BUL 934

Evaluating Adaptability of Alternative Crops in Eastern Idaho

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Introduction

CROPPING SYSTEMS IN EASTERN IDAHO mainly include cereal, potato, sugar beet, and forage. In order to improve soil health and decrease pest pressure, growers have tried to integrate alternative crops into their current cropping systems. Examples of these crops include quinoa, legumes, and brassicas. However, best management practices of each alternative crop species under semi-arid or arid conditions with or without irrigation have yet to be determined. This extension bulletin will highlight results from experiments evaluating various alternative crops and recommend management practices specific to eastern Idaho cropping systems.

Evaluating Quinoa Growth in Eastern Idaho

Native to the Andes Mountains of South America, quinoa (*Chenopodium quinoa* L.) is a highly nutritious food. The quantity and quality of protein and mineral nutrients (e.g., Ca, P, Mg, K, Fe, Cu, and Zn) in quinoa seeds are often superior to cereal grains such as wheat, rice, and barley. In recent years, quinoa has been planted in eastern Idaho, including American Falls, Blackfoot, Grace, Soda Springs, Aberdeen, Idaho Falls, Tetonia, and Swan Valley. Accordingly, the acreage of quinoa has increased since 2014 (20 in 2014, 400 in 2015, 600 in 2016, 1,600 in 2017, and 3,500 in 2018). Southern Idahoans have used it to make gluten-free flours and in bread making.

Among various factors affecting quinoa production, weed management is the most challenging. Quinoa is from the family Amaranthaceae, the same family as the weed species redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album* L.). As such, available broadleaf herbicides could cause damage to quinoa, and to date, very few herbicides have been registered for weed control in quinoa production.

Quinoa grows relatively slowly after emergence and does not compete well with established and/or emerging weeds. In trials conducted during the 2016 growing season at the Aberdeen Research and Extension Center in eastern Idaho, common lambsquarters and witchgrass (*Panicum capillare* L.) were the most prevalent weed species. Other weeds that were observed included redroot pigweed, common mallow (*Malva neglecta* Wallr.), cutleaf nightshade (*Solanum triflorum* Nutt.), hairy nightshade (*Solanum physalifolium* Rusby), common purslane (*Portulaca oleracea* L.), and shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.). In the same experiment, researchers planted quinoa in early, mid-, and late April. Weed biomass from plots planted in early April was lower than that collected from plots planted in late April. Therefore, early planting enables quinoa's emergence and crop canopy establishment because fewer competitors like these weed species are prevalent.

Quinoa performs better under cool temperatures (e.g., 59°F–68°F); temperatures above 95°F could cause plant dormancy and pollen sterility. Quinoa plants usually tolerate light frosts (e.g., 30°F–32°F), but should not be exposed to temperatures below 28°F, especially before the soft-dough stage, to avoid significant yield loss. Air temperatures during the summer in the Tetonia area are generally between 30°F and 90°F (Figure 1), which makes it a promising region for quinoa production.

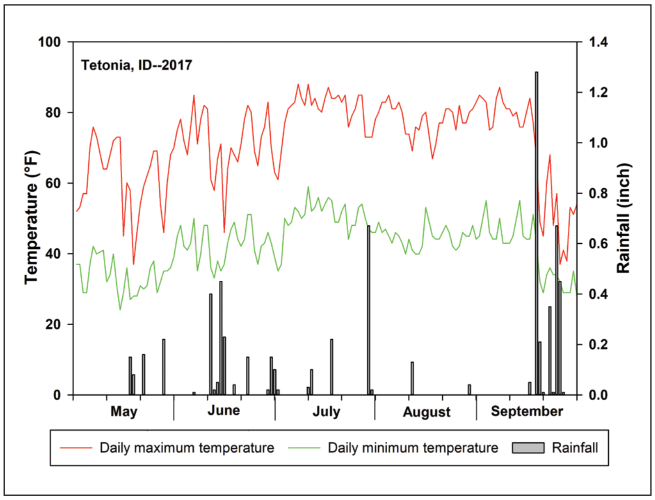

Figure 1. Daily maximum and minimum air temperatures and rainfall during the 2017 growing season at Tetonia, Idaho (https://www.usclimatedata.com).

