

Adopting Quinoa in Southeastern Idaho

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Introduction

Quinoa is a species of the goosefoot genus (*Chenopodium quinoa*), Amaranthaceae family. It is closely related to weeds such as common lambsquarters (*Chenopodium album*) and pigweed (*Amaranthus* spp.).



Figure 1. Quinoa (top) and common lambsquarters (bottom).

At the early stages of growth, quinoa resembles common lambsquarters, but the two species can be distinguished based on stem coloration. The base of the quinoa stem is pink to red, whereas common lambsquarters stems usually remain green to gray (figure 1). Quinoa grows 1.5 to 6.5 feet tall and reaches maturity in 90 to 150 days, depending on the variety and environmental factors.

Quinoa is grown primarily for edible seeds and has been considered a “superfood” or “supergrain” (figure 2). The seeds contain 10 essential amino acids in a healthy balance. They do not contain amino acid in the form of gluten protein. Seeds also supply fiber, various vitamins (e.g., vitamins A, B₂, and E), and minerals (e.g., calcium, magnesium, copper, zinc, and iron).

Depending on variety and environmental conditions, quinoa yields may range from 760 to 3,100 lb/acre. In an optimal scenario, yield can exceed 5,000 lb/acre. In Pacific Northwest trials, however, yields were as low as 100 lb/acre.



Figure 2. Quinoa seeds of variety Red Head.



Figure 3. Mixed quinoa varieties growing in an approximately 35-acre field (2015, Koopin Brothers Farm, near American Falls, ID).

In southeastern Idaho, quinoa has been planted in the area of American Falls, Blackfoot, Grace, Soda Springs, and Aberdeen (figure 3). Yields were 800 to 1,000 lb/acre in 2015, with a price of \$1 per pound of seeds. A market for quinoa is being developed in eastern Idaho.

Environmental requirements

Quinoa originated in high elevations of the South American Andes Mountains and is relatively tolerant to cold temperatures and light frost. The optimal average temperature for growth is 59 to 68°F. Before the soft-dough stage, quinoa is negatively affected by temperatures below 28°F; however, after that stage, the plants can tolerate temperatures as low as 20°F. Quinoa is sensitive to high temperatures during flowering, and temperatures over 90 to 95°F may cause sterility.

Quinoa can grow in a variety of soil types, from coarse sand to heavy clay, at a pH ranging from 4.5 to 9. The saline soils found in the western United States, including eastern and southeastern Idaho, present a unique challenge for crop growth. Quinoa is one of the most salt-tolerant crops, but salinity tolerance differs among varieties. Quinoa has potential as a crop for these problematic environments; however, further research is needed under Idaho conditions to identify varieties with maximum yield potential and tolerance to adverse conditions.

Cultural practices

Seeding

The length of the growing season required for best quinoa seed yields varies among varieties and environmental conditions. Set the planting date so that flowering does not coincide with peak summer temperatures. Optimal germination has been observed at soil temperatures between 40 and 60°F. Based on these requirements, early- to mid-April is the recommended quinoa seeding time for eastern and southeastern Idaho. In the presence of adequate soil temperatures and moisture, germination can occur within 24 hours. Seedling emergence usually occurs within 5 days.

Row spacing can vary from 10 to 20 inches. Wider rows allow for mechanical weed control at the early stages of quinoa growth.

With the varieties currently being grown, stands of 130,000 plants/acre (0.5 to 0.75 lb seeds/acre) have proved to be optimal. Seeding rates may need to be increased where growing conditions are not optimal.

Quinoa is usually planted at a depth of 0.5 to 1 inch, depending on soil texture and other conditions at planting time. Excessively deep sowing can lead to poor emergence, whereas shallow seeding may expose the seeds to drying.

Fertility requirements

To date, no studies have been conducted to develop fertilizer recommendations for quinoa grown in Idaho. Thus, precise fertilizer recommendations are unavailable. Based on results from studies conducted in other regions, it appears that nitrogen (N) rates in the range of 90 to 135 lb N/acre are likely to produce reasonable yields (i.e., nearly 3,000 lb/acre). Seed protein has also been shown to increase in response to N applications. However, excessive N may decrease time to maturity and increase lodging. Yield response to phosphorus (P) and potassium (K) application is unclear.

Water requirements

Quinoa is relatively drought tolerant. It can produce acceptable yields (940 lb/acre) with as little as 7 inches of seasonal rainfall/irrigation. Optimal water input is 10 to 15 inches. With 18 inches of water, yields of 3,300 lb/acre have been reported.

Moderate drought stress prior to flowering usually does not reduce yield. In fact, excessive early irrigation does not increase yield and tends to produce tall plants, which may subsequently lodge, especially in windy areas such as eastern and southeastern Idaho. Thus, early-season irrigation (at or before the 12-leaf stage) is not recommended. Water availability is more critical for grain yield, so a small amount of irrigation can be applied after flowering.

