



# GRAINS: GROWING QUINOA IN HOME GARDENS

## *Home Gardens Series*

By  
**Julianne A. Kellogg**, Sustainable Seed Systems Lab, Dept. of Crop and Soil Sciences, Washington State University. **Dr. Kevin M. Murphy**, Sustainable Seed Systems Lab, Dept. of Crop and Soil Sciences, Washington State University

# Grains: Growing Quinoa in Home Gardens

## Crop at a Glance

**Growing Season:** Spring through late summer or early fall.

**Time of Planting:** Early spring.

**Spacing:** Sow quinoa seed at a rate of 5–8 g per 100 square feet in rows spaced 8–24 inches apart with the option to later thin to 3–5 inches between plants. For transplant plugs, plant quinoa transplants 12 inches apart in rows spaced 12–24 inches apart.

**Days to Harvest:** 90–150 days, depending on the variety.

**Yield:** Varies by variety and location with an average 3.34 lb per 100 square feet. Irrigation and fertilizer will further improve yields.

**Common Starting Method:** Direct-sowing seed or planting young transplants.

white, brown, red, and black. Typically prepared in a similar manner as boiled rice, quinoa can be served as a grain side dish or incorporated into salads and other recipes. Quinoa is desirable not just for its flavor, described as earthy, nutty, and sweet, but also for its nutritional profile. Quinoa is gluten free, high in protein, and contains all necessary amino acids required for human health. Many people are now cooking this Andean grain at home, and most of the quinoa consumed in this country is imported from South America, primarily Bolivia and Peru. This publication is for home gardeners interested in growing quinoa and provides information on methods to grow quinoa, how to save seed for future planting, and how to process seed for consumption.

## Selecting Types to Plant

Quinoa varieties best suited to growing in Pacific Northwest latitudes require long days and cool summer temperatures. **Day neutral** quinoa varieties will also grow well. Quinoa purchased from grocery stores is typically unsuitable for planting. Store-bought quinoa likely contains short-day quinoa varieties grown in Bolivia and Peru that may not mature in our climate. Washington State University conducts variety trials in eastern and western Washington to determine yields of nine commercially available quinoa varieties in two very different Washington climates (Table 1). Varieties developed by Wild Garden Seed in Philomath, Oregon, (Table 2) are well adapted to maritime climates. Many quinoa varieties produce seed covered with a soap-like compound called **saponin** that is removed prior to consumption. Saponin-free varieties exist (also called ‘sweet’ varieties), but are difficult to find as

## Introduction

Quinoa, pronounced “KEEN-wah,” is a **pseudocereal**. Unlike the **monocot** cereal crops wheat and rice, quinoa is not and does not look like a grass. Quinoa is in the Amaranthaceae family along with garden favorites spinach and beets as well as the weed lambsquarters. It is a tall, broadleaved, ornamental **dicot**. The seeds are small, round, and range in color:

Table 1. Yields for commercially available varieties (lb per 100 square feet)

Quinoa Variety	2014 Albion, WA	2015 Albion, WA	2014 Chimacum, WA	2015 Chimacum, WA
Black	0.26	0.19	4.92	1.40
Blanca	0.42	0.06	4.68	1.42
Cahuil	0.21	0.06	4.22	1.04
Cherry Vanilla	0.43	0.02	4.40	0.10
Colorado 407 Dave	1.15	0.48	4.23	1.70
Kaslaea	1.49	0.29	6.67	1.32
Linares	0.90	0.23	4.32	0.71
Red Head	0.30	0.01	3.72	0.38
Temuko	0.28	0.03	3.25	0.84

This WSU variety trial data comes from non-irrigated production using a 16-inch interrow spacing. Albion, WA, is located in eastern Washington with high summer temperatures and annual precipitation of about 20 inches. Chimacum, WA, is located on the Olympic Peninsula of western Washington experiencing lower summer temperatures than Albion and has an annual precipitation of about 28 inches. Extreme drought and high temperatures caused low yields in the 2015 Albion, WA, trial. The 2015 Chimacum, WA, trial experienced lower rainfall than in 2014.