A field trial with four quinoa varieties was conducted in Tetonia, Idaho, in 2017. Approximately 150 lb N/acre was applied before planting, following the recommendations for cereal production. Experimental plots of 10 by 15 feet were established on June 1 and harvested on September 12, 2017 (Figure 2). Plots were seeded using an Earthway Precision Garden Seeder at a row spacing of 14 inches. The experiment consisted of quinoa varieties of Cherry Vanilla, French Vanilla, Oro de Valle, and Red Head, and was arranged in a randomized complete block design with four replicates. Data was analyzed using the generalized linear mixed model of SAS (ver. 9.4, SAS Institute, Cary, North Carolina), treating variety as a fix effect and replicate as a random effect. The established plant density was measured from 11.6 to 16.5 plants in a five-foot row, and no significant difference was found among varieties ($P > 0.05$) (Table 1). Cherry Vanilla and Oro de Valle produced relatively higher seed yields than the other two varieties, but the differences were not significant ($P > 0.05$).

Figure 2. Quinoa plant growth at Tetonia during the 2017 growing season. Quinoa was planted on June 1, 2017. Photos were taken on July 17 (upper left), July 27 (upper right), August 29 (bottom left), and September 12 (bottom right), 2017.

Table 1. Quinoa plant density and seed yield in 2017 at Tetonia, Idaho.

Variety	Number of plants in a five-foot row	Seed yield (g/plant)
Cherry Vanilla	11.6	32.8
French Vanilla	16.5	22.8
Oro de Valle	13.6	30.6
Red Head	12.1	27.5

Quinoa is relatively drought tolerant and well adapted to environments with low precipitation. Since quinoa was newly introduced to the Tetonia area via this experiment, irrigation was applied to ensure good crop establishment. Irrigation application was through wheel lines following the irrigation recommendation for cereals and terminated by the end of July with a total irrigation amount of 10 inches.

Evaluating a Cover Crop Mix in Dryland Areas in Eastern Idaho

Cover crops are usually planted during or between primary growing seasons, which can be considered part of the crop rotation. The most common cover crops are legumes, brassicas, and grasses, but in cereal-based cropping systems, grasses are not usually selected. Hairy vetch (*Vicia villosa* Roth) and field peas (i.e., winter and spring peas) (*Pisum sativum* L.) are legume crops and have been planted as cover crops in eastern and southern Idaho. As legumes, they are able to fix nitrogen and provide a large amount of nitrogen to subsequent crops. Hairy vetch is drought tolerant and winter hardy, while the primary challenge for winter pea is winter survival. Although some winter pea cultivars are able to tolerate temperatures as low as 10°F with only minor injury, sustained cold hardiness below 18°F with little snow cover usually causes severe damage to the plants or even winter-kill.

Brassica crops, including rapeseed (*Brassica napus* L.), mustard (*Sinapis arvensis* L.), turnip (*Brassica rapa* L.) and radish (*Raphanus sativus* L.), are known for their rapid growth, large biomass production, and nutrient-scavenging ability. Most Brassica species also release chemical compounds (e.g., glucosinolates) that may control soil-borne pathogens and pests such as nematodes, fungi, and some weeds. Brassica crops are sensitive to freezing; winter-kill may happen below 25ºF, especially with little snow cover in the winter.

Growers in eastern Idaho are becoming increasingly interested in integrating cover crops into their current cropping systems to suppress pests and improve soil health, such as building soil fertility, reducing erosion, improving soil quality (e.g., aggregation, infiltration, soil biological activity, etc.), and increasing soil organic matter. In irrigated production, growers can plant cover crops after harvesting primary crops, and after a few weeks of growth, cover crops can be incorporated into the soil. In dryland production, with short and dry growing seasons, integrating cover crops into winter/spring cereal production with fallow is more challenging. Experimentation with such practices is thus needed before making recommendations to growers. To address this shortfall, a field study was established on two dryland cereal farms in Arbon Valley and Rockland in eastern Idaho.

