BUL 1032

Crop Yield in Barley-Pulse Intercropping Systems under Well-Watered and Drought-Stressed Conditions

Asia Akter
Graduate Research Assistant, Department of Plant Sciences, University of Idaho

Xi Liang
Associate Professor of Cropping Systems Agronomy, Department of Plant Sciences, Aberdeen Research and Extension Center, U of I

Zachary Kayler
Assistant Professor of Soil Biogeochemistry, Department of Soil and Water Systems, U of I

Torrey Stephenson
Graduate Research Assistant, Department of Soil and Water Systems, U of I

Contents

University of Idaho Extension

Introduction

CROPPING SYSTEMS IN EASTERN IDAHO mainly consist of cereals (e.g., wheat and barley), potatoes, sugar beet, and forage. In fact, the entire state leads the nation in barley production, growing malt, food, and feed varieties, with the eastern area the state's largest contributor. Eastern Idaho receives a small amount of annual precipitation (e.g., ≤ 280 mm or 11 inches in dryland areas) and thus drought often occurs during the growing season, when irrigation supplies are limited.

While improving irrigation management practices, growers can also diversify their cropping systems by incorporating crops with different water requirements through rotation and intercropping. Pulse crops (e.g., lentil, pea, and chickpea) use less water than cereals. Although the market for peas and other pulse crops is uncertain, compared to rotations, intercropping pulse and cereals can reduce the risk of economic loss because it yields two products from a single field in one growing season. In addition, pulse crops provide symbiotically fixed nitrogen to cereals in intercropping and their rooting systems are complementary, which may lead to improved water-use efficiency. Therefore, including pulses in cereal-dominant cropping systems may improve overall soil health, plant growth, and yield stability.

To incorporate barley-pulse intercrops in existing cropping systems, first evaluate their production under different water availabilities. Also, before recommending intercropping to growers, conduct a number of comprehensive trials at different locations. This Extension bulletin highlights the results of three trials of barley-pulse intercropping at high and low water availabilities at Aberdeen, Rockland, and Springfield in southern Idaho.

Field Trial at the Aberdeen Research and Extension Center

We conducted the first field trial at the Aberdeen Research and Extension Center, University of Idaho in 2020 by establishing plots of monocropping barley (cultivar 'GemCraft'), lentil (cultivar 'Avondale'), pea (cultivar 'Hampton'), and barley-lentil and barley-pea intercropping (alternate rows of pulse and barley) under two irrigation treatments (Figure 1). The irrigation treatments were applied throughout the growing season at 100% crop evapotranspiration (ET) as a well-watered condition and at 50% ET as a drought-stressed condition. The daily ET data was retrieved from AgriMet (https://www.usbr.gov/pn/agrimet/); seasonal precipitation was 66 mm in 2020. During the growing season, the well-watered treatment received irrigation of 283 mm, whereas the drought-stressed treatment received 142 mm. Irrigation was supplied using solid-set aluminum pipelines.

