Ancient Wheat Production in Wyoming:

Effect of location, nitrogen, and crop species on growth, yield, and quality in irrigated and dryland fields

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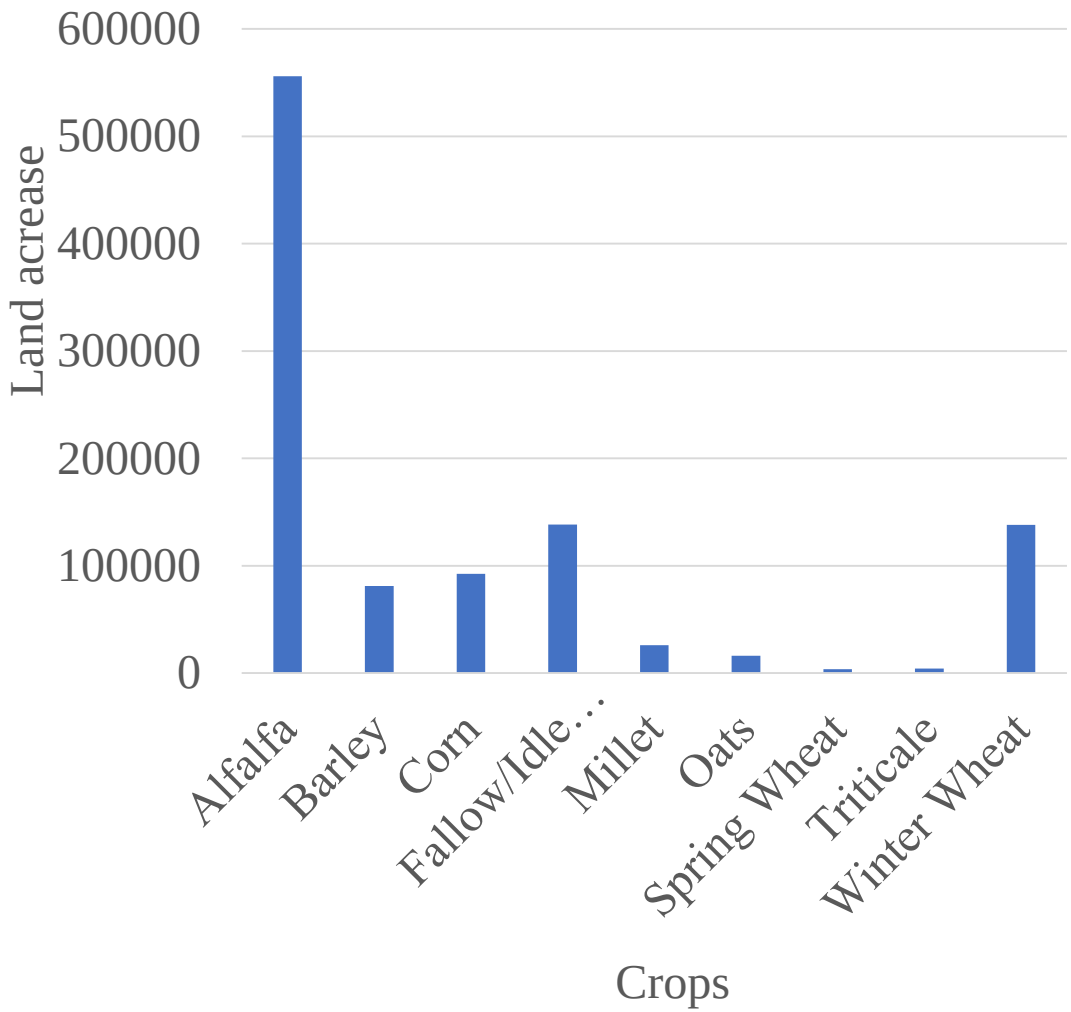
Background

- Wyoming agronomic challenges
  - Hot dry summer and wet winters
  - High evapotranspiration
  - Arid conditions
  - Fast draining sandy or heavy clay soil
  - Low soil fertility and quality
  - Isolation from markets
- Soil, climate, geographical conditions lead to limited crop diversity
- Small grains are one of the widely grown crops in Wyoming
  - Wyoming grows about 250,000 acres of wheat, oats and barley

