BUCKWHEAT PRODUCTION WEST OF THE CASCADES

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Buckwheat Production West of the Cascades

By

Rachel Breslauer, Graduate Research Assistant, Department of Crop and Soil Sciences, Washington State University
Justin O'Dea, Regional Agriculture Specialist Faculty, Clark County Extension, Washington State University
Stephen Bramwell, Associate Professor and County Director, Thurston County Extension, Washington State University
Kevin Murphy, Professor, Department of Crop and Soil Sciences, Washington State University

Abstract

Buckwheat is a promising crop to integrate into crop rotations west of the Cascades. This publication aims to synthesize research and regional experiences with the crop to guide new producers in this region. The starchy, gluten-free seed has a variety of food system applications, including flour, groats, and malt, which opens a variety of niche and regional marketing opportunities for the crop. Additionally, well-established buckwheat stands can provide excellent weed suppression in organic and conventional systems alike. Key considerations for establishing a strong stand, such as nutrient management, field preparation, planting conditions, and irrigation, are discussed. Major challenges and potential management strategies for buckwheat production west of the Cascades are outlined in this publication and include avoiding flooding stress, determining irrigation requirements, harvesting and processing the crop, as well as accessing regional markets.

Introduction

Buckwheat is a unique, grain-like crop that has primarily been a minor feature in Pacific Northwest (PNW) crop rotations but has strong production potential in the region. Washington State is among the top buckwheat-producing states in the United States, with production concentrated in the irrigated Columbia Basin. Buckwheat produces starchy, edible seeds that can be ground into flour and incorporated into a variety of food products, much like cereal grains. Despite the misleading name, buckwheat is not a type of wheat at all and is more closely related to rhubarb. The seeds of this "pseudocereal" are completely free of gluten, the seed protein that causes an autoimmune response in people with celiac disease, making it an attractive crop for gluten-free (GF) food markets.

Outside of GF markets, buckwheat has a wide array of culinary uses in unleavened baked goods, noodles, and cereals when blended with cereal grain flours. Buckwheat is used in a range of traditional Asian and European dishes, including kasha (toasted groats, Russia), blintzes (cheese-filled crepes, Poland and Czech Republic), Breton galletes (crepes, France), pizzoccheri (pasta, Italy), soba (noodles, Japan), and naeng myun (noodles, Korea). Buckwheat flour can also partially or entirely substitute wheat flour in a variety of leavened baked goods, including pancakes, waffles, and breads (Figure 1).

The term "buckwheat" can refer to three different species: *Fagopyrum esculentum*, *Fagopyrum tataricum*, and *Fagopyrum homotropicum*. Common buckwheat (*F. esculentum*) constitutes 90% of global buckwheat production and is the only *Fagopyrum* species cultivated at scale in the United States. Common buckwheat (hereafter "buckwheat") was domesticated in the Yunnan Province of China; the first archeological evidence of its use dates back to 2500 years ago (Konishi et al. 2005; Wen et al. 2021).

Buckwheat is a summer annual that is well adapted to regions with temperate, humid climates and consistent in-season precipitation. At this time, nearly all commercial buckwheat production in the PNW is east of the Cascades in the Columbia Basin. Buckwheat production west of the Cascades is less common but promising because of the favorable climate. Depending on the distribution of precipitation in a given year and planting time, buckwheat can either be produced as a completely rainfed crop or with supplemental irrigation. Many growers also use buckwheat as a cover crop and value it for its fast-growing and weed-suppressive properties within a crop rotation during the summer. Buckwheat can also provide forage for pollinators when there is otherwise little available in the late summer or early fall (Figure 2). As a grain-like crop, it can fill a similar niche within a crop rotation, as long as growers have access to grain production equipment.

Figure 1. Baked goods with partial substitution of wheat flour with buckwheat flour. Buckwheat flour can add flavor and nutrition to a variety of leavened baked goods without negative effects on baking properties. Products shown here (*left to right*) are pancakes, focaccia, and brownies. Photos: E. Nalbandian.

Figure 2. Two different species of pollinators foraging on a buckwheat crop. Buckwheat is a cross-pollinated species, so pollinators play a major role in its life cycle. A buckwheat crop can provide a welcome source of forage for pollinators in the late summer when there are otherwise few other plants flowering in the environment. Photo: J. O'Dea.

Knowledge of the performance and availability of different buckwheat varieties is much less developed than for other staple crops, such as wheat, barley, or corn. Sometimes buckwheat is referred to as "unimproved" due to limited breeding and selection. This is especially true in North American production systems and is an emerging area of research in the PNW. This publication aims to synthesize available information about growing and marketing buckwheat west of the Cascades for beginning buckwheat growers in the area.

Soil and Crop Management

Fertility

Buckwheat crops are typically grown with minimal added fertilizer, particularly after heavily fertilized crops. Fertility needs are still relevant for buckwheat because, as with any other crop, excessively low fertility will limit plant growth and yield. If persistent spring rains extend into late May or early June, winter-fallowed soils may be notably low in available nitrogen (N) and sulfur at buckwheat planting, which typically occurs from May to June west of the Cascades. Spring nutrient release from incorporated winter cover crop residue may be delayed, especially from grassy cover crops, until soils have warmed sufficiently (Figure 3).