In the study, two treatments, fall- and spring-planted cover crops, were arranged in a randomized complete block design with six replicates at both locations during the 2016–17 season. The cover crops were a mix of spring pea, winter pea, hairy vetch, turnip, and radish with a ratio of 10:10:5:1:1. At both Arbon Valley and Rockland, the cover crop mix was planted in late September 2016 (fall-planted) and early April 2017 (spring-planted) at a seeding rate of 30 lb per acre. Samples for evaluating cover crop biomass production were taken in early July 2017 at both locations before terminating cover crops for winter wheat planting. Biomass data was analyzed using the generalized linear mixed model of SAS (ver. 9.4, SAS Institute, Cary, North Carolina) by treating cover crop treatment (i.e., fall and spring planting) as a fix effect and replicate as a random effect at each location.

Air temperature in Rockland is generally lower than Arbon Valley during the winter, and it was measured as low as -6°F at Rockland during the winter of 2016–17, mostly with snow cover (Figure 3). For the fall-planted cover crop mix, winter pea and hairy vetch exhibited good winter hardiness at both

Arbon Valley and Rockland, but spring pea failed to survive the winter at either location. Biomass of legume crops (e.g., peas and hairy vetch) was greater in fall planting than spring planting (Arbon Valley: $P = 0.06$; Rockland: $P = 0.002$) (Figure 4). Fall-planted turnip and radish were observed in Arbon Valley, but were mostly winter-killed in Rockland. In Arbon Valley, biomass of spring-planted brassica crops (e.g., turnip and radish) was relatively higher than the fall-planted, but the difference was not significant ($P = 0.221$). Total biomass of the fall-planted cover crop mix was greater than the spring-planted crops at both locations (Arbon Valley: $P = 0.041$; Rockland: $P = 0.014$).

Decision making on integrating cover crops should thus consider environmental conditions and management practices on the farm. In dryland areas, cover crop species that exhibit good winter survivability (e.g., winter pea and hairy vetch) can be planted in the fall, which enables the crops to have a long growing season for biomass production; cover crops that have poor capability of surviving the winter (e.g., spring pea, turnip, and radish) can be planted in early spring and terminated by low temperatures in the fall.

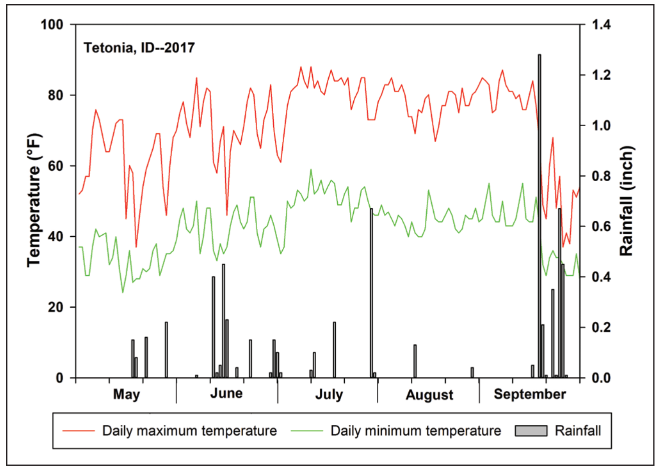

Figure 3. Daily maximum and minimum air temperature and precipitation during the 2016–17 growing season at Rockland, Idaho.

