Organic Seed Alliance
Supporting the ethical development and stewardship of seed
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Weather-Related Risk Reduction Guidelines for Dry-Seeded Specialty Seed Crops

Preventing loss from adverse weather during seed maturation and harvest

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Introduction

The coastal valleys of the Pacific Northwest, from the Siskiyou Valley of Oregon to the Skagit Valley of Washington, are some of the world's premier locations for growing high value, specialty seed crops of vegetables and flowers. Aside from the good soils and favorable latitude (42-48° N), the typical dry period from July through mid-September is an essential feature to the success of dry-seeded crops that are grown in this region (dry-seeded crops are harvested as dry fruit as opposed to wet-seeded crops, such as cucurbits and tomatoes, whose seed are harvested from fleshy fruits). In years when the harvest period is interrupted by punctuated or persistent rain, the growers of dry-seeded seed crops are in a position to lose all or a large percentage of their harvest, especially if wet and windy weather occurs just before peak ripeness or in the midst of the harvest process. The presence of inclement weather during maturation and harvest may adversely affect all dry-seeded seed crops. However, seed crops of some botanical families are especially vulnerable if they lack a pod, shell, or fruit to protect the seed from repeated wetting and infection by wind-borne pathogens. The parsley-carrot family (Apiaceae), spinach-beet family (Chenopodiaceae), and the lettuce-sunflower family (Asteraceae) are all particularly vulnerable in this way. Adverse weather-related impacts may include increased incidence of disease on seed and plants, sprouting of seed both pre- and post-harvest, decreased germination rates and decreased longevity of harvested seed. In addition, wet weather may result in harvest difficulties due to plant lodging and inability to drive in wet fields or properly operate harvest equipment. By following preventative measures and preparing for inclement weather, growers can significantly reduce risks and prevent financial losses. The scope of this publication covers wet-weather-related harvesting issues and recommendations for dry-seeded crops in the Pacific Northwest.

Weather-Related Risks During Seed Maturation and Harvest

Seedborne and Other Plant Diseases

In the Pacific Northwest, cool temperatures, high humidity, and wet conditions present during rainy periods promote the growth of several bacterial and fungal pathogens of seed and other plant tissues. Rainy conditions can also exacerbate the spread of diseases via splashing or wind dispersal of spores. Pathogens can cause significant damage and loss of quality to seed crops by either infesting or infecting harvested seeds or adversely affecting plant growth.

- **Infected seed** results when bacterial or fungal pathogens grow into the seed tissue and feed on the developing seed. Infection with fungal pathogens in particular may damage the seed by: 1) interrupting seed maturation as the pathogen feeds on the developing embryo; 2) physically damaging the seed surface, endosperm, or embryo; and 3) consuming seed reserves. Effects of pathogen infection may include reduced yields, decreased seed vigor, and decreased germination rates and longevity in storage as fungal pathogens continue to feed on the seed post-harvest.

- **Infested seed** has pathogens either present on the surface of the seed or mixed with harvested seed. Pathogens on or in seed may serve as seedborne inoculum, spreading diseases to the following crops. As some seedborne diseases are difficult to control and can cause significant crop losses, production of clean, disease-free seed is a quality criterion demanded by much of the seed industry.

Diseases of seed crops vary by region and are too numerous to cover exhaustively in this publication. It is advised that growers become familiar with the primary plant and seedborne diseases associated with each seed crop in their area in order to follow preventative measures and prepare for identifying and managing affected crops. Wet weather during spinach seed harvest in Washington State is associated with increased incidence of several seedborne fungal diseases including, *Stemphylium botryosum*, *Cladosporium variable*, and *Alternaria* spp. Chard and beet seed crops are commonly harvested late-season in the Northwest due to lengthy days required for seed to mature. These crops often experience high levels of downy mildew caused by *Peronospora farinosa*, which thrives in wet, cold conditions often present during fall harvests. In wet weather, seed crops in the Brassica family, including broccoli, kale, and cauliflower, are subject to higher risk of infection with *Alternaria brassicae* and *A. brassicicola*, as well as downy mildew caused by *P. parasitica*. Under these conditions, carrot seed crops often experience a higher

incidence of bacterial blight caused by *Xanthomonas campestris* pv. *carotae,* another seedborne disease.