Table 2. US and Canadian seed companies selling quinoa

Seed Company	Location	Varieties available	Website
Adaptive Seeds	Sweet Home, OR	Chadmo, Dave 407, Linares, Temuco	www.adaptiveseeds.com
Baker Creek Heirloom Seeds	Petaluma, CA Mansfield, MO Wethersfield, CT	Brightest Brilliant, Cherry Vanilla, Red Faro	www.rareseeds.com
Bountiful Gardens	Willits, CA	Apellewa, Biobio, Campesino, Colorado, Kaslala, Red Head, Temuco	www.bountifulgardens.org
High Desert Seed & Gardens	Montrose, CO	High Desert Quinoa, Kaslaea	www.highdesertseed.com
Resilient Seeds	Deming, WA	Linares, Titicaca	www.resilient-seeds.com
Salt Spring Seeds	Salt Spring Island, BC, Canada	Black, Cahuil, Multi-hued	www.saltspringseeds.com
Seed Dreams	Port Townsend, WA Santa Cruz, CA	Dave's407, Faro, Kaslala, Kcoito, Pison, Red Faro	seeddreams.blogspot.com
Sustainable Seed Company	Chico, CA	Brightest Brilliant Rainbow, Cherry Vanilla, French Vanilla, Oro de Valle, Red Head	www.sustainableseedco.com
Territorial Seed Company	Cottage Grove, OR	Brightest Brilliant, Cherry Vanilla	www.territorialseed.com
West Coast Seeds	Delta, BC, Canada	Brightest Brilliant, Cherry Vanilla, French Vanilla, Mint Vanilla, Oro de Valle, Red Head	www.westcoastseeds.com
Wild Garden Seed	Philomath, OR	Biobio, Brightest Brilliant Rainbow, Cherry Vanilla, French Vanilla, Kaslala Multicolor, Magenta Sunset, Mint Vanilla, Oro de Valle, Red Head, Wild Garden Breeder's Mix	www.wildgardenseed.com

A quick search for quinoa seed on the Internet will result in many available varieties that can be grown in the home garden. This table provides a partial list of seed companies that currently sell small seed packets of quinoa.

commercially available seed.

### Choosing a Planting Site

Quinoa can be grown at nearly any elevation. Successful quinoa crops have been harvested at sea level on the Olympic Peninsula of Washington and at 7,600 feet in the San Luis Valley of Colorado. Quinoa performs best in soils with good drainage and neutral pH, but quinoa is commonly cultivated in South America in marginal agricultural areas with very acidic to alkaline soils (tolerating a range of pH 4.5–9); climates prone to drought, and soils low in natural fertility (Garcia et al. 2015). Select a well-drained garden plot for planting quinoa. Waterlogging causes stunting and **damping off** in quinoa (González et al. 2009).

Locate quinoa plots where summer temperatures do not go above 95°F in early to mid June when plants are flowering. In eastern Washington dryland areas, temperatures exceeding 95°F during flowering caused complete yield loss due to lack of seed formation. High temperatures during flowering can cause flower

abortion and pollen sterility (Jacobsen et al. 2003). Yield losses caused by crop exposure to temperatures greater than 95°F during flowering have also been recorded in Colorado (Johnson and Croissant 1985) and in Minnesota (Oelke et al. 1992).

### Planting Guidelines

Gardeners can sow quinoa in the spring as soon as the seedbed can be properly prepared. Expect nearly 100% seed germination at soil temperatures from 36°F to 68°F; however, germination may be delayed at lower temperatures (Bois et al. 2006). If summer frosts are common, young plants at the two leaf stage can withstand 25°F temperatures, while exposing flowering plants to 25°F or below will result in dramatic yield losses (Jacobsen et al. 2003).

