, and reserve the seeds b) if the fruits are not at risk of damage or disease in the field, and you want more prime melon seed, allow them to remain on the vine until they have softened slightly, but extract seed before they show any signs of serious decay. c) if the fruits are at risk of damage or disease in the field, harvest the fruits right away and store at 65-75F (18-24C) for 7-10 days (until melons are beginning to soften, but are not rotting) before extracting seed.

Good options for processing:

Cut open, scrape out seeds and pulp, rinse or decant

Cut open, scrape out seeds and pulp, soak for 8-12 hours, rinse or decant

Onion (Alliacea) *Allium cepa* and **Leek** (Alliacea) *Allium ampeloprasum*:
Growing Tips: Onions are a biennial crop and require vernalization. They benefit from staking in the field.

Harvesting and Processing Tips: The mature seed of onions is a dull black color, hard and completely dry. A good rule of thumb is when there is a patch of black seed showing at the top of the umbel about a big around as a 50cent coin, it's time to cut the crop. Several different methods are used. The most common method is to cut the umbel leaving about 6 inches of the seed stalk attached and piling the material on paper in the field. Paper is used so that condensation does not form on the ripening seed. Some people have begun to use ground cloth type materials under the crop and then covering the crop with plastic if rain threatens. Smaller sized crops can also be moved into an unused greenhouse or other building as long as it has good airflow. Make sure the piles are no more than 2 feet deep and kept loose and airy to allow good air flow. The later maturing seed will use the moisture from the seed stalks attached to the umbel to continue maturing.

Once all of the seed is mature threshing can begin. Check the seed for full maturity by biting or cutting into the seed from the lower parts of the umbel. The seed should be completely dry. If the endosperm is not fully ripe the inside of the seed will be soft or "doughy". This soft seed is very easily damaged during the threshing process. Usually about 10-14 days in sunny field conditions is enough to get the seed fully mature.

Onion seed needs to be threshed very carefully as the seed coat is very thin. Aggressive threshing with a combine often leads to microscopic cracks in the seed coat that greatly diminish storability. Combines are often equipped with rubber beater bars to minimize the damage.

Because onion seed shatters very easily, small amounts of seed can be extracted by beating the umbels on the inside of a plastic trash can. A great deal of seed generally shatters on the paper or other drying surface. This seed can be carefully swept up and cleaned with the rest of the seed.

A good, quick way to check onion seed for initial quality or to clean small parts of dry matter is to add the seed to a bucket of water. Good seed will sink. Poor seed and small plant material will float and can be poured off. Wet seed should be quickly laid out in a thin layer to dry with good air circulation.

Pepper (Solanaceae) *Capsicum spp*.:
Harvest and processing tips: Peppers are ready for seed harvest when their color development is complete and uniform. Most pepper varieties are completely red when they are ready for seed harvest, but others are yellow, green, orange, purple, or brown. Peppers are particularly susceptible to disease, and can be moldy in the core even when the outside of the pepper looks healthy. To address this, monitor for decay as your peppers are reaching complete color development by cutting some open. The cores should have no mold and the seeds should be ivory, yellowish, or orangish; brown or very dark seeds are diseased. If the peppers you cut open are showing signs of decay, you may need to harvest them early and continue their ripening in a protected location at about 65-75F (18-24C). For maximum seed quality, store peppers that have reached complete color development at about 65-75 (18-24C) for 7-10 days before extracting the seed. Cut this after-harvest ripening time short- or eliminate it completely- if your peppers show any sign of decay.

Good options for processing:

- Blend fruits with water in a food processor (use a thick plastic blade, or wrap tape around metal blades to avoid damaging seeds), rinse or decant.
- Remove cores from peppers, scrape seeds off of cores with a knife, rinse or decant.
- Remove cores from peppers, soak cores 8-12 hours, rub seeds off with gloved hand, rinse or decant.
- Break open fruits, rinse.
- For thin-fleshed peppers: dry peppers, then use dry seeded processing procedures.