Premature Germination/Seed Sprouting

Premature germination (from the initial stages of the embryo imbibing water through to sprouting) is a key concern when there is persistent rain on plants carrying mature seed. Seeds may begin to imbibe water and even fully sprout while still on the plant (referred to as vivipary) or after harvest from the mother plant. This prematurely germinated seed has reduced viability and is usually a complete loss. Seeds of many species have evolved hormonal and physical barriers to prevent premature germination. Most species naturally develop a state of short-term dormancy to prevent germination prior to or shortly after seed maturation. In many species this dormancy develops as the seed dries on the mother plant. There is also a plant hormone (abscisic acid or ABA) which is thought to prevent germination prior to the development of dormancy. Current scientific understanding of the complexity of biochemical and physiological factors related to germination inhibition and seed dormancy is limited. However, it is known that the relative levels of ABA, and the physiological and environmental triggers affecting seed dormancy differ by crop species and variety, resulting in varied tendencies toward pre-harvest sprouting. Familiarity with the relative levels of dormancy of the species or variety being grown for seed can help growers prioritize preventative measures for high risk crops.

Lodging

Wet and windy conditions often increase the tendency of seed crops to fall over in the field (lodge) or for branches of the plant to drop or break. This may result in loss of seed from shattering, and increased moisture and disease incidence due to plants lying on the wet ground. Lodged plants may be more difficult to combine at harvest due to slower drying and greater difficulty picking up seed heads. The tendency to lodge and break varies by crop and variety. In some crops such as carrots, branches of the plant tend to break off, while in others such as brassicas or onions, the entire plant may fall over. In some cases seed stalks are trellised or staked in order to prevent lodging. This practice also significantly aids in disease prevention by increasing air circulation in the field. The importance of air circulation in preventing disease should be reinforced. In Denmark, brassica seed production is focused on islands with high winds to minimize disease pressure. By orienting rows toward the prevailing winds, and staking and trellising the brassica seed crops, the incidence and severity of infection by *Alternaria brassicae* and *A. brassicicola* are significantly reduced (Neergaard, 1977). Seed growers should consider the benefits of air circulation in planning and cultivating their crops.

Harvest difficulties

Seed harvesting may be difficult or delayed in wet weather conditions due to an inability to drive harvesting equipment into muddy fields. Longer drying and curing times of plant and seed materials in wet fields also delay harvest.

Mitigating Risk

Proactive Planning

Following preventative measures can help avoid or significantly reduce the impact of weather-related seed losses. In the Pacific Northwest, chances of rain and inclement weather are highest during the spring, fall and winter months, with chances increasing late in the season. The date of onset of fall rains varies somewhat by region, but tends to begin in September. In all regions, crop and variety choice and timing of establishment should be planned to avoid seed ripening during periods of highest threat of inclement weather. However, in some years inclement weather may occur during months that historically have tended to be dry. In 2004, the Willamette Valley of Oregon received consistent rain throughout July. This resulted in significant seed losses by growers harvesting crops during that month, a month that historically receives less than 1 inch of precipitation. In addition, even with the best planning crops may sometimes ripen during the high risk months due to delayed maturities, physiological barriers to early-season maturity, or the timing of crop rotations within a farming operation. Growers should be prepared to deal with harvesting and handling needs, and have a field management protocol established under such circumstances. The following tools are useful proactive planning measures to consider.

Choice of crops and varieties:

Maturity dates of seed crops vary by crop species, variety and timing of planting. Knowing the estimated days to seed maturity is crucial in order to time plantings in a manner that reduces risk of maturation during inclement weather. Days to maturity differ widely among annual, biennial, and perennial species.

