OPTIMIZING PRODUCTION SYSTEMS FOR QUINOA IN THE PACIFIC NORTHWEST

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1. Introduction

Quinoa (*Chenopodium quinoa;* **Fig. 1**) is an annual dicot related to spinach (*Spinacia oleracea)* and lambsquarter (*Chenopodium album* and *Chenopodium berlandieri).* Although both the leaves and seed are edible, only the seed is currently produced for the global market. The seed contains an unusually balanced profile of amino acids, making quinoa an excellent plant source of complete protein[1].

Fig 1 – *Quinoa (var. Black) during seed set; photo credit V. Nichols*

Quinoa was first domesticated in South America, and today Peru and Bolivia account for more than 90% of global production[2]. The US consumes more than 50% of global production, with imports continuing to rise to the point where domestic production is desired (**Fig. 2**).

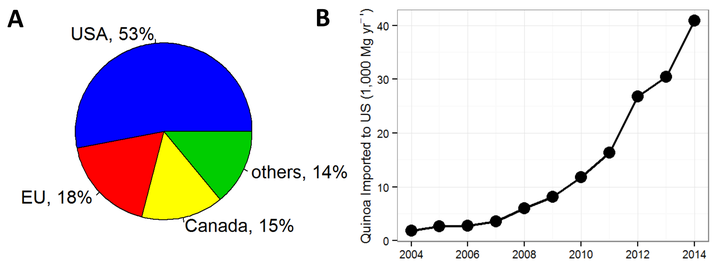

Fig 2A- *Percentage of global quinoa production consumed by region;* ***B-*** *US imports of quinoa 2004-2014[2]*

2. Rationale

Large-scale agronomic production of quinoa in the US has had little research, making it a risky endeavor for farmers. In 2015 quinoa variety trials in Washington and Idaho exhibited mixed results with respect to establishment (**Fig. 3**). To elucidate the role of fertilizer in the reduced plant establishment, we planted quinoa in mini-rhizotrons to observe root responses to fertilizer.

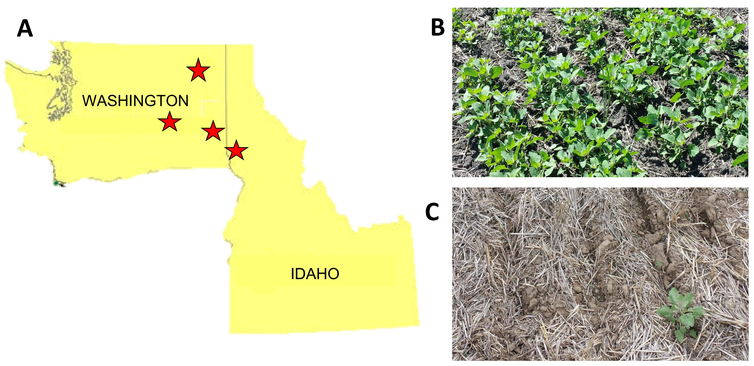

Fig 3A– *Map of site locations;* ***B-*** *Quinoa planted into soil that was harrowed and fertilized with 90 kg N ha^{-1} one day before planting;* ***C-*** *Quinoa direct-seeded into soil with simultaneous fertilization of 28 kg N ha^{-1}*

3. Methods & Materials

Quinoa (var. Jessie) and spring wheat (var. Avocet) were grown with the equivalent of 0 and 90 kg N ha^{-1} (pelletized urea) in a rhizotron attached to a high-resolution flat-bed scanner (**Fig. 4**). Each crop-fertilizer treatment was replicated three times. Four scanners were divided into three sections and treatments were randomly assigned to each compartment.

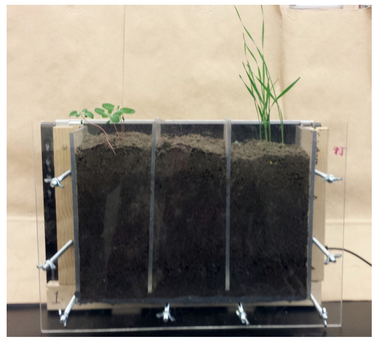

Fig 4 - *Rhizotron attached to scanner two weeks after planting*

Seed-to-fertilizer distance was ~2.5 cm. Rhizotrons were filled to a density of 1.1 kg m^{-3} with 2 mm sieved Palouse silt-loam soil at field capacity moisture . Pictures were taken daily for 3 weeks.