Weeds

Although quinoa can emerge quickly, early growth is relatively slow, so it does not compete well with existing or emergent weeds. Common lambsquarters and redroot pigweed (*Amaranthus retroflexus*) were the most prevalent weeds in quinoa trials conducted at the Aberdeen Research and Extension Center in southeastern Idaho during the 2015 growing season. Other broadleaf weeds common to crop production in that region include, but are not limited to, kochia (*Kochia scoparia*), hairy nightshade (*Solanum physalis*), and common purslane (*Portulaca oleracea*).

If rows are spaced widely, cultivators, rotary hoes, and other tillage implements can be used for between-row weed control. However, weeds growing in the row will not be affected. Cultivation can be conducted multiple times during the season, but weeds taller than 2 inches are usually not well controlled. Hand weeding and hoeing are other methods of weed control. However, they are laborious, could be costly, and probably would not be practical on a large scale.

One approach to weed management is to allow weeds to emerge and control them with tillage and/or nonresidual herbicides before planting. This practice helps deplete the weed seed bank, creates a clean bed for planting, and allows quinoa to emerge and begin growing before more weeds emerge. Another approach is to plant quinoa early enough to enable emergence and crop canopy development before some weed species emerge.

At present, little research has been conducted to identify herbicides that would selectively control weeds and not injure quinoa. Many of the herbicides showing promise do not control common lambsquarters well in other crops and/or have caused little or no injury to sugar beets. Examples are asulam (Asulox); s-metolachlor (Dual Magnum and others); EPTC (Eptam); and other thiocarbamates, such as butylate (Sutan), ethofumesate

(Nortron), quinclorac (Paramount), rimsulfuron (Matrix), and cycloate (Ro-Neet).

Grassy weeds can be controlled with postemergence-applied herbicides that have no activity on broadleaves, e.g., sethoxydim (Poast Plus and others). Glyphosate and other herbicides with foliar activity only, such as paraquat, pyraflufen (Vida), or glufosinate ammonium (Rely), can be applied to emerged weeds before planting or before quinoa emerges.

Insect pests

Because quinoa is a newly introduced plant in Idaho cropping systems, almost no information is available on region-specific insect pests. Due to limited quinoa acreage, insect problems are likely to be sporadic. As quinoa is introduced into more regional cropping systems, studies are needed to identify key pest species, their associated economic losses, and effective management practices.

Species

Seedling damage may be caused by various species of true bugs, including the plant bugs *Melanotrichus coagulatus* and *Atomoscelis modestus* and the seed bug *Nysius raphanus*. These insects use their piercing-sucking mouthparts to feed on plant sap. Heavy infestations of seed bugs have caused plant death in Rocky Mountain regions. These bugs are also known to cause damage in established quinoa plants.

Later in the season, a variety of insects can cause feeding damage to leaves, stems, and seeds. For example:

- **Flea beetles** are small, dark, shiny beetles that can be readily identified by their jumping behavior when disturbed. They have chewing mouthparts and leave small holes in damaged leaves.
- **Beet armyworm**, *Spodoptera exigua*, is the immature stage of a moth. Armyworms are soft bodied and green with dark longitudinal stripes. They can feed on leaves and seed heads, as reported from experimental plots in eastern Idaho. Other caterpillars, such as various species of loopers, have also been reported to cause damage in quinoa.
- **Leaf miners** are the larval stage of beetles and of flies associated with beets. They utilize the tissue between the lower and upper sides of the leaf. Visible tunnels characterize their feeding damage.

- **Aphids** may feed on quinoa foliar tissue and, in large numbers, can result in yield loss. The potato aphids *Macrosiphum euphorbiae* and *Hayhurstia atriplicis* have been reported on quinoa foliage. The sugar beet root aphid, *Pemphigus populivivae*, is one of the aphid species that may cause significant injury toward the end of the season. It is expected to pose a threat to quinoa production, due to the extent of sugar beet production in Idaho.
- **Plant bugs**, *Lygus* spp., seem to be the major insect pest present in Idaho that may inflict significant damage to quinoa seeds. *Lygus* bugs use piercing-sucking mouthparts to feed on plant sap.

Insect pest management

Because no synthetic insecticides are registered for use in quinoa, cultural and biological management options are the only insect-management tools currently available. Selecting an appropriate seeding date, using recommended seeding rates, and adopting recommended irrigation and nutrient management practices help to produce vigorous plants that are less susceptible to insect damage.

In addition, crop rotations (e.g., rotations with cereals and potatoes) will break the continuity of insect pest life cycles, resulting in reduced pest pressure in subsequent years. Increasing habitat biodiversity (i.e., mixed cropping) helps to support populations of natural enemies. Where needed, the release of parasitoid wasps, predators (e.g., lady beetles), and naturally occurring pathogens (i.e., *Bacillus thuringiensis*) can be used to reduce insect numbers.

