Grant Code: AP6318
Title: Planting Dates, Seeding Rates, and Available Moisture for Dryland Winter Wheat Yields
Personnel: Jared Spackman, Assistant Professor, UI Aberdeen; Justin Hatch, Caribou County Extension Educator
Address: Jared Spackman 1693 S. 2700 W. Aberdeen, ID 83210; (208) 312-2454; jspackman@uidaho.edu

Justification/Rationale:

Water is the most limiting factor for dryland winter wheat production in Southeastern Idaho. Its availability affects producer decisions regarding planting date, planting rate, seeding depth, and fertilizer rates[1]. Adequate soil moisture is essential for wheat to germinate, explore the soil profile, access and extract soil nutrients, and assimilate carbon through photosynthesis. In Southern Idaho, annual precipitation ranges from 10 to 20 inches, with approximately half occurring from October through March (https://www.usbr.gov/pn/agrimet/currentdata.html). Approximately 48% of the annual precipitation occurs from April through June when most wheat growth occurs. Current predictions estimate that southern Idaho will become warmer with drier summers and wetter winters[2]. Dryland winter wheat producers must make the majority of their agronomic management decisions before they know what the environmental conditions will be for the coming growing season. One strategy to help minimize risks and to manage input costs is to develop yield-water relationships that take into account stored soil water just before planting and the expected growing season precipitation[3].

Two other management decisions that can affect available soil moisture are planting date and seeding rate. Dryland winter wheat needs to be planted early enough to allow for tiller and crown development and adequate root growth before winter dormancy. The current Southern Idaho dryland wheat production guide recommends planting in mid-August to early September[1]. However, because wheat seedlings require 2.3 inches of available water from germination through tillering[3], some producers may plant immediately following a rain event as early as July to take advantage of available moisture. Planting too early can produce large plants the deplete soil moisture and expose the crop to potential disease and insect problems[1]. In contrast, planting too late can reduce the number of tillers formed and delay the transition from vegetative to reproductive development. Hot temperatures during reproductive development can reduce spikelet and floret numbers and impair kernel set.

Seeding rates that are too low for a given set of environmental conditions produce reduced yields and may have higher weed pressure due to lack of crop competition. In contrast, seeding rates that are too high produce excessive vegetation that exhausts soil moisture, reduces tiller number per plant, may increase disease potential, and negatively impact yield[1]. We are proposing two studies that 1) investigate the impact of planting date and seeding rate on soil moisture and dryland grain yield and quality, and 2) investigate the relationship between available soil moisture at the time of planting plus the expected growing season precipitation and dryland wheat grain yield.

Objectives:

Objective 1: Evaluate the effect of dryland winter wheat planting date and seeding rate on soil moisture availability, nitrogen use efficiency, and grain quality and yield.

Objective 2: Assess the relationship of available water and spring rainfall with dryland winter wheat grain yield.