Overwintering biennial crops such as beets and carrots may require more than a year to mature, while some annuals such as lettuce and some brassicas may complete seed maturation in less than 100 days. Days to maturity may be particularly variable if the species is day-length sensitive, requires vernalization or the variety is bolting sensitive or resistant. For example, a bolt-sensitive, cold-weather lettuce will mature much more quickly than a variety bred for hot weather production. Various crop classes may also vary widely in days to maturity. For example, bush beans may mature in as short as 75 days while the majority of pole beans require upwards of 150 days.

Crop species and varieties also vary widely in the following factors:

- ***Plant physiology*** - Levels of pre- and post-harvest dormancy and rates of maturation affect a variety's tolerance of wet weather conditions.
- ***Plant architecture*** - The shape, structure and growth habit of a variety affects its behavior under wet weather conditions. In general, varieties with sturdy, upright growth and an open canopy will dry more quickly and be more conducive to threshing or combining than one that tends to lodge or has dense foliage that retains moisture. Tall or leggy varieties tend to fall over, retaining moisture and reducing air circulation. Furthermore, species with seed-pods, such as beans and brassicas, may vary in the tendency of the pods to wrap tightly around the seeds when they are wet which results in greater difficulty in threshing and cleaning.
- ***Disease susceptibility*** - Varieties that are susceptible to diseases which flourish in wet, cool conditions may be more affected by rainy periods than disease resistant varieties.

Knowing the behavior of the particular cultivar grown, and managing the crop and timing of planting accordingly is critical in minimizing weather-related risks. When producing seed under contract, the seed company should supply the estimated days to maturity and a detailed variety description, including diseases to which the specific cultivar is susceptible or resistant. Keep in mind that maturity rates and plant behavior may vary under different environmental conditions. It is also useful to check with local extension agents and experienced seed growers in the region to compare notes on varietal performance conditions. Additionally, trialing a new crop or variety prior to investing in field-scale seed production is an excellent way to minimize risks by gaining familiarity with the development and characteristics of that cultivar.

Timing of planting

Seed crops require adequate growing days and the right environmental conditions to complete maturity and reach ideal quality parameters. Ideally, the timing of final maturity should occur during dry weather. Cold sensitive, quick growing annual seed crops (including lettuce and beans) are usually spring planted and harvested in summer or fall. Cold tolerant annuals (including spinach; brassica greens such as arugula, tatsoi, and mustards; peas; and fava beans) can be fall planted and overwintered. This generally results in an earlier establishment and earlier maturity than achieved from spring plantings. However, in many cases fall-seeded annual seed crops may have more severe fungal diseases problems such as downy mildew, Cladosporium leaf spot, and anthracnose in the spring due to the larger crop canopy present while spring conditions are still cool and moist. In some cases, annual crops (particularly those requiring a long season) such as cauliflower, are started early in greenhouses to achieve earlier maturation. Biennial crops requiring vernalization, including onions, carrots, chard and beets, are either fall planted and overwintered as roots, or summer grown and the roots lifted, stored overwinter and replanted in the spring. Overwintering biennial crops in the ground rather than spring planting bulbs and roots results in earlier plant establishment, earlier harvests and reduced risk of harvest during wet weather. Perennial seed crops such as many herbs and some flowers are subject to their natural maturity cycle which varies by species, variety and location.

Infrastructure

Access to appropriate equipment and adequate space is critical when managing a seed harvest during wet weather. Mature seed must be protected from prolonged periods of wetness and be adequately dried. Inadequate drying can lead to difficulties in cleaning, can reduce seed quality, and lead to loss of seed due to shattering. When weather does not allow for finishing and drying naturally in the field (either standing or cut and windrowed) there are several options, all of which require some consideration of infrastructure. (See Fig. 1) A farmer can cover the seed in the field to dry; bring the windrowed plants into sheltered areas for drying; and/or augment drying through the use of plant dryers.

Space, equipment, and materials for drying should be prepared prior to the onset of rains (see additional information in Drying Procedures section).

Fig. 1 - Barns or greenhouses are good seed-drying areas for protection during wet weather.