Pathogens

Although some diseases of quinoa have been identified, information about their epidemiology and impact is limited. Many fungal species that can be detrimental to quinoa have a limited host range and are unlikely to be present in Idaho unless introduced with the seed.

The most serious plant disease on quinoa is downy mildew, caused by the fungus *Peronospora variabilis*. This important and potentially damaging fungal disease is common in the major quinoa production areas (i.e., Peru, Bolivia, Ecuador, and Colombia). Because its oospores can adhere to quinoa grains, this pathogen has spread to most countries where quinoa is grown. However, some cultivars have moderate to high levels of disease resistance.

Downy mildew symptoms appear as chlorotic or yellow lesions on the leaves. Gray fungal bodies are present on the lower surface of the leaf. Eventually, the lesions become necrotic, leading to premature leaf drop, reduced yields, and in some cases stunted plants. Free water and high relative humidity (above 85 percent) are required for *P. variabilis* spores to germinate, and the pathogen is favored by moderate temperatures (64 to 72°F). If downy mildew becomes established, it can quickly spread throughout a field if conditions are favorable.

Although a number of fungicide products are available for managing downy mildew, none is registered for use in quinoa, so growers are presently restricted to cultural controls. Using wide row spacing and avoiding excess irrigation can limit disease development and spread. Since downy mildew can be transmitted on the seeds, it is advisable to use seeds from a field free of the disease.

Several other diseases could occur in Idaho, including leaf spot, seed rot, damping off, brown stalk rot, nematodes, and viruses. Of these diseases, seed rot and damping off by *Pythium* spp. are most likely. To minimize damping off, do not plant in poorly drained, cold, or wet soils.

Harvesting and postharvest processing

Plants are ready to be harvested when the seeds reach the hard-dough stage, plants are dry, and leaves have dropped. The seed heads should be dry enough to allow easy separation of the seeds from the hulls by hand.

Combines can be used for harvest, and growers have had success with swathing first to allow vegetation to dry before combining (figure 4). The combine's cylinder



Figure 4. Quinoa was swathed and left to dry (left) for approximately 1 week before combining (right) (August 2015, Koopman Brothers Farm, near American Falls, ID).

speed and air flow should be greatly reduced below that used with small grains and other crops. Smaller screens are required due to the light weight and small size of quinoa seeds. A fanning mill and gravity separator are usually used to further separate seeds from plant residues after combining.

Seeds must be kept dry during storage. Saponins in the pericarp give quinoa a bitter taste and have negative health effects. Before quinoa is processed for food use, the saponins are removed by soaking the seeds in water or by mechanical abrasion.

Variety selection

Varieties should be selected based on environmental conditions (e.g., temperature and soil types) and management practices (e.g., irrigation). Titicaca, Jesse, and Puno performed well in Moscow, ID. Ongoing studies will identify the most suitable varieties for Idaho.

Conclusions and recommendations

- Quinoa originated in the South American Andes Mountains. It is drought tolerant and has a relatively low water requirement, making it a promising crop for the semiarid, high-altitude environment in eastern and southeastern Idaho.
- Since the crop is new to this region, a market for the harvested product is needed. Successful and sustainable production will also depend on research to determine best management practices specific to the region.
- The planting date should be set so that flowering does not coincide with peak summer temperatures. Early- to mid-April is recommended for eastern and southeastern Idaho.
- Nitrogen rates in the range of 90 to 135 lb N/acre are likely to produce acceptable quinoa yields.
- For acceptable yields, seasonal water (irrigation or rainfall) can be as low as 7 inches, although the optimal amount is 10 to 15 inches.
- Currently, there are no crop protection products registered for use in quinoa in the United States. Until these products become part of an integrated approach to pest management in quinoa, growers must rely on cultural and mechanical methods.
- Weed management can include controlling weeds mechanically or with herbicides before planting,

planting quinoa in wide rows to allow multiple between-row cultivation operations, and/or hand weeding and hoeing. Research is needed to identify herbicides tolerated by quinoa and effective for controlling weeds in this region.

- Various insect species may damage quinoa at different stages of its development. No synthetic insecticides are registered for use in quinoa. Cultural practices and biological controls can be used to manage insect pests.
- The most serious disease on quinoa is downy mildew, but no fungicide product is registered for use in quinoa. Wide row spacing and avoiding excess irrigation can help limit disease development and spread.
- Variety development research is ongoing in eastern Washington and northern Idaho and is planned for eastern and southeastern Idaho.
- Planting mixed varieties instead of a single variety may reduce the risk of yield loss due to poor adaptability. However, this practice may make harvest more difficult due to varied maturity dates and plant height.
- Growers are strongly encouraged to experiment in small areas prior to large-scale quinoa planting and production.

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Trade names

To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

Groundwater

To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

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