Depending on the gardening method, quinoa can be transplanted into a heavily mulched bed or directly sown into a well-drained seedbed and worked to a depth of 6–8 inches. If fertility amendments are deemed necessary following a soil test, an aged compost or



composted manure can be incorporated into the soil during seedbed formation. When selecting fertilizers, be sure to apply only the nutrients that are deficient. Bilalis et al. (2012) found that an application of 4.1 lb of cow manure (1.24% N) per 100 square feet increased quinoa yields from 4.95 lb/100 square feet (unfertilized) to 5.35 lb/100 square feet. Reported quinoa yields have almost tripled with a total application of 0.25 lb of N per 100 square feet when compared to no application of fertilizer (Schulte auf'm Erley et al. 2005). In Colorado, an increased total application of 0.3–0.4 lb of N per 100 square feet resulted in yields of more than 3 lb per 100 square feet for higher yielding quinoa varieties (Johnson and Croissant 1990). For help determining application rates for a preferred fertilizer, refer to the Home Gardener's Guide to Soils and Fertilizers (Cogger 2014). Be careful with overapplication of nitrogen as high levels can decrease yields due to late maturity, excessive production of vegetation, and **lodging**. Avoid planting seed in direct contact with fertilizer; it may severely inhibit germination (Peterson and Murphy 2015).

If planting quinoa into a container, be mindful not to over-fertilize. Quinoa grown in a container will not have the buffer of large volumes of soil and **humus** to protect the plants from toxic levels of fertilizer. Prior to adding additional fertilizer, it is recommended to determine the initial nutrient levels of the potting mix being used. For a total nitrogen rate of 0.25 lb N per 100 square feet, a 12-inch diameter pot would require 2 teaspoons of blood meal (an organic source of nitrogen). The higher rate of 0.4 lb N per 100 square feet would convert to 1 tablespoon plus 1 teaspoon of blood meal. If such small amounts of fertilizer are difficult to incorporate into the potting mix, fertilizer can be mixed with water to help evenly distribute the nutrients. Fertilizer toxicity symptoms for quinoa grown in containers include reduced germination rates, stunting, and low yield (Peterson and Murphy 2015).

Sowing quinoa seed in your garden can be done by hand or with a push seeder like the one shown in Figure 1. Determining the perfect soil moisture for planting can be a difficult task. The soil must be dry enough to till, form beds and furrows, and push a mechanical seeder through. Soil must be moist enough, however, to have good germination and result in an adequate number of plants per row. If gardening in a region that typically grows dryland crops (grown with no irrigation), quinoa can be grown without supplemental irrigation. It is imperative, however, that soil moisture is high, rainfall is expected, or irrigation is available during the flowering and **grain filling stages** that typically occur 40–80 days after sowing depending on the variety. Flowering and grain filling are considered quinoa's most critical growth stages, meaning drought, heat, and poor fertility will be extra harmful during that



Figure 1. The push seeder is a tool used for planting row crops that comes with a row marker, seed hopper, and adjustable ground opener allowing for different planting depths. Photo by Julianne Kellogg.

time period (Geerts et al. 2008). When planting with the intention of not irrigating, be sure to sow the quinoa seed at a depth where soil moisture is visible. Ideally, when sowing into a garden with or without irrigation, the soil should be at **field capacity** moisture. Field capacity moisture typically occurs two or three days after a rain or irrigation event.

Quinoa can be sown in rows at a rate of 5–8 g (0.2–0.3 oz or 1–2 teaspoons) per 100 square feet. This translates to about 2,000–3,200 seeds. A typical retail quinoa seed packet contains 0.5 g or 250 seeds. Space rows 8–24 inches apart, depending on your preference for bed layout, and sow seed about a half-inch deep, covering lightly with soil. Two weeks after emergence, thin plants to 3–5 inches apart. Planting seeds thick and waiting to

thin will ensure an even plant stand since 100% seed germination and seedling emergence is unlikely. Plants may also be spaced wider, up to 12 inches apart. This will result in larger plants with a branching structure that provides multiple seed-bearing **panicles**. An increased planting rate of 21 g (0.74 oz or about 2 tablespoons) per 100 square feet will result in a high plant density that competes well with aggressive weeds in the row. It has been documented that closely planted quinoa will result in less branching and earlier maturity (Risi and Galwey 1991). This strategy could be useful for gardeners in regions with a short growing season. Expect seeds to germinate in 24 hours and seedlings to emerge in three to five days. In less than ideal growing conditions, double the seeding rate. Quinoa seeds are small and susceptible to desiccation, waterlogging, and failure to emerge through soil crusted over by rain or irrigation.