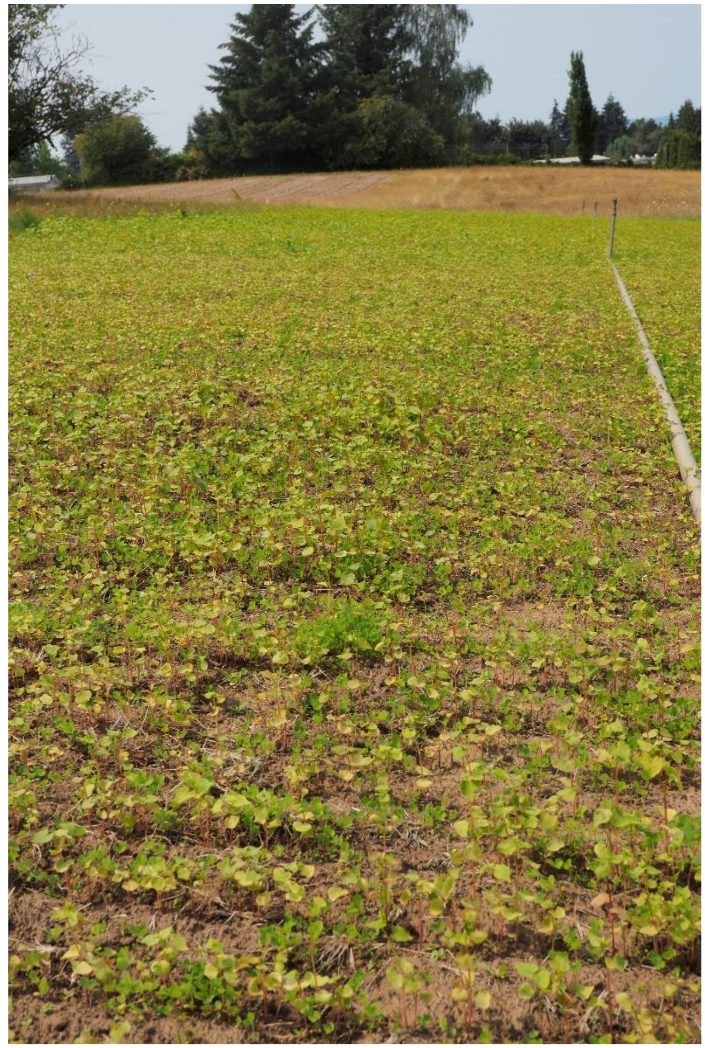

Figure 3. A buckwheat cover crop showing signs of low nutrient availability (pale green color, stunting) due to insufficient sod breakdown and nutrient tie-up by soil microbes. This cover crop was the first crop sown in this field after many years of mowed sod. Microbes outcompete plants by consuming the previous crop residue more efficiently. Nutrient demand is greater the more carbon-rich or "woody" the residue is. Nutrients will remain bound up in the previous crop and microbial biomass until the residues are broken down. This crop would have benefitted from added fertilizer despite buckwheat's reputation as a crop with low fertility needs. Photo: J. O'Dea.

While there are no buckwheat fertilizer guidelines for the PNW, those developed for buckwheat in Minnesota (Kaiser et al. 2011) are used as a baseline for this publication. Minnesota's N guidelines use a yield goal approach and require an estimate of expected yield potential, preplant soil nitrate-N content measured from the top 24 in. of the soil, and any expected N credits from previous legumes or cover crops. These guidelines can inform fertility decisions but should not be strictly followed for buckwheat grown west of the Cascades, because they were developed for a region with different cropping systems, soil types, and climates. For example, the N guidelines use a 24 in. soil sample, whereas many growers west of the Cascades take shallower soil samples, often around 8 in.

Nitrogen requirements for buckwheat tend to be low compared to other field crops because excess N can cause buckwheat to lodge (fall over) during grain fill. Fertilizer N recommendations can be calculated using an expected yield, preplant soil NO_3-N, and expected N supply from a previous crop or cover crop. First time growers may estimate a yield of 750–1,000 lb/acre as a modest and realistic yield for our region. The publication *Estimating Plant-Available Nitrogen Release From Cover Crops* (Sullivan et al. 2020) from Oregon State University can be used to estimate N credits from a previous cover crop (see Equation 1).

Phosphorous (P) fertilizer rates can be similarly calculated below using a Bray P soil test (ppm) and expected grain yield (lb/acre). The Bray P test is used for soils with a pH <7.4, which is typical west of the Cascades. If the soil is alkaline (more common in the inland Northwest), it should be tested using an Olsen extraction instead, and the P fertilizer calculation should be modified accordingly (Equation 2) (Kaiser et al. 2011).

Buckwheat is also known for its ability to scavenge P from soils, even in alkaline soils where P can be strongly bound to calcium (Zhu et al. 2002). Additionally, it is rare to need to apply P to grains grown within high-input vegetable rotations typical in the Puget Sound Basin and Willamette Valley (Sullivan et al. 2017). It is unlikely that P additions will be recommended for soils tested in this region.

Similar to P, potassium (K) requirements for grains are typically lower than that of vegetable crops. Soil test K values higher than 200 ppm are considered sufficient for vegetable crops west of the Cascades (Sullivan et al. 2017). Buckwheat requires less K; no potash is recommended in buckwheat in Minnesota for soils testing higher than 160 ppm. It is also unlikely that K additions are needed for buckwheat production in this region.

Outside of macronutrient requirements, a soil testing lab can be contacted to identify limiting micronutrients in a soil test. While there are no guidelines for micronutrient deficiencies in buckwheat, excessively low levels can impact all crop production.

Field Preparation

While buckwheat is regarded as a resilient crop due to its low fertilizer requirements and rapid maturity, it is acutely sensitive to several environmental stresses early in its life cycle. To ensure strong crop emergence and establishment, growers need to optimize planting conditions.

Buckwheat crops require an even and well-drained seedbed. If the field is coming out of pasture or fallow, work the soil a minimum of several weeks before planting buckwheat so that residues begin to decompose (Björkman 2010). Excess plant residues can cause uneven planting depth, temporarily immobilize plant-available nutrients, and disrupt crop emergence, thereby reducing stands. Similar problems can be caused by excessively rocky soils. If these conditions are unavoidable, stands may be improved by increasing seeding rates.

Growers who use herbicides should ensure that there are no labeled rotational restrictions or residual herbicide effect risks from previous broadleaf herbicide applications. Herbicides containing atrazine, imazethapyr, halosulfuron, and fomesafen will negatively affect buckwheat stand and development (Björkman et al. 2008).

