Grant Code: AP2730

Title: Adopting deficit irrigation practices in spring wheat production in southern Idaho

Personnel: Xi Liang, Cropping System Agronomist. Aberdeen Research & Extension Center; Howard Neibling, Water Management Specialist, Kimberly Research & Extension Center; Juliet Marshall, Crop Management Specialist, Aberdeen Research & Extension Center.

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Justification/Rationale: Seasonal drought conditions occur frequently in southern Idaho especially during the summer months (U.S. Drought Monitor. 2015). The high frequency of drought events in this area results from the precipitation distribution, which is unmatched with wheat growth and development. Growth early in the season mainly depends on water from snowmelt and rainfall. The critical period of flowering in spring wheat starts ranges from early to late June. The rainfall during the summer is relatively low, and by that time a large portion of the soil water from snowmelt is depleted by plants in the field. For instance, seasonal water use in spring wheat (April to August) at Aberdeen is approximately 550 mm (Li et al., 2012), but the rainfall during that period is only 90 mm (AgriMet. 2015). In Idaho, 58% of the harvested spring wheat acreage was irrigated in 2012 (USDA NASS, 2013). Furthermore, ground water consumption will be reduced by 240,000 acre-feet annually (or 13% reduction) to stop the aquifer's decline in Snake Plain (Magicvalley.com, 2016). Under these circumstances, irrigation should be utilized more efficiently and effectively by matching crop critical stages. The deficit irrigation practices evaluated in this study will indicate most effective deficit irrigation techniques for spring wheat production associated with local environments (i.e., precipitation distribution and soil type) for southern Idaho.

Hypothesis & Objectives: To understand the deficit irrigation practices in spring wheat production that result in the most efficient utilization of irrigation resources by: 1) evaluating various cultivars for grain yield, quality, and WUE under well-watered and deficit-irrigated conditions; 2) evaluating deficit irrigation methods in spring wheat production, and identify best deficit irrigation practices in different cultivars in southern Idaho.

Procedures/Plan of Work: Experiments will be conducted at the University of Idaho Aberdeen Research & Extension Center at Aberdeen, ID. The soil is Declo loam, which is the most common agricultural soil in this area. Three spring wheat cultivars (Dayn, hard white; SY Coho, hard red; and Alturas, soft white) will be planted in plots of 10 by 20 feet. Plots will be maintained under well-watered conditions (100% ET) throughout the growing season, and three deficit irrigation treatments will be included. For the three deficit irrigation treatments, 50% ET will be applied from tiller initiation to the end of stem elongation, from booting initiation to the end of heading, and from flowering to soft dough, whereas the plots will be well watered during the other stages. The experiment will be laid out in a split-plot design with four replicates. Irrigation treatments will be the main plot, and cultivars will be the split plot. All nutrients will be supplied as needed, following the current University of Idaho guidelines for crop fertilization. Rainfall and irrigation will be recorded as water inputs, and irrigation will be applied based on the spring cereal ET from the AgriMet system (located on the research station) on a weekly basis. A greenhouse experiment with the same irrigation treatments will be conducted and replicated twice.

During the growing season, crop physiological measurements will be taken in each plot at stages of heading, flowering, and grain-filling to explain the impact of water deficiency on crop growth and development. Measurements of photosynthetic rate (LI-COR 6400 portable photosynthesis system, LI-COR Inc. Lincoln, NE) and biomass sampling will be conducted on a weekly basis from heading to soft dough. The weight of total biomass, spike, and grain will be measured, and a portion of stem will be used to measure water-soluble content (e.g., glucose, fructose, and sucrose).

Prior to combining, plant samples will be harvested from each plot and oven dried at 70°C to determine dry biomass. The samples will be separated into vegetative tissues (e.g., leaves and stems) and spikes, and grain yield components (i.e., grain number per spike, spike numbers in a 3-ft row, and thousand kernel weight, etc.) will be determined. Water use efficiency (WUE) will be calculated as grain yield divided by seasonal water use (including irrigation and rainfall). Grain quality will be evaluated by measuring grain protein, falling number, and in baking tests. Grain yield, yield components, and quality will be statistically analyzed using ANOVA, and significance of means will be established from multiple comparisons to identify cultivars and irrigation treatments with high yield and quality.

Duration: 3 years

Cooperation/Collaboration: Katherine O'Brien, University of Idaho Wheat Quality Lab, Aberdeen R&E Center, Aberdeen, ID.