Recently, garden centers have begun to sell young quinoa plants in ready-to-plant plugs. Whether young quinoa plants are purchased or transplants are grown at home, choose healthy plants that have three or four true leaves. It is important not to let quinoa plants become root bound or the harvest will be significantly reduced. Transplant seedlings on a cool and cloudy morning and water well. Plant quinoa transplants 12 inches apart in rows spaced 12–24 inches apart. Although quinoa requires full sun, other low stature, short season crops such as radish, lettuce, and living mulch **cover crops** like medic or clover, can be interplanted among quinoa to fill wide interrow spaces (Walters et al. 2016). When **intercropping**, keep in mind that quinoa can grow three to six feet tall.

## Plant Maintenance

Perform a soil test to determine fertilizer requirements before applying a nitrogen fertilizer. If you have incorporated an organic source of nitrogen when prepping your garden soil, then additional fertilization may not be necessary. It is up to the gardener to choose to apply fertilizer in one large application or to **split fertilizer applications** between planting and a later growth stage. However, split applications of organic nitrogen fertilizer (e.g., pig manure slurry) do not have an advantage for quinoa (Jacobsen and Christiansen 2016).

If your summers are hot and dry, supplemental irrigation will improve quinoa yields. The amount to irrigate will depend on soil type and whether **drip irrigation** or **overhead irrigation** is used. The sandier the soil, the less water it will hold. The more clay and silt in the soil, the greater the water holding capacity. Although crops such as wheat and canola are often raised under **dryland agriculture** conditions in eastern Washington, quinoa yields have increased nearly

five times over non-irrigated quinoa when drip irrigated with 0.6 inches of water once a week. More importantly, in the following year, irrigated plots produced seed when non-irrigated plots did not produce seed due to high temperatures during a hot growing season (Walters et al. 2016). Irrigation can be used at specific growth stages rather than by following a schedule. Researchers in South America found water savings and increased yield by irrigating quinoa specifically during plant emergence and at flowering (Garcia et al. 2003). For help calculating irrigation requirements based on growing practices, soil type, and vegetation, refer to Washington State University's Irrigation in the Pacific Northwest online calculator (WSU Extension 2016a).

## Pest Management

In high rainfall areas, downy mildew (*Peronospora variabilis* Gäum) is the most damaging disease of quinoa. Other diseases of quinoa include damping off (*Sclerotium rolfsii*), stalk rot (*Phoma exigua* var. *foveata*), leaf spot (*Ascochyta hyalospora*), and grey mold (*Botrytis cinerea*) (Oelke et al. 1992). To best manage diseases and insect pests, inspect the quinoa crop on a regular basis looking for the plant symptoms, weeds, and insects described in Figures 2–9.

### Downy Mildew

Symptoms: Leaves display irregularly shaped patches of pink and yellow discoloration (**chlorosis**). Grey sporulation is visible on both the top of the leaf and the underside (Figure 2). Leaves with lesions become pale and **necrotic** resulting in **defoliation**. It is possible to have nearly 100% yield loss.

Corrective action: Cool, rainy conditions and a relative humidity of 90% or greater encourage the spread of downy mildew. Widening the inter- and intrarow spacing, orienting the field to increase wind flow through rows and avoiding excessive overhead irrigation can help control downy mildew. Downy mildew can be



Figure 2. Downy mildew (*Peronospora variabilis* Gäum). Photos by Julianne Kellogg.



seedborne.