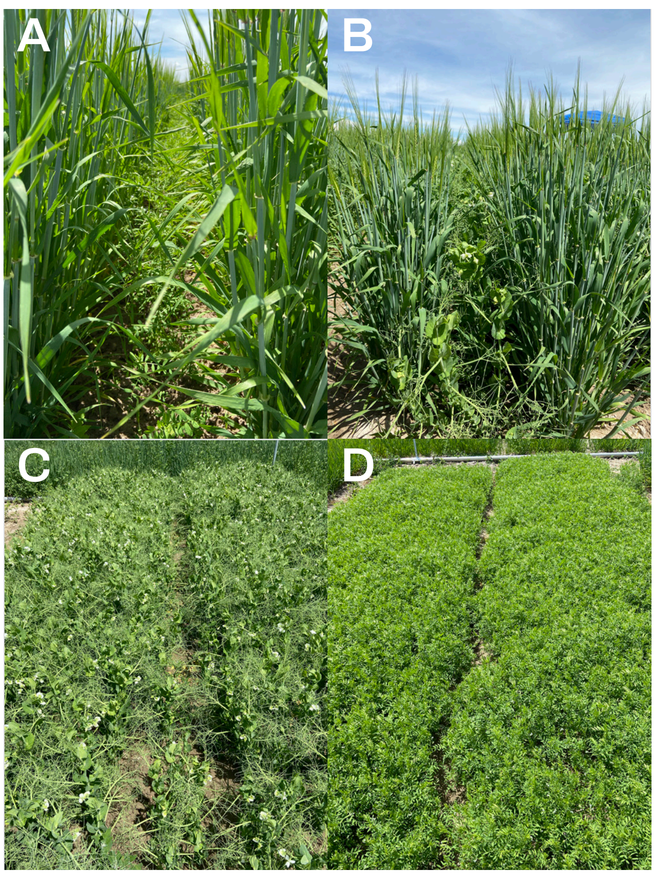

Figure 1. Barley-lentil (A) and barley-pea (B) intercropping treatments and monocropping pea (C) and lentil (D) in the field.

The study followed a split-plot design with four replicates (total of 40 plots). Each plot (3 × 6 m) consisted of 14 plant rows with a distance of 18 cm between rows. The seeding rate of monoculture barley was 198 seeds/m^2 and 99 seeds/m^2 for intercropping barley. The seeding rate of monoculture pea was 86 seeds/m^2 and 43 seeds/m^2 for intercropping pea. The seeding rate of monoculture lentil was 129 seeds/m^2 and 65 seeds/m^2 for intercropping lentil. No fertilizers were applied during the growing season.

Our first-year results indicated that drought stress (50% ET) significantly reduced total biomass yield compared with the well-watered condition (100% ET) (P = 0.006) (Figure 2). Across the irrigation treatments, the highest total biomass yield was found in monocropping barley followed by barley-pea and barley-lentil intercropping, but barley-pea intercropping was not different from monocropping barley. The lowest total biomass was observed in monocropping lentil. For barley biomass, the differences between the two irrigation treatments were also significant (P = 0.019); also, monocropping barley had greater barley biomass yield compared with barley intercropping with lentil and pea. Pulse biomass yield was not affected by irrigation treatment (P = 0.260); however, intercropping with barley dramatically reduced pulse biomass.

Barley grain yield was strongly affected by the interaction effect of irrigation treatment and cropping system (Figure 3). Under the well-watered condition, barley grain yield of the monocropping treatment was greater than barley-pea intercropping, but not different from barley-lentil intercropping. Under drought stress, barley grain yield did not differ between monocropping barley and barley intercropping with lentil or pea. Pulse grain yield was not significantly affected by irrigation treatment. Monocropping pea produced the highest pulse grain yield followed by monocropping lentil, barley-pea intercropping, and barley-lentil intercropping.

On-Farm Trials at Rockland and Springfield

Two field trials were established at Rockland and Springfield in eastern Idaho in 2021. At Rockland, the trial consisted of three cropping system treatments:

monocropping barley (cultivar ‘GemCraft’) and pea (cultivar ‘Banner’) and barley-pea intercropping (Figure 4). At Springfield, the trial consisted of treatments of monocropping barley (cultivar ‘Voyager’) and barley-pea (cultivar ‘Hampton’) intercropping. The intercropping treatment was planted as a barley-pea mix at Rockland and in alternate rows at Springfield. Rockland is a dryland site with an average annual precipitation of 305 mm (12 inches), whereas the Springfield site is an irrigated field. At Rockland, the seeding rate of monoculture barley was 78 kg/ha and 39 kg/ha for intercropping barley; the seeding rate of monoculture pea was 168 kg/ha and 84 kg/ha for intercropping pea. At Springfield, the seeding rate of monoculture barley was 134 kg/ha and 67 kg/ha for intercropping barley; the seeding rate of pea was 91 kg/ha for intercropping pea. At maturity, four replicates of plots (1 × 1 m) from each cropping system treatment were randomly selected at both locations and whole plant samples were collected to estimate crop biomass and grain yield.