Radish (Brassicaceae) *Raphanus sativus*
Growing Tips: Radishes can be annuals or biennials depending on the variety. Radishes are cool season crops that, in order to produce superior roots, are best grown at temperatures that rarely exceed 80F (26C). During seed set and maturation, radish seed crops can tolerate slightly higher temperatures. As with other root crops, radishes can only be properly maintained for trueness to type when grown using the "root-to-seed" method, which allows for selection of the roots before seed production begins. Radishes are first planted closely, harvested to evaluate superior roots upon maturity and then re-planted with wider spacing to prepare for seed production. You may also choose the "seed-to-seed" method where you plant the radish seeds and wait until seed maturation without evaluating the root qualities. Unless you do not have any other choice, this method is not reliable to produce viable seed except when the seed stock used was proven to be genetically uniform.

Harvest and processing tips: Radish seed crops mature in approximately 150 days depending on variety, climate and planting date. Radish seed is ready to harvest when about 60 to 70% of the seed pods turn from a green-yellow to brown and lose their fleshy appearance, becoming papery thin and light.

For small plots, hand harvest entire seed stalks with pruning shears or clippers. One grower utilizes a chain saw to cut large stands in the field. Windrow and dry in field, on a tarp if possible. If further drying is necessary, place pods on wire mesh tables to allow air circulation. Pods should be brittle when sufficiently dried. Dry for 10 – 14 days depending on weather conditions and relative humidity.

There are several methods for processing radish seed on a small scale (less than 50 lbs).

1. Place pods in sturdy bag and stomp until seeds break loose from pods.
2. Place seeds on a tarp and walk on them with soft-soled shoes.
3. Hand method: break pods by hand (with gloves!) to keep seed clean and allow for sorting as you clean.

Remove seed from crushed pods by hand screen, gravity table, box fan, or mechanized screen cleaner. If using hand screens, a 9/64 in. round hole will allow seeds to pass through and chaff to remain on top of the screen. A 5/64 in. hole can then be used to remove small debris and chaff and allow the seed to stay on top. Winnowing with a box fan can be used to further clean seed.

For processing on a large scale (50 lb or more), a small combine can be used as a thresher by hand feeding the entire seed stalk through. Feed the thickest part of the stalk first to prevent over-feeding of the thresher. Make sure the distance between the rollers is at least 1 ½ times the thickness of the largest seeds. The cylinder speed of the combine should be less than 700 rpm to avoid crushing the seed. Repeat cleaning section as detailed above.

Spinach (Chenopodiaceae) *Spinacia oleracea*
Growing tips: Spinach is a cool weather annual. It must be planted in early spring (by April in the Pacific Northwest) inorder to grow large enough before bolting to produce a good seed set. Spinach flowering is triggered by increasing day length. Spinach seed requires a unique climate limited to cool, wet springs followed by cool summers (temps not exceeding 75F (24C) and relatively dry fall weather for harvesting. Especially during pollination and early seed development, temperatures that exceed 75F (24C) can dramatically lower germination rates, seed size and yield.

Harvest and processing tips: Spinach seed is ready for harvest when 60 to 70% of the seed is is a brownish color. However, some varieties differ and plant diseases can allow the same overall appearance. To assure maturity, the seed must be opened and inspected for its color. If the inside of the seed transforms from translucent or milky at the beginning of maturity to grayish or flinty in the middle to a final and mature starchy and whitish color. The plant is mature when the majority of the interiors of these seeds are a starchy white color.