4. Results

Clear differences in above-ground growth reflected differences in root responses to the presence of 90 kg urea-N ha^{-1} located 2.5 cm below seeds (**Fig. 5**). Wheat roots grew around the fertilizer bands, while quinoa roots simply stopped growing when they encountered the band.

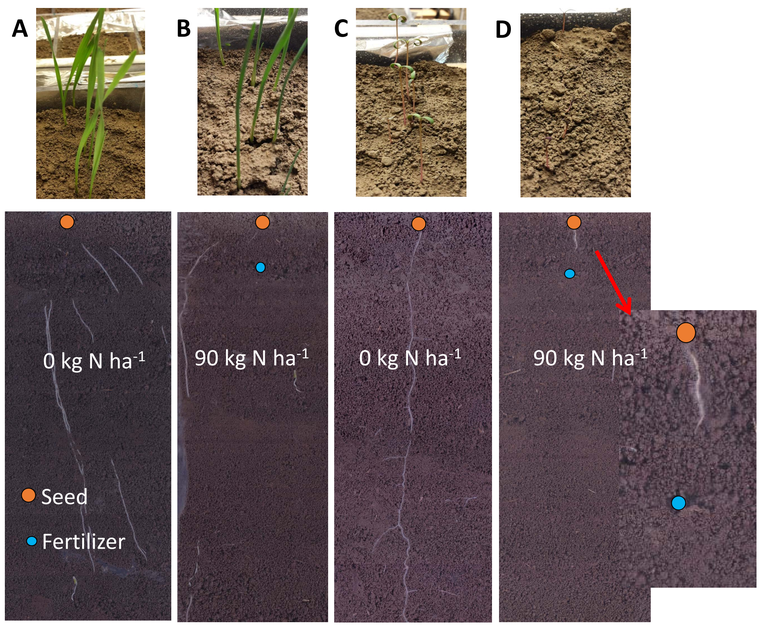

Fig 5 - *Above- and below-ground growth was affected by fertilizer , photos taken 7 days after planting;* ***A-*** *Wheat with no fertilizer;* ***B-*** *Wheat with 90 kg urea-N ha^{-1};* ***C-*** *Quinoa with no fertilizer ;* ***D-*** *Quinoa with 90 kg urea-N ha^{-1}*

5. Discussion

Due to their fibrous root structure, monocots do not rely heavily on one root for plant function. Dicots, however, often depend heavily on taproot development. This may explain why wheat roots were able to grow around the fertilizer band while quinoa roots were not. Canola (*Brassica napus)* has shown sensitivity to fertilizer placement in a silty-clay-loam in Canada[3]. Canola and quinoa have similar seed sizes (**Fig. 6**) and root structures.

Fig 6 – *Canola (upper) and quinoa (lower) seed sizes; photo credit V. Nichols*

However, quinoa is routinely planted in France with 100 kg urea-N ha^{-1} in-row placement adjacent to the seed with no visible reductions in plant establishment[4]. We hypothesize that differences in both soil texture and seasonal moisture patterns may influence how quinoa roots respond to in-row fertilizer placement.

5. Future Research

The experiment should be repeated with different soil types and watering regimes. Different depths and offsets of fertilizer placement should be investigated, as well as varying amounts and types of fertilizers. Root growth responses to fertilizers could be quantified using Geographical Information Software. Although more research is needed, quinoa growers should use caution when using one-pass planting and fertilization in the Pacific Northwest region.

References

1. Repo-Carrasco, R., Espinoza, C., & Jacobsen, S. E. (2003). Nutritional value and use of the Andean crops quinoa (Chenopodium quinoa) and kañiwa (Chenopodium pallidicaule). *Food reviews international*, *19*(1-2), 179-189.
2. FAOSTAT (2015). Food and Agriculture Organization of the United Nations Statistics Division. http://faostat3.fao.org/home/E Accessed October 2015.
3. Malhi, S. S., & Gill, K. S. (2004). Placement, rate and source of N, seedrow opener and seeding depth effects on canola production. *Canadian journal of plant science*, *84*(3), 719-729.
4. Jason Abbott, personal communication.

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