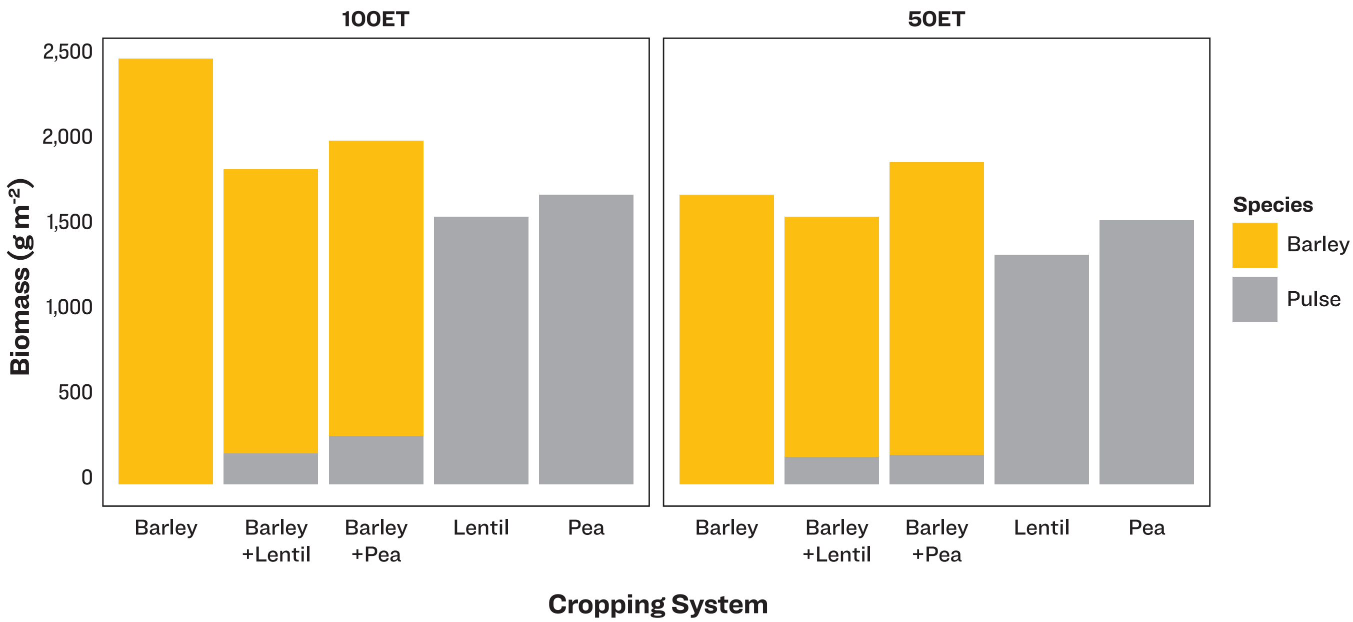

Figure 2. Whole-plant biomass of monocropping and intercropping plots at well-watered (100% ET) and drought-stressed (50% ET) conditions at the Aberdeen Research and Extension Center.