## Aphids

**Symptoms:** Aphids are found mainly on the underside of leaves. These leaves may curl, become distorted, and eventually become necrotic (Figure 3). Aphids produce honeydew that becomes visible on plant stems and leaves. The black bean aphid is dull dark olive green to black. The Chenopodium aphid is green with a white, waxy powder.

**Corrective action:** Look for aphids that build up on nearby weeds, such as sow thistle and mustards, and remove these weeds before the aphids move onto your quinoa plants (Flint 2013). If planting quinoa transplants, check transplants for aphids before planting. Since high levels of nitrogen fertilizer can favor aphid reproduction, use a less soluble form of nitrogen, such as organic fertilizers. Oils such as neem oil effectively kill aphids when applied to the tops and undersides of leaves (Flint 2013). Few home garden pesticide products are allowed to be used on grains, so be sure to follow product labels. Grain crops are listed on several neem oil products that are available for purchase within the United States and are allowable for use on a quinoa crop. Predatory insects of aphids



Figure 4. Pests of the *Gelechiidae* and *Noctuidae* families. Photos by Julianne Kellogg.



Figure 3. Black bean aphid (*Aphis fabae*) and Chenopodium aphid (*Hayhurstia atriplicis*). Photos by Julianne Kellogg.

include lady beetles, green lacewing larvae, syrphid fly larvae, and parasitoid wasps (Flint 2013).

## Gelechiidae and Noctuidae Pests

**Symptoms:** The larvae of these pests damage quinoa plants by mining the developing **inflorescence**, defoliating plants, feeding on grains, and boring into stems potentially leading to plant death (Figure 4). Early in the season, larvae may cause considerable yield loss by feeding on the **terminal bud**, causing the plant to become bushy in architecture. You may

notice such pests form shelters by rolling quinoa leaves. Young plants afflicted with stem borers will begin to flag and the interior of stems will be gutted and full of insect frass. Mature quinoa plants that have survived stem borer damage may still produce seed, but stem borer holes will be noticeable along the plant stalk and remaining orange-colored stem borer pupa will be in the stalk.

**Corrective action:** Carefully watch your quinoa plants during panicle development. Pest control is crucial at this phenological stage because insect damage at this time causes **lateral branching** and can make crop management difficult and reduce yield (Gandarillas et al. 2013). The **seed milk stage**, the phenological stage when quinoa seeds are soft and still developing, is another critical time to observe your plants for pests. Currently, no pesticides for such pests have a label that would allow their use on quinoa. The optimal pest control strategy is the prevention of an infestation through increased crop diversity within the garden and increasing the presence of insectivorous birds and beneficial predatory insects by planting appropriate habitat. Adult moths are nocturnal and light traps can be used to capture and kill the moths, but the



traps are non-specific, also capturing moths that are not pests. Chickens can be allowed into the garden after plowing when larvae and pupae are exposed. For more information on these pests and additional management options, refer to the Food and Agriculture Organizations's comprehensive report, *The State of the Art Report on Quinoa: Around the World in 2013* (Bazile et al. 2015).

### Lygus Bugs

**Symptoms:** Lygus bugs damage developing flowers and seed, as well as destroy terminal meristems, causing bushy plants (Figure 5; Godfrey et al. 2015). Lygus bug adults are flat, oval, small, and only about the size of a pencil eraser. They vary in color from pale green to yellowish brown. Markings are reddish brown or black with a large, light-colored triangle in the center of the back. Do not confuse with the beneficial bigeyed bug. Young lygus bugs (nymphs) look similar to adults, but they are uniformly pale green with no wings.