Cultural practices

Establishing and managing seed crops in a manner that facilitates air circulation in the field and avoids moisture on plant leaves and seeds can help minimize problems associated with wet weather conditions. Use of drip or furrow irrigation avoids moisture on plant foliage, preventing development of plant and seed diseases. Use of overhead irrigation may lead to earlier disease establishment on wet plant material. The establishment of wide plant spacing, orienting rows toward the prevailing wind direction, and staking and trellising plants are all practices that increase air circulation in the field and can significantly reduce disease pressure. These practices also provide the added benefit of facilitating drying of plant material in the event of wet weather conditions. These cultural practices are particularly critical tools for organic seed growers who are limited in availability of disease control measures.

Responsive Measures

Evaluating, strategizing, and prioritizing relative risks are crucial steps that can reduce loss when it is apparent that adverse weather will occur during maturation/harvest season. This is especially true when multiple seed crops are in the field at harvest time. Recommended actions depend on the intensity and duration of the adverse weather event and tolerance of the crop.

Evaluating Risk and Prioritizing Actions:

When managing the harvest of multiple crops, the following classification of crop status may aid in prioritizing efforts:

- ⇒ Those that will survive without your efforts
- ⇒ Those that will not survive regardless of efforts
- ⇒ Those that will survive if you make an effort

Generally, the closer the seed is to full maturity the greater the risk from wind and rain. Therefore, the most mature crops may require prioritized attention under intense and persistent adverse conditions. Any crop less than two-thirds ripe is usually best left standing in the field until adverse conditions lift, to avoid reduced seed quality due to harvesting premature seed. If there is no change in weather (i.e. the rainy season west of the Cascade Mountains is fully in swing) then premature harvest may be the only option but will, in all likelihood, result in a significant drop in seed quality.

Response options:

1. ***Do nothing.*** If predictions are for light rain of short duration, the best option may be to let it pass, especially if the crop is on the immature side. The more mature the seed crop, the more loss a short duration of rain will induce through shattering, pathogen infection, and lodging. The more mature the crop, the more important it becomes to do something in anticipation of rain.

2. ***Harvest whole plants (early if necessary), and cure the crop in windrows on tarps, paper, or fabric under cover at a moderate temperature.*** If a very valuable variety is at risk and ready to harvest during adverse weather, the best option is to harvest the crop, haul it to cover and dry it in an enclosed shelter using drying boxes and/or fans. However, this approach is limited in profitability, space, and time and may not be feasible for large-scale production. This is only possible where there is enough covered area to protect the crop, while allowing air circulation for drying. Though the most expensive option (in consideration of labor and the cost of covered area), this is the best practice for insuring the safety and quality of a valuable seed crop in the face of a prolonged wet period. If the seed is not mature and plants are harvested early because the adverse weather is not expected to pass be aware that some crops will continue ripening after harvest, but some crops, such as carrots, may have significantly reduced quality in terms of germination and vigor.

3. ***Harvest only the seed heads (slightly early if absolutely necessary) and treat as above.*** This greatly reduces the size of the covered area

needed for the curing process but will reduce the amount of post-harvest seed ripening that can be expected. This is also an option when a crop has been caught in the rain, dry weather is not forthcoming, and threshing is not possible due to water in the seed-head. Rain-soaked seed heads should be dried by blowing cool air, and repeated turning of the seed heads. Handle seed heads carefully to minimize seed shattering until heads are dry, since a lot of fallen seed will tend to cake, delaying the drying process. This is a labor intensive option, but worthwhile for valuable seed crops at risk. It is important to be aware that harvesting some crops when seed is immature may result in significantly reduced seed quality in terms of germination and vigor.

4. ***When crop size precludes the possibility of bringing in the harvest, and rain is expected to last several days to a week (or more), the best option may be to windrow and cover the crop in the field.*** This process presents several challenges of its own, especially since strong wind gusts frequently accompany late summer rains, and heavy rains may be interspersed by intense sunny periods. In such circumstances, plastic sheeting should be avoided for multiple reasons: It tends to catch wind, tear and blow away; it can heat up and "solar cook" the crop between showers; and moisture will condense beneath plastic sheeting, so that each heating and cooling cycle will wet the crop, promoting disease development. For these reasons, breathable "geotextile" landscaping fabric (see the Equipment section) is a more suitable material for protecting windrowed seed crops in these unfavorable conditions.