Methods/Plan of Work:
Experiment 1: A pseudo dryland field experiment will be conducted at the Aberdeen R&E Center for three growing seasons. The study will be a split-plot design. The main plots will consist of four planting dates occurring the third week of July, August, September, and October and the split plots will be four seeding rates of 300K, 500K, 700K, and 900K seeds per acre replicated four times (64 total plots). Aberdeen annually receives 7.6 inches of precipitation compared to Grace, Ririe, Ashton, Preston, and Tremonton that receive an annual average of 14.4 inches. Three to five inches of irrigation will be supplied before study initiation in May and June to artificially increase soil available moisture to be similar to other southern Idaho dryland sites. Until planting, the field will be chemically fallowed. A composite soil sample will be taken from each replicate at 1-foot increments down to three feet and analyzed for nutrient status. Immediately before each planting event, soil samples will be collected from each main plot at the 0-6, 6-12, 12-24, 24-36, and 36-48" depths and analyzed for gravimetric water content. These soils will be dried, ground, and analyzed for inorganic nitrogen content. In March after the ground thaws and in August after harvest, soil samples will be taken from each plot at the 0-6, 6-12, 12-24, 24-36, and 36-48" depths and analyzed for gravimetric water content and inorganic nitrogen content. The soil bulk density will be used to convert gravimetric water content to volumetric water content. Additional plot measurements include stand count, tiller number, lodging, insect and disease ratings, grain yield, and other yield metrics (test weight, grain protein, etc.). Whole plant tissue nitrogen will be measured from each plot at harvest. The response of the dependent variables to planting date and seeding rate will be assessed using analysis of variance.
Experiment 2: Each year, we plan to collaborate with 7 dryland winter wheat grain producers across southern Idaho. Targeted locations may include Ashton, Ririe, Soda Springs, Grace, Preston, Pocatello Valley, Rockland, and/or Oakley. Soil samples will be collected at three sampling events (fall planting, the following March, and at physiological maturity) from the 0-6, 6-12, 12-24, 24-36, and 36-48" depths from three or four georeferenced locations in each field (28 georeferenced data points annually). Each soil sample will be analyzed for gravimetric water content and bulk density. The post-harvest soil will be composited across the 5 soil sampling depths and analyzed for nitrate plus ammonium N. To estimate yield components, a 5-foot by 5-foot section of grain will be hand-harvested from each georeferenced point by cutting the straw at the soil surface, separating the grain from the straw, and analyzing the grain and straw for total nitrogen content. Post-harvest tissue and soil samples will allow us to evaluate the nitrogen use efficiency of each data point. We will also collect field management information for each georeferenced point (e.g., seeding rate, variety, planting date, seeding depth, field aspect, slope, planting direction, residue cover, fertility rate, soil taxonomy, etc.). Daily precipitation will be recorded from the NOAA or AGRIMET weather station in the closest proximity to the field. Each collaborating producer will also be provided with a rain gauge to correct for deviations in daily precipitation if needed. The relationship between grain yield and available soil moisture plus precipitation will be calculated using linear regression. The three soil moisture measurement timings will allow us to evaluate available soil moisture at the time of planting, the amount of moisture accumulated in the soil profile over the winter, and how much moisture remains in the soil at harvest.
Duration: Three years (Year 2 of 3)
Cooperation/Collaboration: Dr. Spackman's team is primarily responsible for establishing the Aberdeen R&E research plots and collecting data at participating grower fields. Justin Hatch will

assist in collecting soil and plant tissue samples. We are unaware of any on-going public or private projects that seek to predict yield given initial soil moisture conditions for southern Idaho/northern Utah. This project builds on research conducted by Mr. Hatch in Soda Springs in 2020.

Anticipated Benefits / Expected Outcomes: The seeding rate by planting date data generated from this study will be used to update the dryland wheat production guide. Additionally, this research will allow us to develop the relationship between dryland wheat grain yield with available soil moisture plus precipitation. This could be a valuable tool to help dryland wheat growers better estimate their potential yield for the coming growing season potentially saving money through improved input management.

Transfer of Information / Technology: The results will be shared at professional meetings Extension events (Cereal School, field days), and Extension publications. The raw dataset will be published in a publicly available data repository to ensure the longevity of the dataset and its availability for future research applications.

Literature Review:

The relationship between available water in the soil profile plus spring rainfall and grain yield has been investigated for multiple environments including the Columbia Basin[3], southeastern Idaho[1], and Colorado[4]. In the Columbia basin, a 1953-1957 dataset found the relationship was described as $Yield = 5.6X - 22.3$ while a 1993 – 2005 study found the relationship was $Yield = 5.8X - 13.5$, where X is total available water (stored soil water plus growing season precipitation) measured in inches. A southeastern Idaho study (1991 – 1996) found the relationship was $Yield = 5.81X - 13.13$ for hard red winter wheat and $Yield = 9.38X - 41.0$ for soft white winter wheat. These equations indicate that a producer with 5 inches of available soil moisture at planting and 11 inches of precipitation over the growing season could expect grain yield of 67.3, 79.3, 79.8, or 109 bu/ac, respectively. These equations also indicate that 4, 2.3, and 2.3 inches of available water are required just for vegetative growth of hard red winter wheat or 4.4 inches of available water are required for soft white winter wheat, respectively. Each additional inch of available water then increased grain yield by 5.6, 5.8, 5.8, and 9.38 bu/ac, respectively. These equations could be further developed into a decision support tool that accounts for wheat price, production costs, and disease and weed pressure.