Equation 1. $Nitrogen\left(\frac{lb}{acre}\right) = 0.0458 * Expected\ yield\left(\frac{lb}{acre}\right) - Soil\ test\ NO_3{-}N_{[0-24\ in.]}\left(\frac{lb}{acre}\right) - N\ supply\ from\ previous\ crop$

Equation 2. $P_2O_5\left(\frac{lb}{acre}\right) = [0.0275 - 0.0014 * Bray\ P\ (ppm)] * Expected\ yield\ (\frac{lb}{acre})$

Sourcing Commercial Varieties

In major buckwheat-producing areas of the US and Canada, seed is primarily sourced directly from mills through closed-loop contracts. Because there are no major buckwheat mills in the PNW, growers must identify independent sources of certified seeds and named varieties.

While there is value to growing named varieties, it is most common for growers to find buckwheat seed for which the variety is not specified (VNS). This is because buckwheat cross-pollinates and requires isolation from other varieties to produce certified seed. For example, the Montana Seed Growers Association requires at least 660 ft isolation between buckwheat varieties (including VNS buckwheat) for their producers. A VNS seed source is an excellent option for growing buckwheat cover crops and can also be used for growing buckwheat for seed and sale. The challenges that come with VNS seed include crops that have variable seed color, size, yield, time to flowering, and time to harvest both within a seed lot and in lots purchased across years. Variable maturity, yield, and seed characteristics can pose challenges for management and consequent marketing. Additionally, any named buckwheat varieties grown near VNS buckwheat can only be marketed as VNS if the seed is sold for seed or replanted and sold.

Certified buckwheat seed will have less variability in plant characteristics (height, flowering time, maturity) and seed characteristics (size, color) (Figure 4). Varieties that are early maturing or have a long flowering period are more likely to be suitable for production west of the Cascades. Early-maturing varieties help avoid crop maturation that is too close to the start of fall rains. A long flowering period helps assure that the crop has ample opportunities to yield seed when conditions are favorable, which can compensate for yield losses during high summer temperatures due to seed abortion.

Seed improvement associations often provide updated information on which commercial varieties are available for purchase each year. For this publication, we reviewed available crops and varieties of crop improvement associations in Washington, Minnesota, New York, North Dakota, Manitoba, Saskatchewan, Ontario, Quebec, and Alberta/British Columbia. In Washington State, certified seed for buckwheat was last available in 2017 (Washington State Crop Improvement, n.d.). The Manitoba Seed Growers Association is the only organization that has listed contact information for certified buckwheat growers for the past five years. The most commonly available varieties from growers in this association are ‘Koma’, ‘Mancan’, and ‘Horizon’.

The commercial varieties that have been registered in the US or Canada are summarized in Table 1. It is challenging to find certified seed of the newest varieties outside of closed-loop contracts with mills. The most likely varieties to be available on the market, such as ‘Mancan’, ‘Manisoba’, and ‘Koto’, are older but still have high yields. If you decide to buy from a Canadian seed supplier, be aware that the importation process may delay or prolong delivery.

Table 1. List of commercial buckwheat varieties registered in Canada or the United States.

Variety	Year	Country	Submitted by	Issued Plant Breeder Rights or Plant Variety Protection Certificate
Mancan	1974	Canada	Agriculture and Agri-food Canada	
Manor	1980	Canada	Agriculture and Agri-food Canada	
Winsor Royal	1983	USA	Winsor Grain, Inc.	Yes
AC Manisoba	1996	Canada	Agriculture and Agri-food Canada	
AC Springfield	1997	Canada	Springfield Mills	
Koban	1999	Canada	Agriculture and Agri-food Canada	
Koto	2000	Canada	Agriculture and Agri-food Canada	Yes
Koma	2005	Canada	Kade Research	Yes
Horizon	2011	Canada	Mancan Genetics	

Variety	Year	Country	Submitted by	Issued Plant Breeder Rights or Plant Variety Protection Certificate
Kenmar	2016	Canada	Springfield Mills	
Takane Ruby 2011	2016	USA	Takano Co. Ltd.	Yes
Aoi	2017	USA	McKay Seed Co. Inc.	Yes
Agassiz	2019	Canada	Mancan Genetics	

Figure 4. Commercial buckwheat varieties with different seed shapes and colors: La Harpe (*top left*), Manisoba (*top right*), Koto (*bottom left*), Zoe (*bottom right*). Photos: A. Chatman.

Day Length Sensitivity

Similar to soybeans, which have different maturity groups, buckwheat can exhibit a range of day-length sensitivity (response of crop growth and development in response to the length of time exposed to sunlight) from short-day (SD) to day-neutral (DN) (Romanova and Koshkin 2010) . Short-day varieties flower sooner and set more seed when growing in decreasing day lengths (after the summer solstice) whereas DN varieties do not develop differently in response to day lengths. Unlike soybeans though, there is little information about day-length sensitivity of North American buckwheat varieties, such as those listed in Table 1.

Because ideal seeding dates can be influenced by the degree of day-length sensitivity of the buckwheat variety being grown, more research is needed in our region to guide ideal planting times west of the Cascades. While this knowledge gap persists, it is safest to assume that a buckwheat variety is SD unless there is information otherwise. For SD varieties, seeding as late as soil moisture allows (or using irrigation) will optimize flowering and grain yield. Planting a SD variety too early will lead to excessive vegetative growth and poor yield and should be avoided if possible.

In the inland PNW, growers are able to plant after the solstice in decreasing day-length conditions and still have their crop mature in the fall before harvest conditions become unfavorable due to rain and poor drying conditions. In these systems, there is no issue with growing SD varieties. In contrast, using SD varieties and planting this late is not ideal west of the Cascades because it will require more in-season irrigation and the crop may not mature before harvest conditions decline. This should be considered when determining a seeding date west of the Cascades. Otherwise, if available, growing DN varieties would be preferable west of the Cascades.

