EFAO
ECOLOGICAL FARMERS ASSOCIATION OF ONTARIO

SEED PRODUCTION & BREEDING

FARMER-RESEARCHER

Dean Orr
Mill Valley Farm

Mill Valley Farm is located in King City on the traditional territories of the Wendat, the Haudenosaunee, and the Anishinaabe peoples, and the treaty lands of the Mississaugas of the Credit.

RESEARCH REPORT 2021

Quinoa variety screening trial

Listen to audio summary of this report

IN A NUTSHELL

In 2021, Dean assessed 6 varieties of quinoa under organic management practices. The goal was to choose the best suited variety for future large-scale production and direct market sales to local consumers.

- Quinoa is a slow growing, non-competitive plant that can be a finicky crop to produce!
- It's hard to differentiate between closely related weeds such as lamb's quarters during the first 8 weeks of production.
- In a direct seeded quinoa crop, traditional large scale organic weeding practices were challenging, and the use of a rotary hoe was deemed impractical.
- Buffy and Brightest Brilliant Rainbow were the best performers in this trial under 2021 conditions.

This research was funded by the Weston Family Foundation, in cooperation with EFAO's Small Grains Program.

Farmer-researcher Dean in the quinoa trial.

MOTIVATION

Quinoa (**Photo 1**) has potential to be an accessible grain for direct marketing, as consumers can purchase unprocessed quinoa to use in meals. Unprocessed quinoa would need to be rinsed in cold water to remove the bitter saponin coating before consumption, a processing step easily transferred to the consumer. Even more, the crop appears to be relatively well suited for growing in milder regions, such as Ontario (**1**).

The current challenges for quinoa production in Ontario, however, are seed availability and information on regionally-appropriate, and regionally-adapted varieties.

Another challenge for organic quinoa production is weed control, the critical weed-free period for quinoa is 16 days after emergence (**1**). Typically in large seeded organic field crops like soybeans, two blind weeding passes are done: 3 days pre-emergence and 3 days postemergence to control weeds in this critical weed-free period. As quinoa is a small seeded crop, Dean wanted to assess the efficacy of using blind weeding.

In this trial, Dean looked at how 6 different varieties of quinoa performed under organic management practices.

The objectives of the trial were two-fold:

1. To assess the best suited varieties for future production and direct marketing to local consumers.
2. To assess side-by-side weed control using rotary hoes, a form of blind weeding.

Photo 1. Head of quinoa plant at ~ 81 days.

METHODS

The area that Dean chose to plant this trial was on certified organic land in its second year of production, following soybeans. The plot area was flat and well drained, had a clay-loam soil with fill, and had a very low weed seed bank.

Dean managed the quinoa organically and treated it as a large scale row crop as much as possible. He disc harrowed, field cultivated, and finished the area with a Salford RTS (Residue Tillage Specialist) for the final seedbed preparation. For fertilization, Dean broadcast OMRI Certified Sulfate of Potash (0-0-50) at a rate of 240 lbs/ac and Good N' Green High Phos Powder (5-12-1-12Ca) at a rate of 275 lbs/ac.

Dean sourced 6 varieties of quinoa from Wild Garden Seed Ltd. Philomath Oregon, USA: Brightest Brilliant Rainbow (commercial standard check variety), Buffy, Cherry Vanilla, French Vanilla, Red Head, and Oro de Valle. Dean chose these varieties based on described traits by the seed company. Oro De Valle was recommended based on positive results in Quebec trials (**2**).

Dean planted the quinoa trial on June 4 on a total of 1.25 acres. He marked rows with a John Deere 12 row 30 inch planter and direct-seeded with a Jang push seeder with the YX-24 roller at a population of ~130,000 seeds/ac.

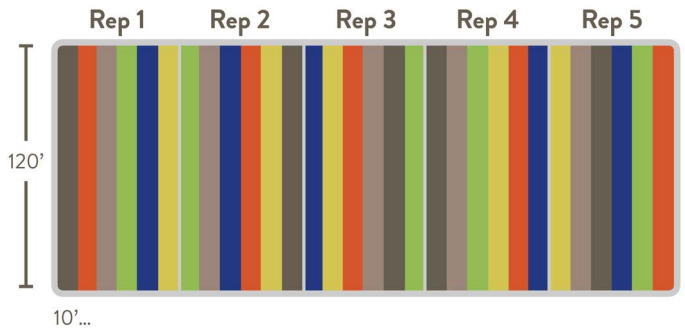

Figure 1. Experimental design of Dean's quinoa variety trial. French (dark brown), Redhead (orange), Cherry (light brown), Rainbow (green), Buffy (blue), ODV (yellow).