Drying Procedures

Seed and plant material may be dried either in the field, in a covered area such as greenhouses or barns, and/or with the assistance of forced air dryers. If the crop is small enough to harvest and transport from the field, mature seed stalks or heads may be cut and brought into the sheltered space. Availability of drying space may require planning and prioritization if multiple seed crops require handling at once. If the crop is large and must be mechanically harvested in the field, the harvested seed should also be laid out and covered/protected in the fields. Some crops, such as carrots, are easier to combine standing, while others such as most brassicas and beans are often windrowed and dried prior to processing with a combine. If the crop is subject to inclement weather, the best measure may be to have harvesting equipment ready and closely monitor crop moisture and weather conditions in order to harvest as soon as weather permits. Windrows in the field may also be protected by covering with geotextile fabric.

Guidelines for Drying Seed Under Cover:

Elevate seed from the ground. Drying racks or tables with a surface made of screen, grated material such as galvanized hardware cloth, or wooden slats are often used to raise seed material off of the ground and increase air circulation.

Spread seed out and stir often. Seed and plant material should not be stacked more than 3 feet thick and should be turned or rotated frequently in order to ensure even drying throughout the material. As seed dries it should be stirred carefully to minimize shatter.

Use fans to increase air circulation. Blowing cool air on damp seed heads greatly facilitates drying. Warm air (from heaters) is sometimes used to decrease humidity, but drying too quickly with heat may damage seed and can result in seed shattering. Temperatures above 90^{o} F may damage seed.

Fig. 2 - Fans force air up through the floor of this homemade seed drying bin.

Catch shattering seed. Capture shattered seed by placing a fine screen or cloth under the drying plant

material. Fallen seed requires immediate drying as it is more vulnerable to premature sprouting than seed on seed heads.

Guidelines for Drying Seed in the Field:

Cut and windrow mature seed stalks. Cutting and windrowing plants in the field begins the drying process but care should be given to protect windrows from rain in the case of continuous wet weather. Windrow plants by cutting stalks and laying plants onto cloth laid on the stubble of the cut stems to elevate the cut plants off the ground, or directly on the ground. Windrowing plants onto a cloth will catch dropped seed, but plastic materials or tarps may also collect puddles in the rain and should be avoided in wet weather. Breathable material such as Remay or geotextile fabric (see Drying Equipment) that allows water to pass through is preferable. If plant material is very wet rotate the windrowed material to facilitate even drying. (Note: Some crops shatter more readily than others. When this occurs and seed drops onto the fabric, the seed should be collected and brought under cover to dry as soon as possible to avoid sprouting.)

Fig. 3 - Covering windrows with geotextile fabric for wet weather protection.

Cover windrows. Covering windrows with geotextile fabric will help shed water and protect the seed against shatter, birds and rodents (see description of geotextile fabric in the Drying Equipment section). However, the covering material and anchoring of this material are critical. Orienting windrows into double rows with the seed heads pointed inward will create a slight hump for crops such as lettuce, carrots, brassicas, beets and chard. This hump will facilitate shedding of water when covered with a breathable fabric such as or tarp as they will not breathe and will hold moisture. Anchor fabric with bailing twine and landscaping staples to prevent the fabric from blowing away. (See Fig. 3 & 4) Covering is easiest when done with two or more people, especially under windy conditions.

Fig. 4 - Bailing twine and landscape staples hold geotextile fabric in place as row cover.

Label crops. Labeling harvested crops well is important when handling multiple crops of the same species as it may be difficult to differentiate varieties under post-rain conditions.

Drying Equipment

In addition to having covered space for drying seed in the event of wet weather, growers should be prepared with necessary equipment for efficient drying and handling of seed. Equipment useful for small- to medium-scale growers include: Rubbermaid totes, tarps of all sizes, geotextile landscape fabric, window screening, landscaping stables, bailing twine, threshing sticks, fans, and drying tables or racks.