References:

1. Robertson, L.D., S.O. Guy, and B.D. Brown. 2004. Southern Idaho Dryland Winter Wheat Production Guide. 1–95.
2. Projections, R.C. 2013. Intergov. Panel Clim. Chang.: 1311–1394. https://www.globalchange.gov/browse/reports/ipcc-climate-change-2013-physical-science-basis-summary-policymakers-technical
3. Schillinger, W.F., S.E. Schofstoll, and J.R. Alldredge. 2012. WSU Extension EM049E http://pubs.cahnrs.wsu.edu/publications/wp-content/uploads/sites/2/publications/em049e.pdf
4. Nielsen, D.C. et al. 2002. Agron. J. 94(5): 962–967. https://doi.org/10.2134/agronj2002.0962.
5. Leggett, G.E. 1959. Washington Agriculture Experiment Station Bulletin 609.

FY2024

COMMODITY COMMISSION BUDGET

Principal Investigator: Jared Spackman

Allocated by ______ *(Commission/Organization)*	**during FY2022**	**$**	**-**
Allocated by Idaho Wheat Commission *(Commission/Organization)*	**during FY2023**	**$**	**27,087**

REQUESTED SUPPORT: **Budget Categories**	*Awarded for FY2023*	*Requested for FY2024*
(10) Salary (*staff, post-docs, et NOTE: Faculty salary/fringe not allowed*	$ 8,723	$ 10,103
(12) Temporary Help/IH	$ 1,800	$ 1,800
(11) Fringe Benefits	$ 3,714	$ 4,999
(20) Travel	$ 3,113	$ 5,416
(30) Other Expenses	$ 9,737	$ 10,772
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -
TOTALS	**$ 27,087**	**$ 33,090**

TOTAL BUDGET REQUESTED FOR FY2024: **$ 33,090**

BREAKDOWN FOR MULTIPLE INDEXES: **Budget Categories**	*Jared Spackman*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*
(10) Salary (*staff, post-docs, et*	$ 10,103	$ -	$ -	$ -
(12) Temporary Help	$ 1,800	$ -	$ -	$ -
(11) Fringe Benefits	$ 4,999	$ -	$ -	$ -
(20) Travel	$ 5,416	$ -	$ -	$ -
(30) Other Expenses	$ 10,772	$ -	$ -	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	**$ 33,090**	**$ -**	**$ -**	$ -
			Total Sub-budgets	**$ 33,090**

Budget Justification

$	10,103	Technician, $19.91, 507 hours, Soil and plant tissue sample collection and processing, data analysis
$	1,800	Temporary Help with PERSI benefits, $15, 120 hours, soil and plant tissue sample collection and processing
$	4,999	42% for technician, 42% for temporary help with PERSI benefits
$	5,416	On Farm Travel: 4 trips to 7 locations with an estimated mileage of 200 miles roundtrip, UI Aberdeen RE vehicle mileage rates are $0.80/mile. No per diem requested. Trailer Rental: 3 trips to 7 locations with a daily charge fee of $40.
$	10,772	**On Farm Expenses:** 140 soil samples analyzed for NH4 NO3 at $5.50/sample=$770 56 plant tissue samples analyzed for total N at a rate of $6.50/sample=$364 Shipping Expenses $525, Other Expenses (bags, labels, rain gauges, work gloves) =$488.85 **Aberdeen Seeding RatexPlanting Date Study:** Field Charge $800 960 soil samples analyzed for NO3 NH4 at Brookside at $$5.50/sample = $5280 Soil and plant tissue shipping Expenses $800, 128 plant tissue samples analyzed for total N at $6.50/sample = $832, Plot Combine: $448, Other Expenses (bags, labels, rain gauges, work gloves) =$464.06