**Corrective action:** Check for lygus bugs on nearby weeds, alfalfa, safflower, sugarbeet, tomato, beans, potato, and oats (Godfrey et al. 2015). When these crops are harvested, the adults will fly off and land on the quinoa crop or other host plants. It is important to reduce the migration of lygus bugs into the quinoa during the summer months when quinoa plants are growing by staggering the harvest of the lush and green host crops of lygus bugs in the garden. Natural predators of lygus bugs include parasitoid wasps, bigeyed bugs, damsel bugs, minute pirate bugs, and crab spiders. If nearby crops are infested with lygus bugs, an option may be to spray those crops with the appropriate

insecticide as long as the product label is followed. Limit the number of uses of pesticide sprays as they can disrupt natural enemies. If the quinoa plot is small, vacuuming the individual quinoa panicles (avoiding damage to leaves) with a cordless hand vacuum may be effective. The use of suction devices (bug-vacs) has been successful in controlling lygus bugs in other crops (Zalom et al. 2012).

### Wireworms

**Symptoms:** Wireworms are the larvae of click beetles that feed on planted seeds and young seedlings. Root feeding will cause wilting, stunting, and often eventual death of quinoa seedlings (Figure 6). The largest impact wireworms have on yield is the dramatic reduction in plant stand density. At a lower plant density, quinoa plants may fill the unoccupied space with branches producing additional seed-bearing panicles.

**Corrective action:** Recently tilled pasture, fallow, and sod can result in high wireworm populations. If wireworms have been a problem in the past, increase the seeding rate. Strive for even germination and emergence by not planting too deep and ensuring proper moisture. Delayed emergence and reduced vigor



Figure 6. Wireworm (unknown species). Photos by Julianne Kellogg.

may leave quinoa seedlings vulnerable to wireworms for a longer period of time.

### Lambsquarters

**Identification:** Lambsquarters appear nearly identical to quinoa as a seedling and young plant. It has succulent **cotyledons** with a mealy white coating. The stem of the young plant can be green, tan, and purple in color. Figure 7 depicts a recently emerged quinoa plant sown to the right of lambsquarters (photo on the left) and the photo on the right was taken twenty days later. The two plants are almost indistinguishable at this young age when weed control is critical.

**Weeding tips:** The best option for controlling lambsquarters is to sow or transplant quinoa in straight rows. During weed cultivation, remove any plants



Figure 5. Lygus bug (*Lygus* spp.). Photo by Julianne Kellogg.





Figure 7. Lambsquarters (*Chenopodium* spp.). Photos by Julianne Kellogg.

not in the planting row. If some lambsquarters are unintentionally left to mature, their weedy growth habit will become apparent. If quinoa seed will be saved to replant the following season, do not let the lambsquarters mature and flower alongside the quinoa. The lambsquarters species, *Chenopodium berlandieri*, can cross with quinoa and contaminate the purity of the seed.

Weed presence and competition will reduce quinoa yield. In the cool spring temperatures, weeds adapted to your growing region may grow faster than quinoa, compete for nutrients, and eventually shade out the young quinoa seedlings and plants. Early control of weeds within and between quinoa rows is important. When first determining when to plant the quinoa seed, one option is to till and allow the first flush of weeds to emerge, till a second time, and then plant immediately. Quinoa may also be planted after the first tillage and, with fast-growing weeds, newly emerging weeds can be flamed before the quinoa seed germinates and emerges.

Weeding between quinoa plants (intra-row) can be done by hand or with a hand hoe. Weeding between rows (inter-row) can be done with a hand hoe, wheel hoe, or small tillage equipment like a rotary hoe if wide inter-row spacing was used. Sowing and then incorporating a cover crop before planting the quinoa crop can reduce weed pressure and increase the organic matter content in the garden soil.

Using organic (e.g., wood chips, straw, shredded leaves, grass clippings, and newspaper) or inorganic (e.g., plastic and landscape fabric) mulches is an alternative method of controlling weeds. Mulch has the added benefits of modifying soil temperature, increasing water conservation, and reducing water runoff during rain or irrigation events. Typically, two inches or more of organic mulch is needed to control weeds (Miles et al. 2013). Growing a **living mulch** alongside the quinoa

crop can also reduce weed presence, but be sure to select a complementary living mulch like clover or medic (Walters et al. 2016).