Simple drying racks, drying bins, and tables can be constructed on-farm to facilitate drying harvested seed and plant material. Drying bins are available commercially, but may also easily be built on-farm. Bins are basically a large box (depending on scale of material), with a slatted floor for airflow and a fan system which forces air up through the drying material. (See Fig. 2) Multiple varieties can be dried at once by building vertically stacked racks into the box, but care should be given to laying fine screening or fabric on

each rack to prevent physical mixing of dropped seed, particularly when drying different varieties of the same species. In addition to drying bins, tables or racks can be made to aid drying in the open air. By framing table tops or racks out of wood and covering the open frame with hardware cloth, durable screening, metal grating, or simply wooden slats, seeds can be laid out on cloths or fine screening and elevated so that air flows below and above the drying seed and plant material.

Fig. 5 - For even drying, harvested and cleaned seed should be laid out in a thin layer.

Geotextile Fabric for Windrow Protection

Geotextile fabric is a spun polyester product used as a weed barrier in landscaping applications. Lightweight versions are familiar to farmers as row covers, while heavier versions are used as an underlay for gravel in new road construction. The fabric ranges in weight from 3.5 to 18.0 ounces per square yard, and is stabilized for UV resistance. The "landscaping weight" comes in rolls 3 or 6 feet wide, and 300 feet long, and is durable enough to be reused for many seasons. Its virtues for this application include breathability and permeability to pooling water, while shedding about 80% of hard rainfall from seed heads in a properly prepared windrow.

Crop Specific Guidelines

Beet and Chard

Beet and chard are biennial seed crops. They are commonly seeded in mid-summer and either overwintered in the ground or the roots are lifted, stored over winter and replanted the following spring. Overwintering results in earlier seed maturity than replanting roots in spring. Seed ripens unevenly. The earliest formed seeds are the largest, and plants are commonly cut and windrowed when the earliest seeds (on the lowest branches) are brown and ripe. Windrows are then combined or threshed once seeds have dried. The seed surface contains a germination inhibitor that prevents premature sprouting, but rain on the seed readily leads to infection by pathogens. Wet weather encourages the development of downy mildew caused by *Peronospora farinosa* f. sp. *betae*, which can affect plant growth and contaminate seed. In smaller-scale production, covering windrows with geotextile fabric may help protect the crop from rain.

Brassicas

Brassicas include annual species (broccoli, mustard, radish, and various brassica greens) and biennial species (kale, cauliflower, cabbage, and Brussels sprouts). In the Pacific Northwest, annual species are commonly spring planted while biennials are usually seeded in flats in the greenhouse in early summer (June), transplanted into the fields in late summer/early fall, and overwintered. Seeds are formed in protective pods that endure some rain. Seed dormancy normally lasts at least a month, which prevents sprouting under wet conditions. For these two reasons, it is often advisable to wait out a rainy period unless rains are expected to continue for a long period of time or disease pressure is high. Diseases of concern under wet weather which can lead to seedborne contamination include: black rot caused by *Xanthomonas campestris* pv. *campestris*, Alternaria leaf spot caused by *Alternaria brassicae* and *A. brassicicola*, and downy mildew caused by *Peronospora parasitica*. Lodging tendencies vary widely depending on species and variety. Staking and trellising is advised for tall, leggy, or lodge-prone varieties and significantly aids in disease prevention, particularly when the risk of wet weather is high. Seeds are commonly harvested when the oldest seed pods are fully ripe, but before they shatter. Remaining seed pods will continue ripening after harvest. Harvesting is normally done by cutting the stalks and windrowing the plants, drying the plants for 7-10 days in the field, and then threshing or combining the dried pods.