To harvest spinach seed cut the plants near the base of the stems to stack into windrows. This should be done preferably during a warm, dry period. The windrowed stalks will be ready to thresh in 4-10 days, depending on the weather. Rotating stalks in the windrows facilitates uniform drying of the seed. Once plants are dry they may be threshed by stripping stalks first by hand and discarding stems. Seed clusters and leaves must then be threshed to break apart seed clusters. Threshing may be done by placing seed clusters in Rubbermaid buckets at least 1 ft thick and stomping by foot with a twisting motion. Once broken down the extra chaff and dust may easily be removed by winnowing with a fan. The threshing and winnowing process may need to be repeated several times. Seed may also be further cleaned with screens. A 9 or 10 size screen may be used to scalp off larger materials and a size 6 screen used to retain seed and remove smaller debris.

Squash, Summer (Cucurbitaceae) *Cucurbita pepo***:**
Harvest and processing tips: The seeds of summer squash are still very immature when the fruit is edible. Leave edible summer squash on the vine for around 6 weeks. Wait for fruits to become very large and hard (you should not be able to dent the flesh with your thumbnail) and for the stem at the point of attachment to the fruit to dry up. Once the squash reaches this stage, you have options for harvest: a) if the fruits are not at risk for disease or damage, allow the squash to remain on the vine until right before the first hard frost. b) if the fruits are at risk for disease or damage, harvest the fruits right away and store at 65-75F (18-24C) for a few weeks before extracting seed.

Good options for processing:
- Cut open, scrape out seeds and pulp, rinse or decant
- Cut open, scrape out seeds and pulp, soak for 8-12 hours, rinse or decant

Squash, Winter (Cucurbitaceae) *Cucurbita pepo***:**
Harvest and processing tips: At the point of edibility, you have some options for harvest: a) if the fruits are not at risk for disease or damage, allow the squash to remain on the vine until right before the first hard frost. b) if the fruits are at risk for disease or damage, harvest the fruits right away and store at 65-75F (18-24C) for a few weeks. In either case, note that squash seed left in the fruit reaches its highest level of quality after two months in cool storage, then quality declines. So, once you have brought your squash in from the field, or after it has sat for a few weeks at 65-75 (18-24C), store the squash at 50-55F (10-13C) for two months, then extract the seed. If maximum quality isn't necessary, simply extract squash seeds as you eat your stored squash through the winter.

Good options for processing:
- Cut open, scrape out seeds and pulp, rinse or decant
- Cut open, scrape out seeds and pulp, soak for 8-12 hours, rinse or decant

Tomato (Solanaceae) *Solanum lycopersicum*:
Harvest and processing tips: At the point of edibility, you have some options for harvest: a) promptly harvest the tomatoes, extract the seeds, and eat the flesh. Use this option if getting to eat perfectly ripe tomatoes is more important to you than extracting the maximum number of fully mature seeds. b) If you want more prime tomato seed, harvest the fruits when they are starting to soften, but before they show signs of serious decay.

Good options for processing:
- Squeeze/scrape out seeds, ferment.
- Crush whole tomatoes, ferment.

Watermelon (Cucurbitaceae) *Citrullus lanatus:*

Harvest and processing tips: At the point of edibility, you have some options for harvest: a) if getting to eat perfectly ripe watermelon is more important to you than extracting the maximum number of fully mature seeds, promptly harvest the watermelon, eat it, and reserve the seeds b) if the fruits are not at risk of damage or disease in the field, and you want more prime watermelon seed, allow them to remain on the vine until they have softened slightly, but extract seed before they show any signs of serious decay. c) if the fruits are at risk of damage or disease in the field, harvest the fruits right away and store at 65-75 (18-24C) for 7-10 days (until they are beginning to soften but are not rotting) before extracting seed.

Good options for processing:

Eat watermelon, spit out seeds, rinse.