## Harvest and Storage

Watch the quinoa plants for leaf senescence in late August or early to mid September. The stalks and leaves will lose their green color and shift to autumnal orange, yellow, red, and pink colors as they dry down. Inspect the panicle for seeds and grab or shake a few seeds into your hands. Quinoa is ready to harvest when the seed is barely dented with a fingernail. Typically, plants will completely dry down and leaves will drop when they are ready to harvest. The seed should be easy to remove (**thresh**) from the panicle by hand. If quinoa plants are present with several branches and several panicles that mature at different dates, the plants can be harvested in stages by harvesting the leading panicle that dries



Figure 8. Variety and plant spacing will determine if the quinoa will have a single seed-bearing panicle or multiple. Plants with multiple panicles may not mature evenly and harvest can occur over several days or weeks. Photos by Julianne Kellogg.

down first, and the remaining maturing panicles at a later date. Figure 8 compares quinoa plants with a single panicle and branched quinoa plants with multiple panicles.

If harvesting during a rainy season, harvested plants should be cut and allowed to dry down in a sheltered location. Mature quinoa seeds will germinate within 24 hours after exposure to moisture. Complete crop loss is possible if a mature quinoa crop is rained on. Figure 9 shows a seed-bearing panicle sprouting after a rain event.

Once plants and seed are dry, or were harvested dry





Figure 9. When a quinoa crop is maturing, early autumn rains can cause seed to sprout on the panicle (left). The white or pink **radicle** emerges from the seed still attached to the plant (right). Photos by Julianne Kellogg.

to begin with, seed can be threshed either manually or mechanically. To manually thresh, hit the panicles against a hard surface or rub them between the hands to separate out the seeds. A stick may also be used to hit the plants so the seeds fall on a clean piece of material. Using a vehicle and a tarp laid out on hard ground like a driveway, dried quinoa plants can be stacked on the tarp and a vehicle can be used to drive over the plants to separate out the seeds. If a thresher is available, the machine will separate the seed from the **chaff**. Check with the local county Extension office or farmers to learn if seed processing and cleaning equipment is available for rent or sale. The Organic Farm School on Whidbey Island, WA, offers equipment rentals to western Washington farmers and gardeners (<http://organicfarmschool.org/organic-seed-project/>).

The next step in cleaning quinoa seed is **winnowing**. Using a fan, allow seed to drop onto a cloth on the ground with the force of the air blowing away the lighter chaff. Seed cleaning screens can be used to help remove larger non-seed material that isn't being removed by the fan.

Stored quinoa seed for planting the next year must have an optimal seed moisture level of about 13% to assure **seed viability** (de Jesus Souza et al. 2016). To reach this level, seed can be spread out to dry in full sun for several days to decrease seed moisture, but be sure to bring in the seed in the evenings in a humid climate with evening dew or rains. Quinoa seed saved for planting can be stored up to twenty years in a dark place at low temperatures (around 50°F) and with an average relative humidity of 45% (Rojas and Pinto 2015). A refrigerator is a suitable location if seed is stored in an airtight container, but a paper bag can be used for short-term storage and is beneficial in that paper allows moisture to escape from the seed (Pollard and Canavis 2007).

## End Uses

Due to saponins coating the seed of most quinoa varieties, quinoa is not suitable to eat right after being threshed and winnowed. If growing a saponin-covered variety, the saponins can be removed by repeatedly soaking the seed, agitating the water and seed, and dumping the water until soapy bubbles are no longer forming in the wash water. Rinsing under fast, hot running water multiple times is also appropriate. A toasted flavor can be imparted on quinoa by first pan roasting saponin-covered seeds until they begin popping, pouring water into the hot pan, and then rinsing multiple times until the water runs clear. A larger amount of seed can be processed at one time using a washing machine. First, run the washing machine with vinegar to remove soap residues, seal the quinoa seed in a pillowcase and run it through a wash cycle (without soap) 2-3 times, taste the seed to determine if the saponins have been removed (saponins taste bitter), and finally empty the seed onto trays or screens to dry before storing (Simpson and McLeod 2013).