Seeding

Buckwheat can be planted using a grain drill or broadcast followed by incorporation. Keeping planting depth shallow (0.5–1 in.) is important for allowing the seeds to get warm enough to germinate well. There are approximately 20,000 buckwheat seeds per pound, and buckwheat has a standard density of 48 pounds per bushel. A seeding rate of 40–60 lb/acre (12–18 pure live seeds/ft^2 for a standard-sized seed) with a drill set up for 6–8 in. row spacing is common for buckwheat. When available, a drill is more effective for producing a uniform stand. If your drill does not have a recommended buckwheat setting in its seeding rate chart, the barley setting that is closest to 50 lb/acre is likely to be close to what the setting should be for buckwheat at 50 lb/acre. The drill can be calibrated from there for a more fine-tuned seeding rate for buckwheat. For broadcast seeding, spread 70–100 lb/acre and harrow in lightly. Overly dense stands of buckwheat may be more prone to lodging. Conversely, thinner stands of buckwheat may gradually fill in via branching off the main stem as long as plant available water and nutrients are sufficient.

In reality, anywhere from 8,700–25,200 seeds/lb have been observed in Washington State University's buckwheat trials, so seeding rates may need to be adjusted for a particular seed source if the thousand seed weight (TSW) is known. The equation below can be used to calculate an appropriate seeding rate in lb/acre given a seed source TSW and seeding density (e.g., 12–18 pure live seeds/ft^2). If the germination rate of a seed source is known, the seeding rate can be further adjusted by dividing by the germination rate (see Equation 3).

Buckwheat should be planted in moist soils due to its shallow planting depth. While moist soils are required for germination, buckwheat is highly susceptible to flooding damage and seedling rot, especially preemergence. It is not optimal to plant if major rain events that might lead to standing water in the field are forecasted within a week after planting. With sufficient soil moisture and temperatures, seeds can germinate within 24 hours and emerge within 2 days or up to 1 week after planting.

Planting Time

Buckwheat cover crops can be planted any time after the risk of frost and standing water has passed. Growing a buckwheat crop for seed requires additional consideration to maximize seed set and ensure that the crop matures at an appropriate time. Conditions that limit buckwheat production are summarized in Table 2. In general, the most important environmental stress to avoid is early-season frost and preemergence flooding. Other limiting conditions, such as flooded soils later in the season and high temperatures at flowering, can factor into planting time choices but ultimately are not foreseeable and therefore cannot be controlled.

Ideal planting times for growing buckwheat west of the Cascades depend on the risk of high temperatures during flowering, soil type, and whether the crop will be irrigated. Our planting time guidelines are summarized in Figure 5.

Equation 3. $$Seeding\ Rate\ \left(\frac{lb}{acre}\right) = 2.2 * \frac{TSW\ (g)}{43560} * Seeding\ Density\ \left(\frac{seeds}{ft^2}\right) \div Germination\ Rate$$

Table 2. Summary of growing conditions that can limit buckwheat production in the western Pacific Northwest.

Limiting Conditions	Explanation
Frost	Frosts at seedling and early vegetative stages can kill or stunt buckwheat plants (Kalinová and Moudrý 2003). Frosts before harvest can also complicate harvest operations.
Flooded soil	Buckwheat is flooding sensitive but particularly at the seedling stage and early growth stages (Bjorkman 2001; Murayama et al. 2004; Sakata and Ohsawa 2006; Choi et al. 2021).
Nighttime air temperatures <45°F around planting	Buckwheat needs a minimum air temperature of 45–50°F to germinate, grow, and develop (Arduini et al. 2016).
Air temperatures >85°F around flowering (4–6 weeks after planting)	Buckwheat female reproductive structures are sensitive to temperatures higher than 85°F. Flowers begin to show signs of heat stress, ovules can be damaged, and the likelihood that forming seeds will abort is high .
Optimum soil temperature of 80°F (between 45 and 105°F)	An ideal soil temperature for buckwheat germination is around 80°F, or otherwise from 45 to 105°F. Nonuniform soil temperatures, which are common in the spring, can result in an uneven stand (Kandell 2019).
Excessive rainfall around harvest	Excessive rainfall around crop maturity can cause fungal growth and preharvest sprouting damage, thereby lowering crop quality at harvest.
Planting in early May	Photosensitive buckwheat varieties develop more quickly in short-day conditions, making planting in June or later ideal. This timing allows for flowering and seed development to occur after the summer solstice, which will shorten the life cycle of the plant (Quinet et al. 2004; Michiyama et al. 2007; Arduini et al. 2016). (See above section Day Length Sensitivity for additional information.)