Carrot

Carrot is a biennial species that requires vernalization, and are commonly planted mid- to late summer and overwintered in the ground. Alternatively, roots are pulled, held in cold storage over the winter, and replanted the following spring. These vernalized roots are called stecklings. Overwintered roots will set seed earlier than spring transplanted stecklings, reducing the risk of maturation during fall rains. Seeds ripen

unevenly and the first umbels may shatter before the crop fully matures. Optimum harvest occurs when the third- and fourth-order umbels turn brown. Seed tends to shatter in wet, windy weather and should be harvested as soon as possible once mature. Harvesting is normally done by cutting the stems and windrowing the plants in the field, drying the plants in the windrows for 1 to 2 weeks in the field, and threshing the dried heads. If seed is harvested wet, it should be brought indoors and laid out to dry as soon as possible. Mature seeds show considerable dormancy, preventing premature germination, but exposure to prolonged rain may cause increased disease incidence. The fungal pathogen *Alternaria dauci* and the bacterial pathogen *Xanthomonas campestris* pv. *carotae* are both seedborne and of particular concern in carrot seed production.

Lettuce

Lettuce, an annual seed crop, is commonly spring planted and harvested summer through fall in the Pacific Northwest. Lettuce seed ripens unevenly on the plant and shatters easily. Prolonged wetting of seed heads increases the incidence of grey mold caused by *Botrytis* spp., which may rot seedlings that develop when the seed is planted. Seed is normally harvested by cutting at 67-85% maturity (depending on weather forecasts) and allowing to dry 7-10 days before threshing. Seeds will continue maturing after cutting or up-rooting the plant. Seed dormancy varies among varieties, from almost no dormancy (48 hours) to prolonged periods (months), and can shift with environmental conditions. Geotextile fabric works well as a ground cloth and a cover for weather protection. Mature seeds may require protection from feeding by goldfinches which is most commonly done by covering plants with netting or through the use of noises or "eye-scare" balloons to scare them off.

Spinach

Spinach, an annual seed crop, can be fall seeded and overwintered, but is usually seeded in early spring (March 15th – May 15th, depending on the cultivar). Mature stalks are usually cut and windrowed when seeds at the bottom of the stalk turn brown. Windrowed stalks are then field dried, and combined 7-10 days later. Rotating stalks in windrows is advisable to facilitate even drying. Mature seed exhibits considerable dormancy, but prolonged periods of moisture increase risks of seedborne diseases. In the Pacific Northwest, *Stemphylium botryosum*, *Cladosporium variable*, and *Alternaria* spp. are seedborne pathogens of particular concern in spinach seed production.

Onion

Onion, a biennial seed crop, requires exposure to an extended cold period (vernalization) in order to set seed. It is also a day-length sensitive crop, with long- to medium-day onions performing best in the Pacific Northwest. Timing of planting is critical to avoid maturity during wet weather. In the Northwest, onion seed crops are typically seeded around mid-July and overwintered in the ground, or seeded earlier in the spring, lifted and cured, and then replanted in fall or stored and planted the following spring. Overwintered bulbs will resume growth early in the spring and set seed early enough to avoid fall rains. However, stored bulbs that are replanted in the spring resume growth later and often may not complete maturation until fall, subjecting them to higher risk of rainy weather. Cool, wet conditions can lead to downy mildew, caused by *Peronospora destructor*, on leaves and seed stalks, which affects plant growth. Mature onion seed has little dormancy and is subject to sprouting when wet for prolonged periods. Full heads are harvested when the dried flowers open and expose about 10% of the black seeds. The seeds are then cured for 2-3 days in dry conditions, and threshed. Onion seed must be dried to about 9-10% moisture in order to thresh. After threshing, the seed often requires additional drying. Seeds are best dried with forced air at ambient temperatures and low humidity, as drying onion seed too rapidly at high temperatures can injure seeds and reduce germination.

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Organic Seed Alliance supports the ethical development and stewardship of seed via research, education and advocacy. We accomplish our goals in collaboration with farmers and other seed professionals.

Our vision:
Seed is both our common cultural heritage and a living natural resource fundamental to the future sustainability of food production. Proper stewardship of our genetic resources necessitates not only its conservation, but careful management in a manner which allows seed to continually evolve with challenges of the environment, cultural practices of sustainable agriculture and the need to feed people. Through advocacy, collaborative education and research, we work to restore and develop seed varieties for current needs while safeguarding invaluable genetic resources for future generations. The stewardship of the natural resources of seed is strengthened through the creation of regional seed systems that provide growers with plant genetics well suited to local needs and conditions.

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