Annual Report

Grant Code: AP6318

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Abstract:
Water is the most limiting factor for dryland winter wheat production in Southeastern Idaho. Its availability affects producer decisions regarding planting dates and seeding rates. Dryland winter wheat producers must make the majority of their agronomic management decisions before they know what the environmental conditions will be for the coming growing season. One strategy to help minimize risks and to manage input costs is to develop yield-water relationships that account for soil water just before planting and the expected growing season precipitation. The objectives of this study are to 1) investigate the relationship between available soil moisture at the time of planting plus the expected growing season precipitation and dryland wheat grain yield and 2) investigate the impact of planting date and seeding rate on soil moisture and dryland grain yield and quality. In the summer of 2022, a pseudo dryland study was established at the Aberdeen RE center where UI Sparrow was planted the third week of July, August, September, and October at 300K, 500K, 700K, and 900K seeds per acre. Immediately before planting, soil samples were collected at the 0-6, 6-12, 12-24, 24-36, and 36-48" depths and analyzed for gravimetric water content and bulk density. July seeded grain successfully emerged due to timely precipitation, but August and September seeded plots did not emerge until early October due to insufficient rainfall.
On-farm observational studies were established at 8 locations in August and September in American Falls, Rockland, Roy, Holbrook, and Soda Springs. We collected soil samples at 0-6, 6-12, 12-24, 24-36, and 36-48" depths from 33 georeferenced locations. Each soil sample was analyzed for gravimetric water content and bulk density. Daily precipitation is being recorded with rain gauges and the AGRIMET weather station in the closest proximity to the field.

Background/Objectives:
Water is the most limiting factor for dryland winter wheat production in Southeastern Idaho. Its availability affects producer decisions regarding planting dates, seeding rates, seeding depths, and fertilizer rates. In Southern Idaho, annual precipitation ranges from 10 to 20 inches, with approximately half occurring from October through March. Approximately 48% of the annual precipitation occurs from April through June when most wheat growth occurs. Current predictions estimate that southern Idaho will become warmer with drier summers and wetter winters. Dryland winter wheat producers must make the majority of their agronomic management decisions before they know what the environmental conditions will be for the coming growing season. One strategy to help minimize risks and to manage input costs is to develop yield-water relationships that take into account stored soil water just before planting and the expected growing season precipitation.

Two other management decisions that can affect available soil moisture are planting date and seeding rate. Dryland winter wheat needs to be planted early enough to allow for tiller and crown development and adequate root growth before winter dormancy. The current Southern Idaho dryland wheat production guide recommends planting in mid-August to early September. However, because wheat seedlings require 2.3 inches of available water from germination through tillering, some producers may plant immediately following a rain event as early as July to take advantage of available moisture. Planting too early can produce large plants that deplete soil moisture and expose the crop to potential disease and insect problems. In contrast, planting too late can reduce the number of tillers formed and delay the transition from vegetative to reproductive development. Hot temperatures during reproductive development can reduce spikelet and floret numbers and impair kernel set.

Seeding rates that are too low for a given set of environmental conditions produce reduced yields and may have higher weed pressure due to a lack of crop competition. In contrast, seeding rates that are too high produce excessive vegetation that exhausts soil moisture, reduces tiller number per plant, may increase disease potential, and negatively impact yield. The objectives of this study are to 1) investigate the impact of planting date and seeding rate on soil moisture and dryland grain yield and quality, and 2) investigate the relationship between available soil moisture at the time of planting plus the expected growing season precipitation and dryland wheat grain yield.

Results/Accomplishments:

Dryland Planting Date x Seeding Rate (Aberdeen RE):

We successfully established a pseudo dryland field experiment at the Aberdeen R&E Center. Because Aberdeen receives less precipitation than other southern Idaho dryland sites, approximately three inches of irrigation was applied in June to artificially increase the soil moisture. UI Sparrow, a soft white winter wheat, was planted the third week of July, August, September, and October at four seeding rates of 300K, 500K, 700K, and 900K seeds per acre replicated four times (64 total plots). We collected a composite soil sample from each replicate at 1-foot increments down to three feet and analyzed them for complete nutrient status. Immediately before each planting event, we collected soil samples at the 0-6, 6-12, 12-24, 24-36, and 36-48" depths and analyzed them for gravimetric water content. We are in the process of grinding these soils and they will be submitted to Brookside Laboratories for inorganic nitrogen content.

We observed that the July seeded grain successfully emerged due to timely precipitation, but August and September seeded plots did not emerge until early October due to insufficient rainfall. For the future years of the study, we will likely apply 0.1 - 0.25" of irrigation immediately after each planting event to better simulate a dryland grower who would try to plant immediately before an expected rainfall event.