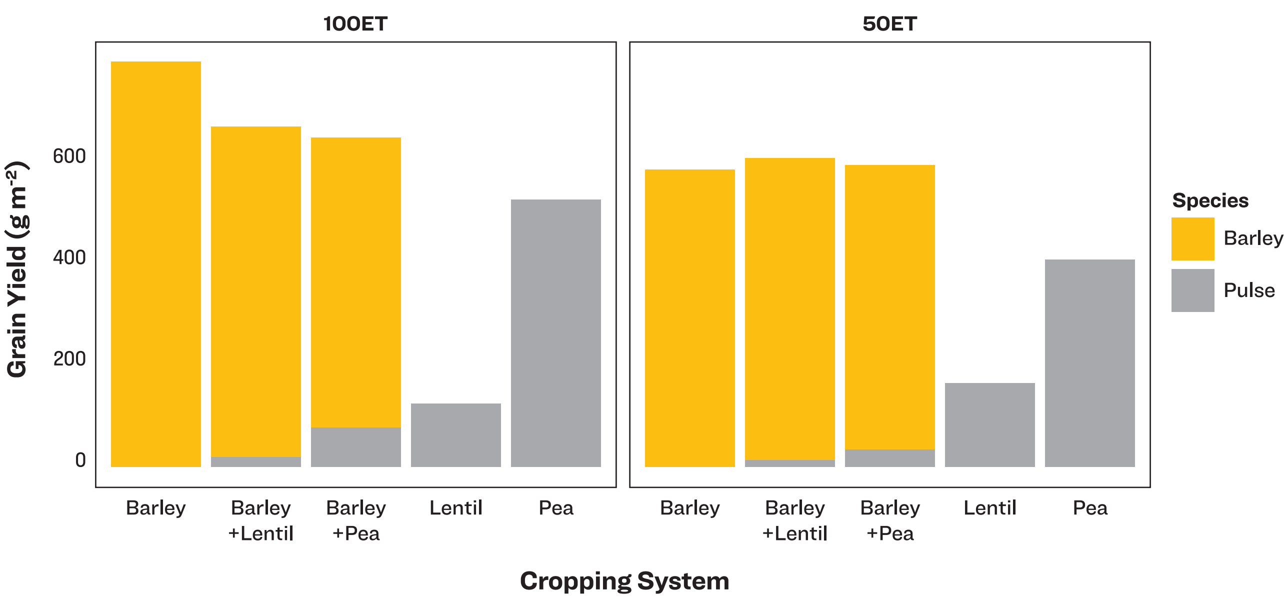

Figure 3. Grain yield of monocropping and intercropping plots at well-watered (100% ET) and drought-stressed (50% ET) conditions at the Aberdeen Research and Extension Center.

At Rockland, the total biomass of monocropping barley was greater than monocropping pea (P = 0.011), whereas the total biomass of barley-pea intercropping was not significantly different from monocropping barley (P = 0.221) or monocropping pea (P = 0.062) (Figure 5). The biomass of pea from the monocropping treatment was greater than the barley-pea intercropping, but the barley biomass did not differ between monocropping and intercropping.

At Springfield, the total biomass of monocropping barley was not significantly different from barley-pea intercropping (P = 0.069) (Figure 5). Barley biomass under the intercropping system was slightly smaller than monocropping barley (P = 0.057).

At Rockland, the grain yield of monocropping pea was greater than pea from the barley-pea intercropping (P = 0.005), whereas barley yield from the monocropping system was not significantly different from barley-pea intercropping (P = 0.133) (Figure 6). At Springfield, barley grain yield under intercropping was smaller than monocropping (P = 0.025).

Summary and Recommendations

- The results of the two on-farm trials agree with the trial at the Aberdeen Research and Extension Center. Under drought stress or dryland conditions, barley grain yield did not differ between monocropping barley and barley intercropping with lentil or pea. These results suggest that barley plants in intercropping could compensate for the low plant density and produce similar yields as the monocropping barley.