Remove seeds and flesh from rind, rinse or decant

Remove seeds and flesh from rind, soak for 8-12 hours, rinse or decant

Crop Specific Chart:
Know the information to manage pollination, isolation and population sizes

Common Name	Scientific Name	Pollination	Life Cycle	*Inbreeder/ Outbreeder	Minimum isolation distance for home use	Minimum isolation distance for commercial production	Minimum Population Size for Genetic Maintenance	Comments
Arugula	*Eruca sativa*	insects	A	VO	1600 ft	1 mi	80	
Basil	*Ocimum basilicum*	insects	A	VO	1600 ft	1 mi	80	
Bean, Common	*Phaseolus vulgaris*	self	A	PI	10 ft	20 ft	10 - 20	
Bean, Fava	*Vicia faba*	self, insects	A	BIO	800 ft	0.3 - 0.6 mi	40	Includes bell beans
Bean, Lima	*Phaseolus lunatus*	self, insects	A	PI	40 ft	160 - 320 ft	40	
Bean, Runner	*Phaseolus coccineus*	self, insects	A	BIO	800 ft	0.3 - 0.6 mi	40	
Bean, Cowpea	*Vigna unguiculata*	self, insects	A	BIO	160 ft	320 - 640 ft	40	Crosses w asparagus bean
Beet	*Beta vulgaris*	wind	B	VO	3200 ft	1 - 3 mi	80	Crosses w/ chard & sugarbeets
Broccoli	*Brassica oleracea*	insects	A or B	VO	1600 ft	1 - 2 mi	80	Crosses w/ all *B. oleracea* crops
Brussels Sprouts	*Brassica oleracea*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ all *B. oleracea* crops
Cabbage	*Brassica oleracea*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ all *B. oleracea* crops
Carrot	*Daucus carota*	insects	B	PO	1600 ft	1 - 2 mi	200	Crosses w/ Queen Anne's Lace
Cauliflower	*Brassica oleracea*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ all *B. oleracea* crops
Celery	*Apium graveolens*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ celeriac
Celeriac	*Apium graveolens*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ celery
Chard, Swiss	*Beta vulgaris*	wind	B	VO	1600 ft	1 - 3 mi	80	Crosses w/ beets & sugarbeets
Chicory, Witloof	*Cichorium intybus*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ wild chicory, radicchio, and Italian dandelion
Cilantro	*Coriandrum sativum*	insects	A	PO	1600 ft	1 - 2 mi	80	
Collards	*Brassica oleracea*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ all *B. oleracea* crops
Corn	*Zea mays*	wind	A	PO	1600 ft	1 - 2 mi	200	
Cucumber	*Cucumis sativus*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	Armenian cucumber is *C. melo*
Dill	*Anethum graveolens*	insects	A	PO	1600 ft	1 - 2 mi	80	
Eggplant	*Solanum melongena*	insects	A	PO	1600 ft	1 - 2 mi	80	

Common Name	Scientific Name	Pollination	Life Cycle	*Inbreeder/ Outbreeder	Minimum isolation distance for home use	Minimum isolation distance for commercial production	Minimum Population Size for Genetic Maintenance	Comments
Endive	*Cichorium endivia*	self	B	VI	10 ft	20 ft	10 - 20	
Escarole	*Cichorium endivia*	self	B	VI	10 ft	20 ft	10 - 20	
Kale, European	*Brassica oleracea*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/all *B. oleracea* crops
Kale, Siberian	*Brassica napus*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ rutabaga and canola
Leek	*Allium ampeloprasum*	insects	B	PO	1600 ft	1 - 2 mi	80	
Lettuce	*Lactuca sativa*	self	A	VI	10 ft	20 ft	10 - 20	Crosses w/ wild lettuce
Melon	*Cucumis melo*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	Crosses w/ Armenian cucumber
Mustard greens	*Brassica juncea*	insects	A or B	VO	1600 ft	1 - 2 mi	80	
Okra	*Abelmoschus esculentum*	self, insects	A	BIO	800	0.3 - 0.6 mi	40	
Onion	*Allium cepa*	insects	B	PO	1600 ft	1 - 2 mi	200	
Parsley	*Petroselinium crispum*	insects	B	PO	1600 ft	1 - 2 mi	80	
Parsnip	*Pastinaca sativa*	insects	B	PO	1600 ft	1 - 2 mi	80	
Pea	*Pisum sativum*	self	A	VI	10 ft	20 ft	10 - 20	
Pepper, Hot	*Capsicum spp.*	self, insects	A	BIO	800 ft	0.3 - 0.6 mi	40	Must isolate equally from hot and sweet peppers
Pepper, Sweet	*Capsicum annuum*	self, insects	A	PI	160 ft	320 - 640 ft	10 - 20	Must isolate from hot peppers using hot pepper isolation distances
Pumpkin, Halloween	*Cucurbita pepo*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	Most Jack O'lantern vars are *C. pepo* and will cross w/ *C. pepo* squash
Pumpkin, Other	*Cucurbita spp.*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	Learn the species of each variety
Radicchio	*Cichorium intybus*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ wild chicory, radicchio, and Italian dandelion