Anticipated Benefits, Expected Outcomes and Impacts and Transfer of Information: Compared with the 100% ET treatment, deficit irrigation at different stages may cause yield loss due to reduction in different yield components (e.g., spike density and thousand kernel weight). Effects of deficit irrigation on end-use quality may also be observed. Results from this study will provide best strategies for adopting deficit irrigation in spring wheat production in southern Idaho, and recommendations can be provided on reduced irrigation input to maximize economic return in spring wheat production. Results of this research will be communicated to growers and researchers through cereal schools, newsletters, websites, progress reports, conferences, and refereed journal publications.

Literature Review: Regulated deficit irrigation is an alternative deficit irrigation strategy that imposes water deficits only at selected phenological stages, such as at early vegetative growth and maturity, but full irrigation during critical reproductive stages (Du et al., 2010; Kang et al., 2000; Li et al., 2005). Regulated deficit irrigation has been successfully used to conserve water in many fruit and nut tree species, as well as row crops without yield loss in a variety of environments, and in some cases has been led to increases in yield, quality and/or WUE (Du et al., 2010; Fereres and Soriano, 2007; Kang et al., 2000; Kang et al., 2002; Rowland et al., 2012; Zhang et al., 2006). Regulated deficit irrigation could reduce shoot growth during vegetative development, contributing to lower water consumption through canopy transpiration, which is particularly beneficial in arid areas (Kang et al., 2000; Zhang et al., 2006).

FY2020

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: Xi Liang

Allocated by	Idaho Wheat Commission	during FY 2018	$ 18,011
Allocated by	Idaho Wheat Commission	during FY 2019	$ 18,046

REQUESTED FY2020 SUPPORT:

Budget Categories	(10) Salaries (*staff, post-docs, etc.*)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	$ 8,950	$ 3,000	$ 1,465	$ 600	$ 4,000	$ -	$ 18,015

TOTAL BUDGET REQUEST FOR FY 2020: $ 18,015

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	*Liang*	*Neibling*	*Marshall*	*(Insert CO-PI Name)*
(10) Salaries	$ 8,500	$ -	$ 450	$ -
(12) Temp Help	$ 1,700	$ 800	$ 500	$ -
(11) Fringe Benefits	$ 886	$ 265	$ 314	$ -
(20) Travel	$ 100	$ 500	$ -	$ -
(30) Other Expenses	$ 2,000	$ 1,000	$ 1,000	$ -
(70) Graduate Student Tuition/F		$ -	$ -	$ -
TOTALS	$ 13,186	$ 2,565	$ 2,264	$ -

Total Sub-budgets $ 18,015

Explanatory Comments:

Fall 2018 Version

ANNUAL REPORT

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Accomplishments: The second-year experiment was conducted with some modifications. Three spring wheat varieties (Dayn, hard white; SY Coho, hard red; and Alturas, soft white) were planted in plots of 10 by 20 feet. Plots were maintained under well-watered conditions throughout the season (100% ET), and three deficit irrigation treatments were included. For the three deficit irrigation treatments, 50% ET was applied from tiller initiation to the end of stem elongation (50_T1), from booting initiation to the end of heading (50_T2), and from flowering to soft dough (50_T3), whereas the plots were well watered (100% ET) during the other stages. The experiment was laid out in a split-plot design with four replicates. Irrigation treatment was the main plot, and variety was the split plot. All nutrients were supplied as needed, following the current University of Idaho guidelines for crop fertilization.

During the growing season, we took biomass samples and measurements of photosynthetic rates for four times from each plot. At harvest, grain yield and component parameters were measured, including biomass, number of kernels per spike, spike density, and thousand kernel weight. End-use quality is being analyzed in the wheat quality lab.