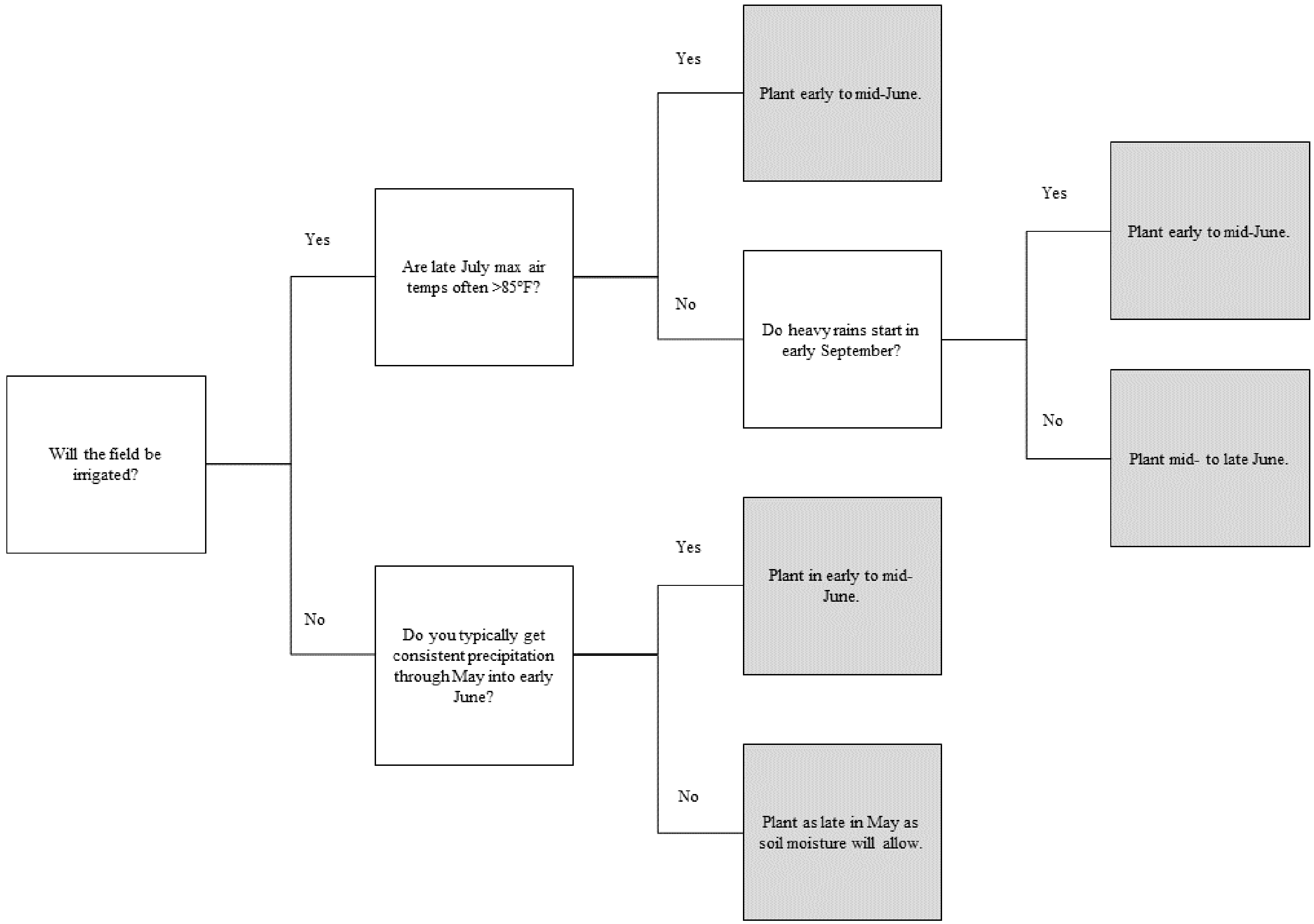

Figure 5. Buckwheat planting time flowchart for production systems west of the Cascades.

Irrigation and Water Requirements

Buckwheat requires relatively little water to complete its life cycle. Nonetheless, as a crop with a shallow root system that is well adapted to temperate, humid climates, it responds strongly to available water, and its ability to thrive in droughty conditions is limited. It is normal for unirrigated buckwheat to begin to wilt throughout the heat of the day during dry spells and recover at night. If the crop does not recover overnight and still looks wilted in the morning, it is likely drought-stressed and would benefit from irrigation.

Considering the planting time and soil type is key to reducing the risk of drought stress in a buckwheat crop. Since buckwheat is planted at shallow depths, it is optimal to have moist soils, rain in the forecast, or irrigation to ensure that the crop will emerge quickly and compete with weeds but is not irrigated so much that it will cause flooding stress. Additionally, be sure to select fields carefully as buckwheat grown on coarse-textured soils without irrigation or in-season precipitation will likely be drought-stressed. Because the Willamette Valley, Chehalis, and Puget Sound Basin commonly experience prolonged dry, hot spells from July through September, growers may generally consider irrigation for their buckwheat crops even if they are on more fine-textured, well-drained, non-floodplain soils (Figure 6).

Buckwheat is a good crop choice for floodplain soils that otherwise are not workable until late May or June. The high water table in these soils can also provide moisture later into the growing season.

Figure 6. Buckwheat responses to different levels of available water. The left image illustrates high water stress causing stunted stature, thin stems, and premature leaf yellowing. The middle image illustrates typical moderate water stress exhibited in an unirrigated crop during midday with plants showing some leaf wilting, moderate stunting, and light leaf yellowing on some lower leaves. The image on the right illustrates a well-irrigated, dense cover crop with succulent, tall vegetative growth (~4') and negligible levels of wilting or leaf yellowing. Photos: J. O'Dea.

Growers may also choose to irrigate due to the crop's strong growth and yield response to water. Yields of irrigated buckwheat nearing one ton/acre (40 bu/acre) may be possible in the PNW, based on a reported estimate from eastern Washington (Pavek 2016). Irrigation rate guidelines have not been determined for buckwheat in any parts of the PNW though. In general, it is preferable to conclude irrigation as seeds begin to set to prevent preharvest sprouting and allow the crop to mature.

Weed Management

Buckwheat grows rapidly and can be very weed-suppressive if the stand is strong. Having a strong stand depends on low early-season weed pressure, high emergence rates, and limited early-season water stress.

Early-season weed pressure can be reduced using a stale seedbed before planting. In this approach, the seedbed is prepared two to three weeks before planting, allowing weeds to germinate following the initial soil preparation. Shallow cultivation or herbicide burndown is then used to eliminate weeds before seeding. Minimal disturbance is used at seeding to prevent additional weed germination. More information on the stale seedbed approach can be found in the Site Preparation, Stale Seedbeds, and Directed Nonselective Applications section of the Pacific Northwest Pest Management Handbooks (Peachey 2022). Once buckwheat is planted, harrowing is not advisable, as this could easily damage seedlings and young plants. All herbicides registered for buckwheat in Washington and Oregon can be found at the WSU PICOL website. Most of these are either preemergence or preplant burndown products. Several of the burndown products can also be used in certified Organic production. The only herbicide registered for selective postemergence weed control of grasses in buckwheat in Washington and Oregon is sethoxydim (Poast). Instructions for its use in buckwheat can be found on the supplemental label for borage, buckwheat, dill, okra, and root vegetables.