Common Name	Scientific Name	Pollination	Life Cycle	*Inbreeder/ Outbreeder	Minimum isolation distance for home use	Minimum isolation distance for commercial production	Minimum Population Size for Genetic Maintenance	Comments
Radish	*Raphanus sativus*	insects	A	VO	1600 ft	1 - 2 mi	80	May cross w/ wild radish
Rutabaga	*Brassica napus*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ Siberian kale and canola
Spinach	*Spinacea oleracea*	wind	A	VO	3200 ft	1 - 3 mi	80	
Squash, Summer	*Cucurbita pepo*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	
Squash, Winter	*Cucurbita pepo*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	
Squash, Winter	*Cucurbita maxima*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	
Squash, Winter	*Cucurbita moschata*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	
Squash, Winter	*Cucurbita argyrosperma*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	Formerly *Cucurbita mixta*
Tomato, modern	*Solanum lycopersicum*	self	A	VI	10 ft	20 ft	10 - 20	If multiple tomato types are present use the greatest isolation distance
Tomato, Potato Leaf or Heirloom	*Solanum lycopersicum*	self, insects	A	PI	40 ft	160 - 320 ft	10 - 20	If multiple tomato types are present use the greatest isolation distance
Tomato, Currant	*Solanum pimpinelifolium*	self, insects	A	BIO	160 ft	320 - 640 ft	40	If multiple tomato types are present use the greatest isolation distance
Turnip	*Brassica rapa*	insects	B	VO	1600 ft	1 - 2 mi	80	Crosses w/ many Asian greens
Watermelon	*Citrullus lanatus*	insects	A	PO	1600 ft	1 - 2 mi	10 - 20	

** very inbreeding (VI), primarily inbreeding (PI), very outbreeding (VO)*
both inbreeding and outbreeding (BIO), primarily outbreeding (PO)

Resources:

Books

Basic Seed Saving. McDorman, Bill. 1994. International Seed Saving Institute.

The Biology of Seeds: Recent Research Advances. G. Nicola, K.J. Bradford, D. Come, M. Curie, and H. Protchard. 2003. CABI Publishers, Cambridge, MA.

Breed Your Own Vegetable Varieties: The Gardener's and Farmer's Guide to Plant Breeding and Seed Saving. Deppe, Carol. 2000. Chelsea Green Publishing, Vermont.

Collecting, processing and germinating seeds of wildland plants. 1986. J.A. Young and C.G. Young. Timber Press. Portland, Oregon.

Flower Seeds: Biology and Technology. M.B. McDonald and F.Y. Kwon. 2004. CABI Publishers, Cambridge, MA.

From Seed to Bloom. Powell, Eileen.1995. Storey Books.

Garden Seed Inventory: An Inventory of Seed Catalogs Listing All Non-Hybrid Vegetable Seeds Available in the United States and Canada. Whealy, Kent. 2000. Seed Saver Publications.

Heirloom Vegetable Gardening: A Master Gardener's Guide to Planting, Seed Saving and Cultural History. Weaver, William Woys. 1999. Henry Holt and Co. Inc.