Within the plot area, he planted five replications, with the six varieties being randomized within each replication (**Figure 1**). Each replication was 120' long, and 60' wide, each variety consisted of four rows measuring 10' wide. Conditions prior to June 3 were extremely dry and warmer than usual, as such Dean planted the quinoa at a depth of ~ ¾ - 1inch (deeper than the recommended ~ ½ inch). He did this so that the quinoa seed would have enough moisture, and to achieve good soil to seed contact given that he had worked up the plots to a fine soil texture.

With extra seed, Dean planted side-by-side plots (~15'; 6 rows at 30"; 1 variety per row) to look at two different timings for rotary hoeing, which were 3 days pre-emergence (June 7) and 5 days after emergence (June 15). Emergence date and % emergence were similar to those found in the variety trial (**Table 1**). Dean collected observational data for this trial.

DATA ANALYSIS

Dean had planned to measure plant vigor and hardiness, emergence, maturation, head sprouting, and seed set. The initial objective was to also measure yield, but due to the unforeseen circumstances of a wet and cool fall, getting the crop off to take this measurement was impossible. Although we could have made statistical calculations because Dean's experimental design involved replication of the treatments (**Figure 1**), due to several issues no statistical analysis was performed.

FINDINGS

Vigour and Hardiness

Dean measured vigor and hardiness by taking observations throughout the season, and he compared each variety across replicates and assigned a rating (e.g. 1- slow growing and noncompetitive; 10- excellent) (**Table 1**).

Table 1. Observed plant vigour, hardiness, emergence, maturation for each variety.

VARIETY	VIGOUR	HARDINESS	EMERGENCE		MATURATION	
			<10%	<50%	10%	100%
Rainbow	1.5	6	June 11	June 13	Sept. 17	Oct. 9
Buffy	2	6	June 10	June 13	Sept. 17	Oct. 9
Cherry Vanilla	NA*	NA*	NA*	NA*	NA*	NA*
French Vanilla	NA*	NA*	NA*	NA*	NA*	NA*
Red Head	1	6	June 11	NA*	Sept. 17	Oct. 9
Oro de Valle	NA*	NA*	NA*	NA*	NA*	NA*

NA = No data available

Dean found that plant vigour and hardiness were easier to assess in quinoa relative to other crops. Dean noted that the vigour was extremely poor early on, and this made plants susceptible to weed pressure. However, he found it hard to determine vigour between each variety as vigour was so poor in general.

While Dean found hardiness was generally good when the plants were established and mature, he found it was hard to rate. With the low emergence, and fairly normal, albeit wet, weather, it was hard for Dean to tell much difference between varieties.

Emergence and Maturation

Dean assessed each replicate individually for emergence (**Photo 2**) and maturation by marking the dates when each variety had approximately 10%, 50%, and 100% emergence (beginning of season) and maturation (end of season) (**Table 1**).

Dean observed that during emergence most of the quinoa appeared to be coming up through cracks in the soil, which indicated that there could be an issue with crusting - or the crop just didn't have a strong emergence. Unfortunately, emergence became hard to assess with the indistinguishability between quinoa (*Chenopodium quinoa*) and lamb's quarters (*Chenopodium album*) until approx. 7-8 weeks (**Photo 3**). Dean observed the crop again when quinoa heads were visible and concluded that his assessment of % emergence was correct. For the varieties Dean found hard to assess at time of emergence (French, Cherry, Oro De Valle) he noted that % emergence for these varieties was under 5%. Although there were spots in the plots where emergence looked decent, no variety surpassed 50% emergence.

Dean observed that quinoa started maturing around approximately September 20, or 108 days post plant. Full maturity, however, was hard to determine because wet weather - and, therefore, wet plants, affected his ability to assess dry down. Overall, Dean noticed that the plants dried down slowly and dropped their leaves slowly making it difficult to assess the stages of maturation unlike a crop like soybean which drops its leaves and turns brown predictably.

On September 17, the plants had lost most of their leaves but were too wet to thresh, and a hand threshing test provided no seed (possibly too wet or may not have had seed). October was too wet to notice any changes in moisture content in the plants, and by October 9 the plants had dropped all of their leaves and were brown. Dean didn't notice any maturity difference between varieties.

Head Sprouting and Seed Set

Dean assessed both head sprouting (**Photo 4**) (via yes or no) and seed set as a rough estimate of production potential because yield was unobtainable from the trial as of November 4 due to difficulties threshing, as discussed above.