Buckwheat does not tiller like a cereal grain, but it will develop branches to fill in gaps in the canopy. Even though the crop will eventually compensate for gaps, thin emergence may nonetheless impact early season weed suppression. Growers who are especially concerned with weed suppression may consider increasing seeding rates by 50–100%, even when planting with a drill. Overseeding buckwheat is common in organic systems to ensure exceptionally high emergence rates and high early-season weed suppression. There are drawbacks to overseeding though besides the extra seed cost. There can be more competition for water between buckwheat plants, and crowded stands may be more prone to lodging if stand growth is otherwise vigorous.

Buckwheat's shallow root system can efficiently capture water supplied in-season to produce vegetative growth, but it will struggle to compete with weeds with deeper root systems for stored soil water. This can be especially true if conditions become dry early on or when soils are compacted. Managing early water stress with irrigation during crop establishment can be a key strategy to preventing weeds from taking over early. A strong start for the plant also helps establish a more robust root system that can help stands capture soil nutrients early and withstand dry conditions later in the season.

Pests and Disease Management

Pests and diseases that are reported in buckwheat in North America are typically minor and rarely managed in the field. Diseases of buckwheat can include powdery mildew, aster yellow disease, stem rot, Botrytis leaf blight, downy mildew, beet curly top virus, and Rhizoctonia root rot. Insect pests that have been documented in buckwheat include wireworms, aphids, grasshoppers, and cutworms. See the Postharvest Management section for common storage pests.

Harvest

Buckwheat is an indeterminate plant, so it will continue to put out new growth and flowers long after the first wave of seeds have set. Buckwheat harvest timing is a balance of (1) allowing the crop to produce as much seed as possible without risking losing seed to shatter (seed naturally dropping off the plant onto the ground) and (2) being able to harvest before damp fall weather prevents harvest operations and reduces seed quality. As the crop begins to mature, be sure to watch the long-range weather forecasts. If seed is not shattering and the forecast is rain free, growing the crop for longer can increase seed yield if the stand is still flowering. The latter may be especially important in the greater Willamette Valley where high summer temperatures over 85°F may be more persistent, diminishing midsummer yield potential due to seed abortion. Conversely, mature seed that remains in late-season damp conditions for too long may develop mold or cause preharvest sprouting that can reduce seed quality.

Like all grain or seed crops, a combine is needed to efficiently harvest buckwheat at-scale. It is common though for growers to preharvest buckwheat with a swather, which cuts and then lays the plants into windrows on top of the buckwheat stubble to dry before harvesting (Figure 7). Windrows are then harvested with a pickup header attached to the combine.

Figure 7. A swathed buckwheat stand that has been cut and formed into windrows before harvest. These windrows allow for the plants to dry and green seeds to mature before going through a combine. Buckwheat can be swathed when 70–80% of seeds are mature and have turned brown, black, or grey. Photo: R. Breslauer.

If swathing is possible, this practice will shorten the growing period, minimize seed shattering, and help maximize seed yield. Moreover, the dry plant material will allow for the chaff to be more easily separated from seed during harvest. This produces a cleaner and drier crop coming straight out of the combine and may reduce some postharvest management demand. This is one of the major advantages of being able to swath buckwheat, along with the ability to safely time your harvest before the threat of damp fall weather begins to mount.

The stand can be swathed when 70–80% of seeds are mature and have turned from green to brown, grey, or black (Figure 8). This stage can be challenging to determine and may take some practice and familiarity with the crop. Cutting higher on tall stands will enable windrows to dry faster even if it rains after windrows are formed, although this may have drawbacks with a short-statured crop that has seed on lower branches. Some growers may prefer taller varieties for this reason. If conditions permit, allow the windrow to sit for a minimum of one to two weeks. In addition to allowing the biomass to dry, it allows some of the remaining green seeds to mature (Figure 9).

Figure 8. Buckwheat cymes or flower clusters at various stages of maturity. At top, we see only dry flowers and green, unripe seeds. In the middle, approximately half of the seeds on the cymes are mature and brown while green seeds remain. At bottom, we see a nearly mature cyme, with more than half of the seeds fully matured and the remaining underripe seeds beginning to change color. Photos: R. Breslauer.

Direct combining is possible for growers without swathing capacity, although there are some notable drawbacks. The main challenge with direct combining is handling the green matter that will inevitably end up in the hopper at harvest. If weather permits, harvesting later in the season allows for the crop to die back and reduce green matter at harvest (Figure 10). In some years fall rains start earlier and make this strategy difficult. Regardless of the time the crop dries down green matter will still inevitably get into the hopper (Figure 11). Postharvest seed drying and cleaning is therefore very important to prevent seed spoiling in storage. This capacity is often needed immediately postharvest (see section Postharvest Management).

Depending on the combine and manual-suggested crop settings, it is often easiest to start with the settings for another grain if buckwheat is not listed and then adjust from there. For this approach, begin with the settings for barley but with a slower concave speed and higher fan speed. If buckwheat blows out the back of the combine, reduce the fan speed. If the lower fan speed allows excessive chaff into the hopper, increase the fan speed again and steepen the angle of the chaffer. Though some seed damage is expected, many dehulled or cracked seeds in the hopper suggests that the concave may be too tight or the cylinder speed may be too high. A high concave speed may also lead to excessive fine-chopped green matter getting through the sieves in the combine. If excessive green matter is still getting in the hopper, flatten the angle of the chaffer as long as it is not letting excessive buckwheat seed out the back. Rotary combines will need a bean-type rotor to avoid

Figure 9. A freshly cut buckwheat plant with mature and immature seeds (*top*) and the same plant after drying (*bottom*). Terminating buckwheat stands by swathing helps green seeds mature and biomass dry down for a smoother harvest and higher yields. Photos: J. O'Dea.