Hybrid Seed Production in Vegetables: Rationale and Methods in Selected Crops. A.S. Basra. 2000. Food Products Press, New York, NY.

Principles of Seed Science and Technology. L.V. Copeland. 1976. Burgess Publishing Company, Minneapolis, MN.

Seeds: Ecology, Biogeography and Evolation of Dormancy and Germination. Baskin, Carol C and Jerry M. Baskin. 1998. Academic Press.

Saving Seeds: The Gardener's Guide to Growing and Storing Vegetable and Flower Seeds. Roger, Marc. 1990. Storey Books, Vermont.

Seed Production Principles and Practices. M.B. McDonald and L.O. Copeland. 1997. Chapman and Hall, New York, NY.

Seeds Handbook: Biology, Production, Processing, and Storage. B.B. Desai, P.M. Kotecha, and D.K. Salunkhe. 1997. Marcel Dekker, Incorporated, New York, NY.

Seed Sowing and Saving: Step-By-Step Techniques for Collecting and Growing More Than 100 Vegetables, Flowers and Herbs. Turner, Carole B. 1998. Storey Books, Vermont.

Seed to Seed. S. Ashworth. 1991. Seed Savers Publications, Decorah, IA.

Vegetable and Flower Seed Production. L.R. Hawthorn and L.H. Pollard. 1954. Blackiston Co., New York, NY. Out of print.

Vegetable Seed Production. R.A.T. George. 1999. CABI Publishing, New York, NY.

Web

ATTRA

Seed Production and Variety Development for Organic Systems, 2005. K.L. Adam. ATTRA. http://attra.ncat.org/attra-pub/PDF/seed_variety.pdf

Ohio State University, Guidelines for Hot Water Treatment
Miller, S. A. and Lewis Ivey, M. L. Hot water and chlorine treatment of vegetable seed for eradication of bacterial pathogens. Sourced at: http://ohioline.osu.edu/hyg-fact/3000/3085.html (accessed February, 1, 2010).

Organic Seed Alliance
OSA has free downloads of crop specific seed production manuals, other seed related publications, organic seed advocacy information and news. www.seedalliance.org

Organic Seed Resource Guide
eXtension.org http://www.extension.org/article/18340

Saving Our Seed
SOS offers several publications on seed saving available for download online.
http://www.savingourseed.org/pages/ResourceGuide.html

WSU
Plans to make a homemade thresher from a chipper mulcher.
http://sustainableseedsystems.wsu.edu/nicheMarket/smallScaleThreshing.html

Sources for Seed Cleaning Equipment

Welborn Devices, Laurel, MS
Bean and Pea thresher
http://www.rotofingers.com/id19.htm

Hoffman Manufacturing, Albany, Oregon
Seed Cleaning Screens, equipment, and lab growth and germination equipment
http://www.hoffmanmfg.com/

Oliver Manufacturing, Rocky Ford, Colorado
Gravity Tables
http://www.olivermfgco.com/

Seed Saving Organizations

Seed Savers Exchange
3076 North Winn Road
Decorah, IA 52101
Phone 563.382.5990 fax 563.382.5872
www.seedsavers.org

Saving Our Seed Project
286 Dixie Hollow
Louisa, VA 23093
Ph. 540.894.8865 Fax 540.894.8060
www.savingourseed.org

Seed Savers Network
PO Box 975
Byron Bay, NSW 2481
Australia
Ph. +61 02 6685 6624 Fax +61 02 6685 7560
www.seedsavers.net
info@seedsavers.net

The Flower and Herb Exchange
3076 North Winn Road
Decorah, IA 52101
www.seedsavers.org

Native Seeds/SEARCH
526 N.4th Ave.
Tucson, AZ 85705
www.nativeseeds.org

Seeds of Diversity Canada
PO Box 36
Station Q, Toronto, ON M4T2L7
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Educational Materials

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