The variety of quinoa grown will determine the cooking time and resulting texture. The harder the seed and higher the protein content, the firmer, gummier, and chewier the texture (Wu et al. 2014). Also, the longer quinoa is cooked, the softer, less crunchy, and pastier the texture (Wu et al. 2014).

The seed is not the only part of the plant people eat. When quinoa plants are young, the leaves are delicate and crisp like baby spinach. Quinoa can be grown solely as a leafy vegetable or salad green, or a few leaves can be harvested from plants intended for seed while they are growing. Harvesting a large quantity of leaves from the plants meant to grow through to full maturity will lead to decreased seed yield.

## Glossary

**chaff.** Plant material separated from seed during threshing and winnowing.

**chlorosis.** An abnormal reduction of the green coloration of the plant leaves. The loss of chlorophyll typically results in a yellowing of plant tissues.

**cotyledons.** The embryonic leaves of a plant. They are not considered the first "true" leaves.

**cover crop.** Also called green manure. Crops added to a crop rotation to suppress weeds, reduce soil erosion, minimize soil surface crusting, increase soil organic matter, penetrate hardpans, fix atmospheric nitrogen or scavenge soil nitrogen, improve soil structure, and control pests and diseases.

**damping off.** A disease of young seedlings that typically

occurs in damp conditions causing plant death.

**day neutral.** A plant that can form flowers regardless of day length.

**defoliation.** The removal or destruction of plant leaves.

**dicot.** Short for dicotyledon. A flowering plant that produces two cotyledons.

**drip irrigation.** A system of crop irrigation designed to conserve water by applying a slow drip of water to the root zone of plants via a network of tubes or pipes.

**dryland agriculture.** Also known as dry farming. The cultivation of crops without irrigation.

**field capacity.** The water content of the soil several days after a rain or irrigation event and the excess water has been drained away by gravitational forces.

**grain filling stage.** The period that begins with the initiation of seed development following pollination.

**humus.** Considered passive soil organic matter and comprises about 70% of soil organic matter. It is not biologically active, but is important in the retention of soil nutrients and availability of nutrients to plants.

**inflorescence.** The complete flower head of a plant. A panicle is a type of indeterminate inflorescence.

**intercropping.** The practice of growing two or more crops in close proximity, typically as alternating rows, to make use of resources not used by a single crop.

**lateral branching.** Branches develop and grow outward from the side of the main stem of the plant.

**living mulch.** A cover crop interplanted or undersown with a main crop to provide the services of a mulch. Living mulch crops include, but are not limited to, buckwheat, clover, hairy vetch, medic, oats, and phacelia.

**lodging.** The collapse of a plant stem or an uprooting of the plant.

**monocot.** Short for monocotyledon. A flowering plant that produces a single cotyledon.

**necrotic.** The adjective of necrosis. Necrosis is the premature death of tissue cells due to disease or injury.

**overhead irrigation.** An irrigation system simulating rainfall by applying pressurized water over a crop canopy.

**panicle.** A branched inflorescence with many clusters of flowers on each branch.

**pseudocereal.** A plant that does not belong to the grass family but produces seeds or fruits that are used the same way as cereals.

**radicle.** The embryonic root of a plant that emerges from a seed during germination.

**saponin.** A soap-like compound that coats the seed of some varieties of quinoa and foams when shaken with water.

**seed milk stage.** The development stage when the seed has formed, but is still soft and contains a white milky fluid.

**seed viability.** The ability of a seed to germinate.

**split fertilizer applications.** The practice of splitting the total amount of a recommended fertilizer into two or more applications.

**terminal bud.** Also known as the apical bud. It is the primary growing point at the tip of a plant stem.

**thresh.** The act of separating seeds or grain from a plant.

**winnow.** The blowing of air through seeds or grain to separate out the the chaff.

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Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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**FS258E**