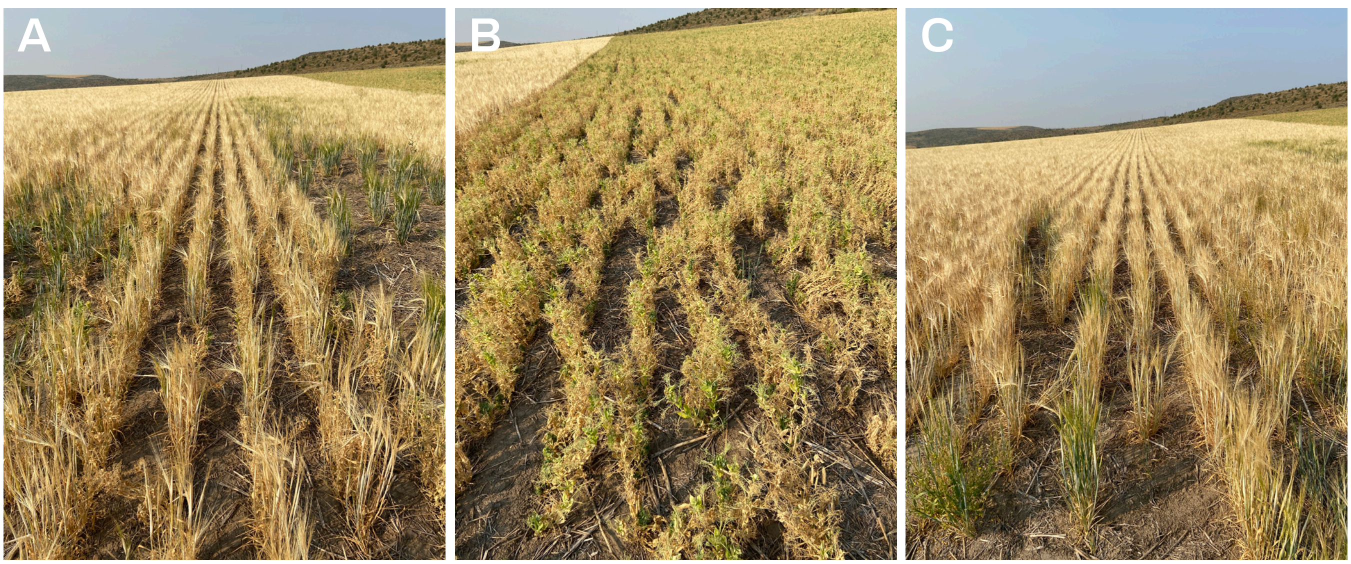

Figure 4. Barley-pea intercropping in a mixture (A) and monocropping pea (B) and barley (C) at Rockland.

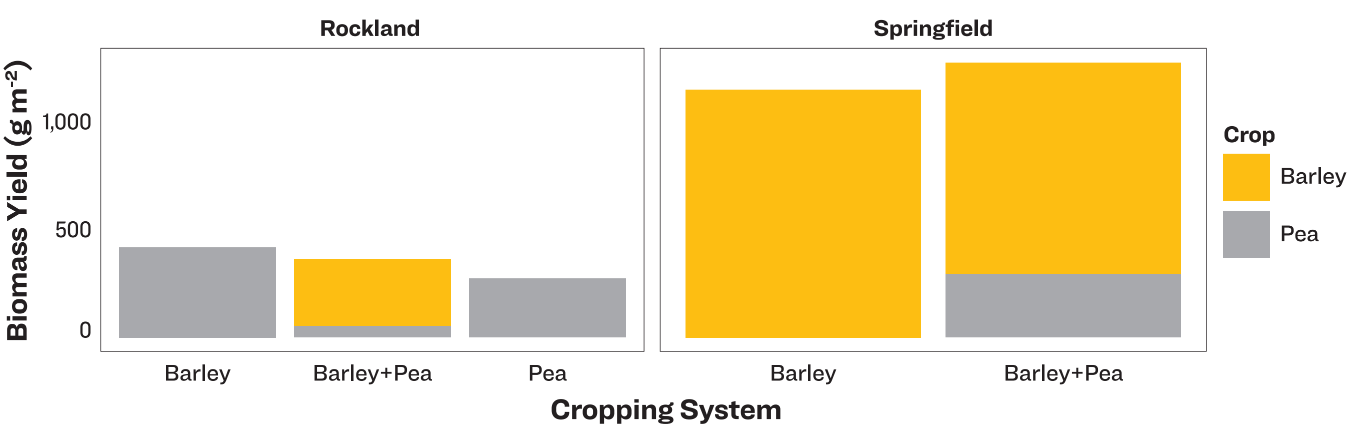

Figure 5. Whole-plant biomass of pea and barley from monocropping barley and pea and their intercropping systems at Rockland and Springfield.