Dean estimated seed set levels by stripping off the seed head into his hand, rubbing it around, blowing the chaff away and seeing how many seeds were present. Dean did this for each variety and across each replication, then rated each plot as: Very low = 0-10 seeds; Low = 10-20 seeds; Medium = 20-30 seeds; High = 30-50 seeds; and Very High = 50+ (**Table 2**).

The extremely wet fall from late September to the end of October produced little sun and heat to dry crops or the fields, making quinoa harvest difficult. For example, Dean discovered early on in this wet period that the quinoa had started to sprout in the seed heads. Dean assessed head sprouting in early November, but it became difficult to determine because the head had dried back down and turned the sprouts grey! The only variety Dean did not consisently notice any

Photo 2. Four rows of the best-growing variety Buffy on July 15.

Photo 3. Quinoa (big plant), next to lamb's quarters (small plant to the left). It's tough to distinguish between!

Photo 4. Sprouted quinoa grain in seed head.

Table 2. Mean estimate of seed set and head sprouting over the five replications for each variety.

VARIETY	SEED SET	HEAD SPROUTING
Rainbow	Medium	Yes
Buffy	Medium	Yes
Cherry Vanilla	Low	Yes
French Vanilla	Very Low	NA*
Red Head	Low	No
Oro de Valle	Low	Yes

**NA= No data available*

sprouts on was Red Head, and he posits this was possibly due to the seed head being less dense than other varieties.
Given the difficult year, Dean used seed count as a proxy for yield. Overall, seed counts were low for most varieties - getting only 10-20 seeds per plant. However, **Buffy** and **Brightest Brilliant Rainbow** performed relatively well with medium seed sets.

Rotary Hoe Side-by-Side Trial

Dean observed that weed pressure was lower in the pre-emergent rotary hoe plot, although it also appeared that the quinoa population was severely reduced by the operation.
In the post emergent rotary hoe plot, weed pressure was similar to the pre-emergent plot but the quinoa survival rate appeared higher. **Buffy** was the variety that appeared to have a better survival rate after blind weeding than all other varieties.

Overall, rotary hoeing did reduce weed populations, but the reduction in the plant stand after the pre-emergent weeding was detrimental and would have negatively affected yield.

As quinoas' small seeds and slow growth make it easier to disturb, this makes it easier to accidentally terminate during pre and post emergent blind weeding. As such, Dean doesn't believe rotary hoeing is a feasible option on direct-seeded quinoa crops using the currently available varieties. He notes that rotary hoeing or tine weeding may be feasible on a transplanted quinoa crop.

CAVEATS

Dean found that weed control was nearly impossible this season. Poor germination and slow growth led to an abundance of open ground for weeds to grow. To add insult to injury, the primary weed growing in the plots was lamb's quarters, a closely related plant that is nearly indistinguishable from quinoa up to about 8 weeks of growth when the seed head for quinoa forms. This makes in-row weeding impossible to do even by hand, as you can't tell the difference between the crop and the weeds!

Dean also found that the small seeds of quinoa make blind weeding, which is typically used for larger seeded crops, not feasible. Scuffling would also be difficult from a tractor operator's point of view because it is very hard to determine the small rows of quinoa from the cab — especially on a first pass. Dean notes that weed control might be improved by seeding at a higher rate, which is a common method of weed control in organic practices.

NEXT STEPS

Moving forward, Dean will try to plant earlier in hopes of achieving better germination in colder weather. In turn, this would allow for earlier harvest to avoid wet fall conditions that are conducive to head sprouting. He'd also like to assess:

- Germination at different planting dates
- Other varieties
- Direct-seeding at a higher plant population
- Comparing direct-seeding with transplanting

TAKE HOME MESSAGE

Quinoa, while a potentially profitable crop, was extremely difficult to grow given the varieties available and the environmental conditions in Ontario in 2021. It is extremely slow growing, and non-vigorous. While this season had its troubles for the production of organic quinoa, Dean learned a lot and is still interested in finding a variety and weed control that can fit into his production system.

ACKNOWLEDGEMENTS

Dean would like to thank his Mom and Dad for allowing him the opportunity to get a good education; fostering his appreciation for science and research, and for supporting him in his often far-fetched ideas.

REFERENCES

1. Nurse et al. 2015. Optimal planting date, row width, and critical weed-free period for grain amaranth and quinoa grown in Ontario, Canada. https://cdnsciencepub.com/doi/10.1139/cjps-2015-0160.
2. Akpakouma. 2021. Cultures émergentes: Lin et quinoa. Video (27:30). youtube.com/watch?v=Acglhuqu_DE&t=507s.