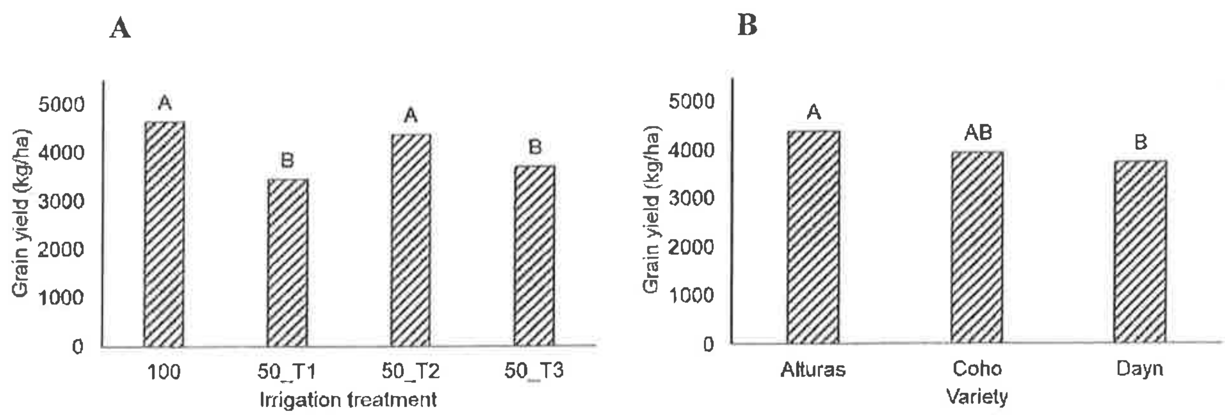

Figure 1 Effects of irrigation treatment (P < 0.001) (A) and variety (P = 0.030) (B) on grain yield were significant.

We collected all the data corresponding to the objectives that we proposed, and a summary of our results from 2018 is presented here. The total rainfall during the growing season was 0.84 inch, which is lower than previous years (e.g., 2.2 and 2.7 inch in 2016 and 2017, respectively). The total irrigation quantities were 13.5, 12.5, 11.9, and 9.8 inch for 100% ET, 50_T1, 50_T2, and 50_T3, respectively. The duration of deficit irrigation of 50% ET was approximately two weeks for 50_T1 and 50_T2 in May and June, respectively, and approximately three weeks for 50_T3 from late June to mid-July.

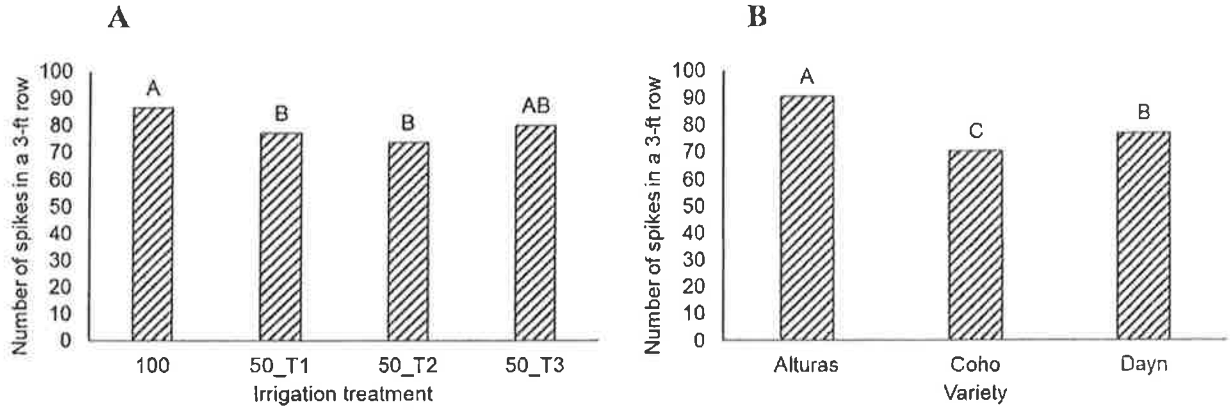

Figure 2 Effects of irrigation treatment (P = 0.002) (A) and variety (P < 0.001) (B) on the number of spikes in a 3-ft row. The results were from multiple sampling during the growing season and at maturity: 6/20/2018 (heading), 6/28/2018 (flowering), 7/5/2018, 7/12/2018, and 8/7/2018 (maturity).