On Farm Trials Assessing Available Moisture on Wheat Grain Yield

We successfully established on-farm observational studies at 8 locations in August and September in American Falls, Rockland, Roy, Holbrook, and Soda Springs. We collected soil samples at 0-6, 6-12, 12-24, 24-36, and 36-48" depths from four or five georeferenced locations in each field (33 total georeferenced data points). Each soil sample was analyzed for gravimetric water content and bulk density. Georeferenced points in each field were selected to capture differences in hillslope (top of the hill, side slope, toe slope) and aspect (north, south, east, or west facing). As we collected the soil samples, we found that differences in soil texture could be quite extreme. Thus, we plan to measure the percentage of sand, silt, and clay in each soil sample beyond the original scope of the study. The cooperating farmers planted the field within +/- 3 days of soil sampling. Daily precipitation is recorded from the NOAA or AGRIMET weather station in the closest proximity to the field. To help correct for deviances between weather stations and grower fields, rain gauges were placed along the field edge and cooperating farmers have recorded rainfall amounts through October. We will resume precipitation measurements in the spring.

Outreach/Applications/Adoption:
Given the early stages of the study, we do not yet have sufficient data to present to Idaho wheat producers. The seeding rate by planting date data generated from this study will be used to update the dryland wheat production guide. Additionally, this research will allow us to develop the relationship between dryland wheat grain yield with available soil moisture plus precipitation. This could be a valuable tool to help dryland wheat growers better estimate their potential yield for the coming growing season potentially saving money through improved input management. The results will be shared at professional meetings Extension events (Cereal School, field days), and Extension publications. The raw dataset will be published in a publicly available data repository to ensure the longevity of the dataset and its availability for future research applications.

Next Steps/Projections
<u>Dryland Planting Date x Seeding Rate (Aberdeen RE)</u>

In March after the ground thaws and in July – August after harvest, soil samples will be taken from each plot at the 0-6, 6-12, 12-24, 24-36, and 36-48" depths and analyzed for gravimetric water content and inorganic nitrogen content. The measured soil bulk density values will be used to convert gravimetric water content to volumetric water content. Additional plot measurements include stand count, tiller number, lodging, insect and disease ratings, grain yield, and other yield metrics (test weight, grain protein, etc.). Whole plant tissue nitrogen will be measured from each plot at harvest. The response of the dependent variables to planting date and seeding rate will be assessed using analysis of variance.

<u>On Farm Trials Assessing Available Moisture on Wheat Grain Yield</u>

Post-harvest soils will be composited across the 5 soil sampling depths and analyzed for nitrate plus ammonium N. To estimate yield components, a 5-foot by 5-foot section of grain will be hand-harvested from each georeferenced point by cutting the straw at the soil surface, separating the grain from the straw, and analyzing the grain and straw for total nitrogen content. Post-harvest tissue and soil samples will allow us to evaluate the nitrogen use efficiency of each data point. We will also continue to collect field management information for each georeferenced point (e.g., seeding rate, variety, planting date, seeding depth, field aspect, slope, planting direction, residue cover, fertility rate, soil taxonomy, etc.). Daily precipitation will continue to be recorded from the NOAA or AGRIMET weather station in the closest proximity to the field. The relationship between grain yield and available soil moisture plus precipitation will be calculated using linear regression. The three soil moisture measurement timings will allow us to evaluate available soil moisture at the time of planting, the amount of moisture accumulated in the soil profile over the winter, and how much moisture remains in the soil at harvest.

Dr. Spackman recently hired a postdoc who will help with the textural analysis of the georeferenced soil samples.

Publications/Presentations/Popular Articles/News Releases/Variety Releases:
UI to start study on dryland wheat soil moisture in southern Idaho. Capital Press. https://www.capitalpress.com/ag_sectors/grains/ui-to-start-study-on-dryland-wheat-soil-moisture-in-southern-idaho/article_062e2a08-1fef-11ed-9c01-b796cb1a9245.html Aug. 19, 2022.
Spackman, J.A. 2022. Upcoming Planting Dates, Seeding Rates, and Available Moisture for Dryland Winter Wheat Study. Small Grain Summer Field Day. Soda Springs, ID. 21 July, 2022. (27 attendees, 15 minutes).

Spackman, J.A. 2022. Upcoming Planting Dates, Seeding Rates, and Available Moisture for Dryland Winter Wheat Study. Small Grain Summer Field Day. Rockland, ID. 29 June, 2022. (17 attendees, 15 minutes).