clogging. Outside of these guidelines, the following settings can be used as a starting point for figuring out the optimal settings for a combine (modified from Myers, 2002, and Björkman, 2010):

1. Fan speed: 600–800 rpm
2. Cylinder: 500–800 rpm (~ 1/3 to 2/3 the speed used for wheat, barley, or oats)
3. Concave: 3/4 to 1/2″ (front), 3/16 to 1/2″ (rear)
4. Chaffer: 5/8 to 3/4″ open (or ~2/3 open)
5. Sieve: 1/4 to 3/8″ open (or 1/4 to 1/3 open)

Other direct-combining guidelines are as follows to reduce combine clogging and maximize cleanliness of seed:

1. Wait until most seeds easily come off the plant (but do not shatter).
2. If the crop is very dry with seeds that shatter easily, combine early in the morning when dewy or keep reel speeds low to limit shattering.
3. If the crop is tall (~3–4′), cut high to avoid stem wrapping around the header auger.
4. Keep ground speed low to avoid overloading the combine with green matter.
5. If the crop is short (<3′), cut low enough to capture seeds on the lower branches of the plant.
6. Harvest before frost to avoid limp stems and the risk of shatter.

Figure 10. A mid-September buckwheat crop showing signs of becoming optimal for direct harvest (*top*). Flowering begins to decline, and plants begin to look more "autumnal" as the crop completes its life cycle. A buckwheat stand ready to direct combine (*bottom*). Most seeds are mature, leaves have died back, and flowering has ceased even while stems are still holding some color. Mature buckwheat stands will rarely be completely dry before harvest. Photos: J. O'Dea (*top*); S. Bramwell (*bottom*).

Figure 11. Direct-combined buckwheat is very likely to be contaminated with green matter since the plant is usually still alive at harvest. Optimized combine settings are helpful, but the capacity to dry the harvested crop as soon as possible is imperative to avoid spoilage of the crop, even in short-term storage. Photo: S. Bramwell.

Small harvests for specialty markets, farmers markets, or home use may be harvested by hand and threshed using a stationary combine (Figure 12). Standing buckwheat can be hand-harvested using a hand scythe and left to sit for ripening. Bundles can be bound together in sheaves and further hung to dry if necessary. Alternatively, a sickle bar mower can be used to terminate the stand, but the crop will need to be windrowed manually to cure in the field. A stationary thresher can be comanaged by several growers and easily transported for use on small scales. Threshing by hand is also possible but is likely to be labor intensive and uneconomical if producing for market.

Postharvest Management

A two- or three-screen cleaner is usually the most common, accessible, and versatile option for cleaning buckwheat seed. The majority of buckwheat will not pass through a 7/64″ round hole. Standard screen sizes and hole shapes used for cleaning buckwheat with an air screen cleaner are shown in Table 3. Keep in mind that buckwheat seed size can vary dramatically by variety. In one Washington State University buckwheat trial, we found some varieties with seeds twice as large as others. Consequently, the optimal screen sizes will depend on the seed size of the variety grown.

Figure 12. Swanson B1 stationary thresher. This machine has typical grain threshing adjustments, including fan speed, concave spacing, and chaffer angle. It can be used to thresh a variety of grain sizes and is effective for threshing buckwheat with minimal green matter contamination. Sheaves are fed into the threshing unit from the tray as shown here. Threshed seed deposits into a base below the unit and chaff is blown out the end to the right. Power is generated from the mounted auxiliary engine. Photo: J. O’Dea.

Table 3. Standard sizes and shapes of screens used for buckwheat seed cleaning.

	Screen 1	**Screen 2**	**Screen 3**	**Screen 4**
Two-screen cleaner	14/64 to16/64″, round	6/64″ × 3/4″, oblong, or 7/64 to 8/64, round	N/A	N/A
Three-screen cleaner	16/64″, round	14/64″, round	6/64″ × 3/4″, oblong, or 7/64 to 8/64, round	N/A
Four-screen cleaner	16/64″, round	7/64″, round	14/64″, round	6/64″ × 3/4″, oblong

Heated drying is useful, particularly when direct combining, because green matter from buckwheat or weeds can easily become mixed with the harvested seed (Figure 12). Similar to other grains, buckwheat can be damaged if it is heated above 110°F during drying. If heated drying is not available, natural air drying can be effective when the weather is warm and the relative humidity is below 65%. Under most circumstances, running drying fans at night or on rainy days without heated drying can be counterproductive. Natural air drying should only be used in these conditions if the seed contains green matter.

Seed will dry out more quickly when spread out in thin layers. Deep layers of grain can develop a layer of accumulated moisture that can be difficult to move through and out of the seed. Seed should be flattened out evenly in the dryer to facilitate even movement of air through the seed; seed containing very wet material should also ideally also be stirred intermittently to prevent pockets of spoilage where fine green matter may have accumulated. Avoid overdrying to maintain test weight (48 lb/bu) and seed hardness for milling.

Three methods can be used to monitor seed moisture during drying. Seed moisture content needs to be less than 13% to store, but higher than 16% and seed is at risk of spoiling (Wilke and Bjorkman 2009). The most straightforward method is using a grain moisture sensor with a buckwheat setting. If this is not possible, another simple method is inserting a humidity probe into the grain. It can be used to check the relative humidity (RH) of the air in between the seeds after turning the fans off for an hour. If the RH remains under 60%, the seed is likely to be ≤12–13% moisture content and is safe for long-term storage. A more precise but time-consuming method is manually determining moisture content. Take and weigh a representative 1-pint sample, dry it for 24 hours at 275°F, and weigh it again. Calculate the moisture content using the formula in Equation 4.