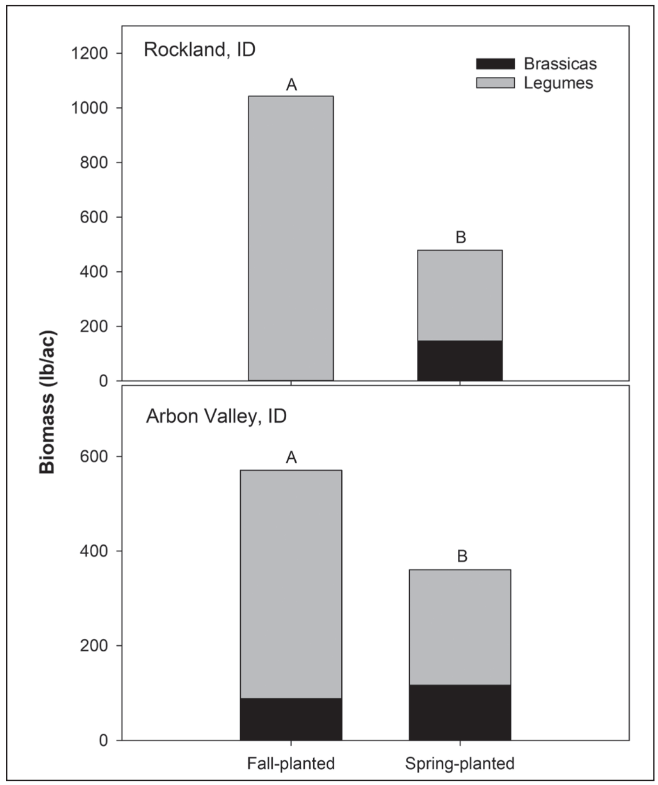

Figure 4. Total biomass from fall-planted cover crop mix was greater than the spring-planted crops at both Rockland and Arbon Valley, Idaho.

Other Alternative Crops

Other alternative crops, such as safflower and flaxseed, are of interest to growers in eastern and southern Idaho. Safflower and flaxseed have been planted in dryland areas in eastern Idaho (e.g., Rockland). However, their suitability and agronomic practices have not been evaluated in this area.

Safflower (*Carthamus tinctorius* L.) is an annual, broadleaf oilseed crop, whose seeds contain approximately 75% linoleic acid and are considered a high-quality edible oil. Due to its suitability to semi-arid conditions, safflower's growth and production are adequate in environments with warm temperatures and sunny, dry conditions during flowering and seed-filling stages. Safflower can be rotated with cereals and has been adapted to the small-grain production areas of the western Great Plains. Safflower requires 100–120 lb/acre of nitrogen to achieve high yields, but its deep roots (e.g., 7 ft) enable it to effectively use residual nitrogen from previous crops, especially from small grains.

Flax (*Linum usitatissimum* L.) is an important source for linseed oil and linen fiber and has been grown mostly in North Dakota and Minnesota in the United States. Flax has been well integrated in crop rotations with cereals (e.g., wheat, barley, and oat) and legumes (e.g., peas and lentils). Integrating flax in crop rotations reduces pest pressures (e.g., diseases and insects) that are dominant in cereal crops. Flax is usually planted in soils that are similar to the types of soils in which cereals are grown, and its fertility requirement is also similar to small grains. Seasonal crop water use of irrigated flax is similar to cereals, with a typical irrigation requirement of 14–18 inches.

Conclusions and Recommendations

- Since most alternative crops are new to this region, research on best management practices specific for the region is needed, along with developing a market for the harvested products.
- Early planting dates enable quinoa's emergence and crop establishment before some weed species emerge. Successful quinoa production has been demonstrated in eastern Idaho (e.g., Tetonia), where the air temperature is generally lower than 90°F during the summer.
- Decision making on integrating cover crops should consider environmental conditions and management practices on the farm. In dryland areas, cover crop species with good winter hardiness (e.g., winter pea and hairy vetch) can be planted in the fall, which enables the crops to have a long growing season for biomass production; cover crops that have low winter hardiness (e.g., spring pea, turnip, and radish) can be planted in early spring and terminated by low temperatures in the fall.
- Safflower and flax have been adopted in Rockland, eastern Idaho. They are promising alternative crops in eastern and southern Idaho and are well adapted to crop rotations with cereals.
- Growers are strongly encouraged to experiment in small areas prior to large-scale planting of alternative crops.

Additional Reading

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Acknowledgments

The cover crop project was funded by USDA NRCS Conservation Innovation Grants. We would like to thank Cory Kress, Hans Hayden, and Twain Hayden for providing access to their fields and helping with the planting and harvesting of these crops.

BUL 934 | Published April 2019 | © 2019 by the University of Idaho