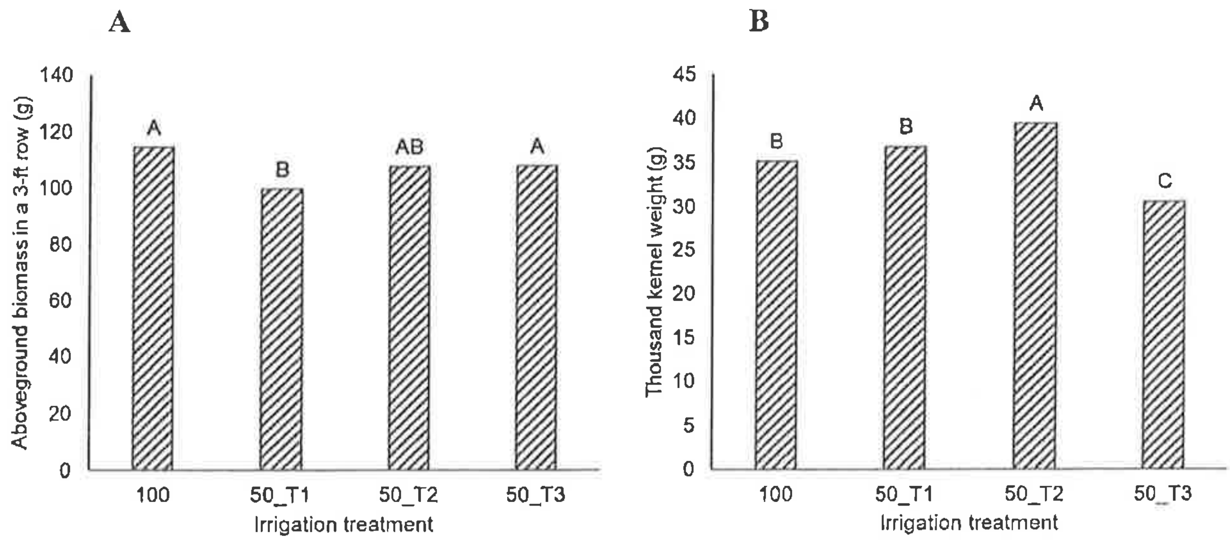

Figure 3. Effects of irrigation treatment on aboveground biomass (P = 0.005) (A) and thousand kernel weight (P < 0.001) (B). The aboveground biomass (i.e., vegetative tissues and spikes) was from multiple sampling during the growing season and at maturity: 6/20/2018 (heading), 6/28/2018 (flowering), 7/5/2018, 7/12/2018, and 8/7/2018 (maturity). The thousand kernel weight was measured at maturity.

Grain yield of deficit irrigation applied from tiller initiation to the end of stem elongation (50_T1) and from flowering to soft dough (50_T3) was significantly lower than 100% ET (100) (Figure 1A). Deficit irrigation from booting initiation to the end of heading (50_T2) did not cause severe yield loss compared with the 100% ET treatment. Across all the irrigation treatments, Alturas produced greater grain yield and Dayn, which was not significantly different from Coho (Figure 1B).

The lower grain yield of deficit irrigation applied from tiller initiation to the end of stem elongation (50_T1) could be related to its lower spike density (i.e., the number of spikes in a 3-ft row (Figure 1A; Figure 2A). Among the three varieties, Alturas produced more spikes than Coho and Dayn, and Dayn's spike density was greater than Coho (Figure 2B). Consistent with the response of spike density, aboveground biomass of deficit irrigation from tiller initiation to the end of stem elongation (50_T1) was smaller than the 100% ET treatment and deficit irrigation from flowering to soft dough (50_T3) (Figure 3A). The smaller grain yield of deficit irrigation applied from flowering to soft dough (50_T3) could be related to its smaller thousand kernel weight (Figure 1A; Figure 3B).

Projections: We have observed differences in grain yield and yield components in response to deficit irrigation during different stages, as well as differences among varieties. With one more year replication in 2019, we can be more confident on our results and conclusions. In the 2019 field experiment, we will also observe the growth of specific organs (e.g., spikelet and floret). A greenhouse experiment with similar treatments as the field experiment is planning for more intensive in-season measurements.

Results from this study will provide references on adopting deficit irrigation in spring wheat production in southern Idaho, and recommendations can be provided on reduced irrigation input to maximize economic return in spring wheat production. Results of this research will be communicated to growers and researchers through cereal schools, newsletters, websites, progress reports, conferences, and refereed journal publications. A Masters' student has been hired to work on this project as her thesis.

Publications: This project was introduced at the Aberdeen field day in July 2018. Some of the preliminary results from 2018 was presented as part of "Effects of drought Stress and deficit irrigation management on wheat yield and quality", at the 45th Annual Hermiston Farm Fair, Seminar & Trade Show in Hermiston, Oregon on November 28-30 2018. This presentation was invited by the organizer of the event.