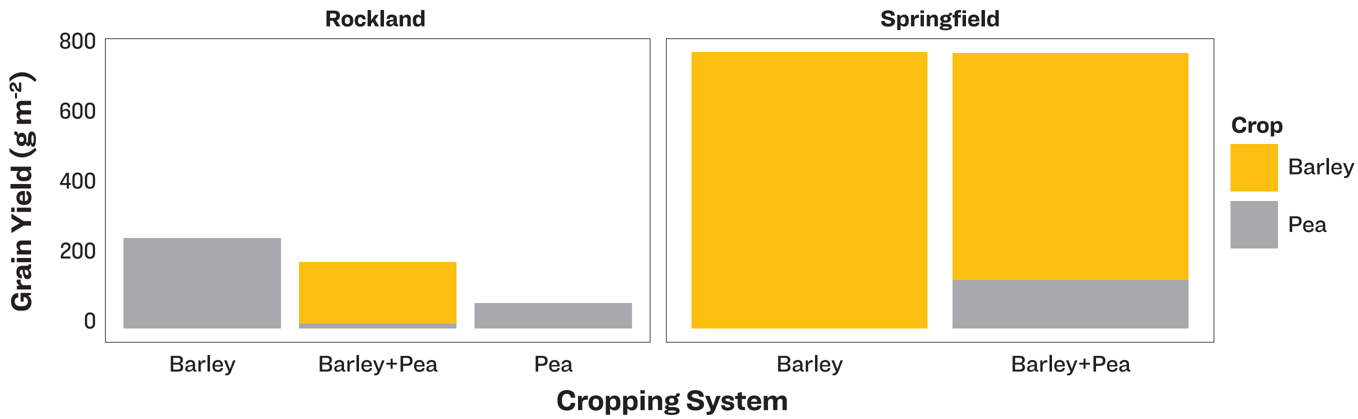

Figure 6. Grain yield of pea and barley from monocropping barley and pea and their intercropping systems at Rockland and Springfield.

- Pulse biomass or grain yield was not strongly affected by irrigation treatment, but dramatically decreased in intercropping systems.
- These results suggest that pulse-barley intercropping systems could be suitable for areas of limited irrigation supplies or dry-land farming.

Further Reading

Bedoussac L., E.-P. Journet, H. Hauggaard-Nielsen, C. Naudin, G. Corre-Hellou, E. Steen Jensen, L. Prieur, and E. Justes. 2015. "Ecological Principles Underlying the Increase of Productivity Achieved by Cereal-Grain Legume Intercrops in Organic Farming. A Review." *Agronomy for Sustainable Development* 35(3): 911–35.

Brooker R. W., A. E. Bennett, W.-F. Cong, T. J. Daniell, T. S. George, P. D. Hallet, C. Hawes, P. P. M. Iannetta, H. G. Jones, A. J. Karley, L. Li, B. M. McKenzie, R. J. Pakeman, E. Paterson, C. Schöb, J. Shen, G. Squire, C. A. Watson, C. Zhang, F. Zhang, J. Zhang, and P. J. White. 2015. "Improving Intercropping: A Synthesis of Research in Agronomy, Plant Physiology and Ecology Improving Intercropping." *New Phytologist* 206: 107–17.

Duchene O., J.-F. Vian, and F. Celette. 2017. "Intercropping with Legume for Agroecological Cropping Systems: Complementarity and Facilitation Processes and the Importance of Soil Microorganisms. A Review." *Agriculture, Ecosystems and Environment* 240(1): 148–61.

Hauggaard-Nielsen H., M. Gooding, P. Ambus, G. Corre-Hellou, Y. Crozat, C. Dahlmann, A. Dibet, P. von Fragstein, A. Pristeri, M. Monti, and E. S. Jensen. 2009. "Pea–Barley Intercropping for Efficient Symbiotic N2-Fixation, Soil N Acquisition and Use of Other Nutrients in European Organic Cropping Systems." *Field Crops Research* 113(1): 64–71.

Yin W., Q. Chai, C. Zhao, A. Yu, Z. Fan, F. Hu, H. Fan, Y. Guo, and J. A. Coulter. 2020. "Water Utilization in Intercropping: A Review." *Agricultural Water Management* 241: 106335.

Zhang F., and L. Li. 2003. "Using Competitive and Facilitative Interactions in Intercropping Systems Enhances Crop Productivity and Nutrient-Use Efficiency." *Plant and Soil* 248: 305–12.

Acknowledgment

The project was funded by the United States Department of Agriculture Agricultural Research Service Pulse Crop Health Initiative and the Idaho Barley Commission. We would like to thank Cory Kress and Ladd Wahlen for providing access to their fields and helping with the planting and harvesting of the crops.

BUL 1032 | Published September 2022 | © 2022 by the University of Idaho