Science Societies

# Growing quinoa in Washington State

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*Washington State University researchers have been exploring the feasibility of growing quinoa in the Pacific Northwest. Photo courtesy of Kevin Murphy.*

Washington State University researchers have been exploring the feasibility of growing quinoa in the Pacific Northwest. In their effort to develop new varieties adapted to Washington State, they focused on key traits for improvement and are close to releasing their first varieties that address and improve upon one or more of these characteristics. A new crop to most farmers in Washington, quinoa presents significant production challenges, particularly with susceptibility to heat in the central and eastern parts of the state, susceptibility to pre-harvest sprouting due to early rains in western Washington, and susceptibility to weed pressure almost everywhere.

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At Washington State University, we are exploring the feasibility of growing quinoa in the Pacific Northwest by testing 44 accessions, obtained from the USDA-ARS quinoa germplasm repository in Ames, IA, in three locations across Washington State. Of these 44, only 10 successfully made seed; the rest were short-day varieties that did not flower until late summer to early fall—far too late to produce viable seed. These early trials showcased the need to identify quinoa varieties that were adapted to the long-day conditions of our northern high-latitude (>46°N) environment.

In 2011, we began making crosses between varieties of quinoa that performed well in each location, and our breeding program was off and running. We continue to make crosses and test our material in multiple locations each year. We used a bulk-pedigree selection method and included farmers in an evolutionary participatory breeding trial (Peterson et al., 2015; Kellogg and Murphy, 2019).

In our effort to develop new varieties adapted to Washington State, we focused on key traits for improvement, including seed yield, heat, drought, and salinity tolerance, resistance to downy mildew and pre-harvest sprouting, early maturity, plant height, panicle type, end-use quality, nutritional value, and flavor (Hinojosa et al., 2019b; McGinty et al., 2021; Murphy et al., 2018; Peterson and Murphy, 2015). We are close to releasing our first varieties that address and improve upon one or more of these characteristics.

It quickly became apparent that agronomic studies were also needed to explore best management practices for growing quinoa. A new crop to most farmers in Washington, quinoa presents significant production challenges, particularly with susceptibility to heat in the central and eastern parts of the state, susceptibility to pre-harvest sprouting due to early rains in western Washington, and susceptibility to weed pressure almost everywhere.

## Intercropping

Intercropping is one strategy that can be used for weed control. In 2012 and 2013, we conducted an experiment testing three intercrop treatments—a fescue/clover intercrop, a clover/medic intercrop, and no intercrop—in two quinoa varieties across three irrigation rates (Walters et al., 2016). As expected, irrigation increased seed yield. Across all irrigation treatments, neither intercrop treatment negatively impacted quinoa yield, suggesting the potential for intercropping in quinoa without reducing yield due to competition. Additionally, the intercrop provided cover in the field during the winter months, thus decreasing soil erosion and providing green manure the following season. The fescue grass/clover mix created more winter cover compared with the clover/medic intercrop whereas the clover and medic mixture increased quinoa seed protein.

## Transplanting

Quinoa is typically seeded directly into the soil. It has little to no dormancy and emerges quickly if moisture is present. Once established, it begins to send down a taproot, and during the first four to six weeks, there is very little aboveground growth. This is often when weeds can overwhelm the crop. So we decided to test the possibility of transplanting quinoa in western Washington, a region where many farmers have or can get access to a mechanical transplanter. The utilization of transplant methodology could allow for improved weed control and quicker maturation. We evaluated transplant and direct-seed treatments in three quinoa varieties over two locations at three planting dates and found that the transplanted quinoa reached later development stages more quickly and produced higher yields than direct-seeded quinoa. Weeds were easier to control as the quinoa could be planted later in the season and the wider spacing allowed for easier hand and/or mechanical cultivation. This has potential as a viable alternative in areas where mechanical transplanting is a common practice.

## Palouse

In the dryland cropping systems of the Palouse region, predominant crops include wheat, barley, and chickpeas. To determine where quinoa would best fit in a rotation with these three crops, we conducted a study where we compared eight three-year cropping sequences for crop productivity, crop quality, and economic returns in an organic system (Wieme et al., 2020a). Despite using quinoa varieties that were poorly adapted to the high temperatures of the Palouse, some of the three-year sequences with quinoa produced similar net returns to some sequences with wheat. Soil structure was finer after quinoa compared with the other crops with a higher proportion of aggregates in the smaller size classes (Wieme et al., **2020b**).

We are not yet recommending quinoa to be grown by dryland farmers in the Palouse due to potentially significant yield losses due to high summer temperatures combined with low soil moisture during pollen and seed formation. The combination of heat and drought has been shown to negatively impact quinoa productivity (Hinojosa et al., **2018**). Seed yields in the cooler maritime regions west of the Cascades are often two to three times higher than yields in the Palouse; however, there is an increased chance of yield loss due to pre-harvest sprouting if the fall rains come while the quinoa is still in the field. Therefore, we are currently seeking to identify tolerance to pre-harvest sprouting in a collection of more than 200 quinoa varieties.

## Central Washington


*Researchers at Washington State University tested different high-throughput phenotyping techniques* *to evaluate the performance of quinoa varieties under contrasting irrigation treatments. These included a proximal sensing system using ground platform, a remote sensing with unmanned aerial system (UAS), and a handheld multispectral radiometer (CropScan). Photo courtesy of Kevin Murphy.*

In central Washington, a region with both high temperatures and irrigated farmland, there is potential for successful quinoa production with timely deficit irrigation. In a 2019 study, we tested different high-throughput phenotyping techniques to evaluate the performance of quinoa varieties under contrasting irrigation treatments (Sankaran et al., 2019). These included a proximal sensing system using ground platform, a remote sensing with unmanned aerial system (UAS), and a handheld multispectral radiometer (CropScan) that we used at multiple stages of crop development. We found that normalized difference vegetation index (NDVI), water band index, and green NDVI data from CropScan and green NDVI and canopy temperature data extracted from the UAS allowed us to detect irrigation treatment effects. This type of rapid data acquisition can give farmers the technology to detect when different quinoa varieties are under water stress and allow them to apply irrigation in a timely and efficient manner.

In a separate study, we used NDVI, green NDVI, and physiological parameters including stomatal conductance, leaf temperature, and area under soil plant analysis development value decline curve (AUSDC) to compare four heat-tolerant quinoa varieties to four heat-susceptible varieties in irrigated and rainfed treatments in two locations over two years in Washington State (Hinojosa et al., **2019a**). Using AUSDC analysis, we found that the variety QQ74 had the highest leaf greenness and the variety Japanese Strain had the lowest; this fit with our data, which classified QQ74 as heat tolerant and Japanese Strain as heat susceptible. We also found that NDVI could potentially be used to predict grain yield in quinoa.

## Quinoa Market Demands

*Quinoa population growing in Mount Vernon, WA. Photo courtesy of D. Griffin LaHue.*

Throughout the process of breeding new quinoa varieties and exploring effective methods of production, it is critical to keep in mind the demands of the domestic quinoa market. End-use quality is important to quinoa processors and food companies that use quinoa as an ingredient in their products. We work closely with researchers in the Washington State University School of Food Science to characterize physicochemical seed composition in different quinoa varieties that allow us to develop market classes (Aluwi et al., **2017**). Flavor and consumer acceptance is also important to consider, and we work towards identifying varieties that are best suited to fresh eating, use in baked products, or extruded snacks (Wu et al., **2017a**; **2017b**).

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