After drying is complete, aerating intermittently on cool, dry (≤60 RH%) days will help keep seed cool and discourage stored grain pests. Grain pest management is also aided by putting your seed into clean drying and storage vessels that have proofing against rodents. Buckwheat-specific storage pests include the granary weevil (*Sitophilus granaries*), greater rice weevil (*Sitophilus zeamais*), rice weevil (*Sitophilus oryzae*), and saw-toothed grain beetle (*Oryzaephilus surinamensis*).

$$\textbf{Equation 4}. Moisture\ Content\ (\%) = 100 \times \frac{(Wet\ Weight - Oven\ Dry\ Weight)}{Wet\ Weight}$$

Crop Rotation Considerations

As with any grain or seed crop, volunteer management following harvest is important. Few experienced buckwheat growers cite volunteer buckwheat as a major concern in their systems though fear of buckwheat volunteer pressure is common for prospective growers. Generally, buckwheat has low dormancy and does not tolerate frost, so most volunteers will sprout in the fall and be killed by freezing temperatures. Shallow tillage can help stimulate seed germination in the fall and spring after buckwheat harvest (Lyon and Waters 2014). If possible, pairing shallow cultivation with light irrigation can further stimulate germination.

Growers who produce wheat for export should be particularly aware of the tolerance for buckwheat contamination in their export market as buckwheat is considered an important allergen in Japan and South Korea (Food Allergy Research and Resource Program 2023). Several herbicides are available for control of volunteer buckwheat in wheat and can help reduce the possibility of contamination (Lyon and Waters 2014). In addition to chemical control, growers should ensure that their rotation leaves one to two years between buckwheat and wheat grown for export.

Processing and Marketing Opportunities

Buckwheat is typically sold either as whole seeds, dehulled whole groats, ground and sifted (supreme dark) flour, flour from dehulled groats (fancy), or grits made from dehulled groats. There are limited options for specialized buckwheat dehulling west of the Cascades. Therefore, the most immediate marketing opportunities for buckwheat growers in the region are for products made from whole seeds. These products include whole grain flour as well as sprouted or malted buckwheat. Manufacturing supreme dark flour requires the capacity to mill and then sift large pieces of hull out of the final flour product. Malting requires access to craft malting facilities which are mapped by the Craft Maltsters Guild. Products that will include a GF label need additional production considerations and testing to ensure compliance with the FDA voluntary labeling standards (see section Growing Buckwheat as a Gluten-Free Crop).

Selling whole groats, grits, and fancy flour all requires access to a buckwheat grader and dehuller. Buckwheat is most efficiently dehulled using a disc under runner sheller which uses one stationary and one mobile disk to peel buckwheat hulls away from the groat. The opening between the discs can be adjusted by the seed batch to increase the dehulling efficiency. Dehulling efficiency (the yield of whole dehulled groats) varies by machine settings, feed rate, variety, and seed moisture but typically ranges from 40 to 60%. While some impact dehullers, commonly used with oats, are labeled for use in buckwheat, they have a very low dehulling efficiency and are not considered a viable dehulling option for this crop.

Growers interested in accessing buckwheat export markets should be aware of buckwheat commodity standards. The USDA defines three classes of buckwheat commodities for export: groats, grits, and flour. Groats are defined as whole, dehulled seeds, conforming to 99.2% purity and 95% whole groats. Grits are also created from dehulled seeds but can be ground to a desired fineness. Flour can contain some proportion of the hull. For grits and flour, microbiological limits include <5 ppb aflatoxin, <500/g coliform, and being negative for *E. coli* and salmonella. Discounts can be issued for moisture higher than 14% and protein concentration less than 8%.

Growing Buckwheat as a Gluten-Free Crop

Buckwheat is naturally GF due to its seed protein composition. Growers who produce buckwheat may be interested in accessing niche and premium GF markets including certified GF packaged products and GF processors. While buckwheat seeds do not contain gluten, buckwheat can be cross-contaminated with gluten through contact with gluten-containing grains or grain products, such as wheat, rye, or barley. Cross-contamination can occur at any point in the supply chain including in grain combines, cleaning equipment, seed driers, storage bins, transportation containers, and processing facilities. Additionally, any point seed lots are bulked across fields and farms introduces the potential for contamination from another seed lot. Thus the larger the scale of buckwheat production, the easier it is to minimize contamination of a lot from mixing with other fields or farms during processing, storage, and transportation.

Federal standards for GF labeling state that food bearing a GF label must contain no more than 20 ppm of gluten or 20 mg of gluten per kilogram of food product (FDA Center for Food Safety and Applied Nutrition 2014). Labeling a food product as GF is voluntary but must comply with the FDA definition. The FDA monitors compliance by testing food products in the marketplace, responding to consumer complaints, and inspecting food labels. The FDA does not require food manufacturers to test their products for compliance. Consequently, food manufacturers use a variety of approaches to quality control to maintain their GF labeling status. Quality control measures can include:

1. Testing ingredients and products in-house.
2. Testing via a third-party laboratory.
3. Mandating testing from ingredient suppliers.
4. Partnering with a third-party GF certifier.

We can see that there is a wide range of expectations that a GF buyer may have for their ingredient suppliers. Some buyers will put a heavy responsibility on their suppliers to ensure that adequate purity protocols are used in crop production and may ask suppliers to partner with a third-party organization (e.g., Gluten-Free Certification Organization, Pro-Cert, SCS Global Services, FoodChain ID) to conduct inspections and testing. Other organizations may simply conduct testing of incoming and outgoing products for compliance. This variation in expectation underscores the importance of communicating and negotiating expectations with a potential buyer.

There currently are no widely recognized best management practices for the production of GF buckwheat. In the absence of these types of standards, the purity protocol defined for GF oats can provide some guidance for GF buckwheat growers (Allred et al. 2017). Best practices defined in this protocol include planting seed purity, crop rotation, maintaining isolation strips, inspecting fields, equipment cleaning, inspecting harvested seed for purity, dedicated storage, and traceability of seed lots (Figure 13).

Figure 13. Summary of good management practices of gluten-free crop production as defined in the gluten-free oat purity protocol (Allred et al. 2017).

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