Fig1: land acres for different crops in WY



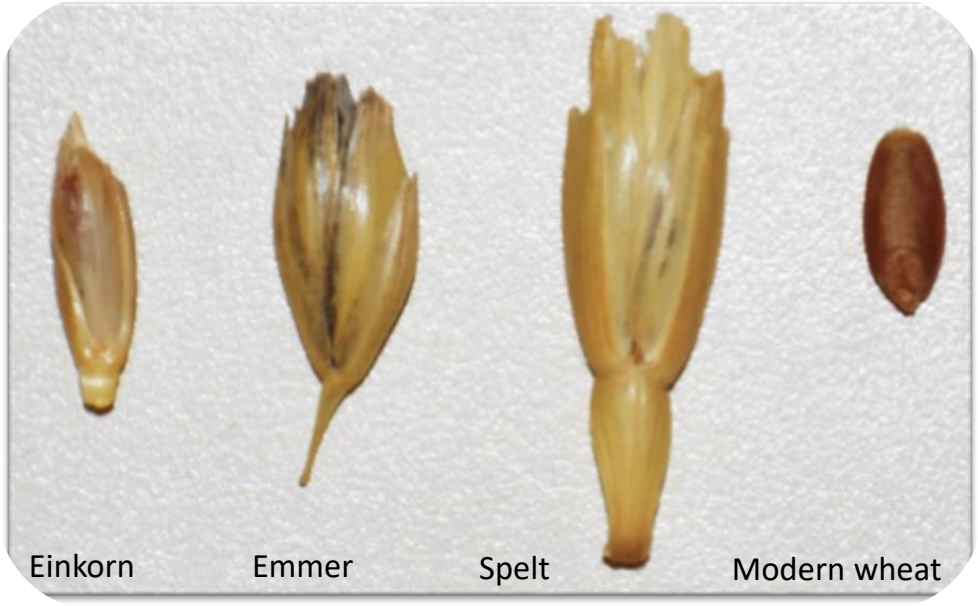
Source: USDA

Background

- Value of conventional small grains has been declining
- Consumer preferences are changing
  - Sustainable agriculture
  - Healthier lifestyle
  - Premium price for healthy products, new flavors, and textures
- Ancient grains are a strong national food trend
  - 269% increase in processed food products labeled as “ancient” from 2010 to 2016 (Roesler, 2018)

Ancient Wheats (*Triticum* spps.)

- Bridging species between modern wheat and wild relatives
- Types
  - Einkorn: first cultivated wheat
    - Diploid (2n=14)
  - Emmer: Intermediate between einkorn and spelt
    - Tetroploid (2n= 28)
  - Spelt: Most closely related to modern wheat
    - Hexaploid
  - Modern wheat
    - Hexaploid
- Hulled and not free threshing
- Most are hulled and not free threshing
- Lower yielding
- Distinct nutrition and flavors



Einkorn in the hull

Einkorn grain

Einkorn heads in the field

Einkorn (*Triticum monococcum* L.)

One grain/hull

Bread, pasta, malt, biscuits, and porridge made in the past.

Generally higher gliadin: glutenin ratio and poor baking performance

Emmer in the hull

Emmer grain

Emmer heads in the field

Emmer (*Triticum diococcum* L.)

Two grains/hull

Products like bread, porridge, groats, crackers, biscuits, pasta, beer made in the past (Buerli, 2006)

Higher gliadin: glutenin ratio and poor baking performance but better than einkorn

Spelt in the hull

Spelt grain

Spelt heads in the field

Spelt (*Triticum spelta* L.)

Two grains/hull

Products like bread, biscuits, cookies, muffins, cakes, pasta, and breakfast cereals made in the past .

Spelt gluten predominated by gliadins like einkorn, and emmer but most comparable to wheat of the 3

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- Require extra dehulling process
- Lower yielding
- not free threshing

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- Lower yielding
- Distinct nutrition and flavors
- Relative economic return high

Rationale of the study

- Ancient wheat should be well suited to Wyoming based on the success of other small grains.
- Premium markets should offset yield losses of ancient wheats produced in WY relative to modern grains.
- Ancient wheats will likely have different growth characteristics and management needs than modern wheat.
- Different ancient wheats may perform better in different growing regions of WY and under different management practices.

Objective

Identify agronomic management practices and nitrogen demand of spelt, emmer and einkorn and how nitrogen affects agronomic traits of these ancient wheats under multiple Wyoming growing conditions and locations.

Research Questions

- Which ancient wheat is best suited for Wyoming growing conditions?
- Do ancient wheats perform differently in different growing regions?
- Are ancient grains able to maintain yield and quality in low N treatments?
- Are the ancient species better suited to dryland or irrigated fields?

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Research Treatments

3 LOCATIONS

2 IRRIGATION TREATMENTS

3 NITROGEN RATES

4 CROPS

MATERIALS AND METHODS

Study site/ Location (factor 1)

- Irrigated studies
  - SAREC: Lingle, WY
  - PREC: Powell, WY
  - ShREC: Sheridan, WY
- Dryland studies
  - SAREC: Lingle, WY
  - ShREC: Sheridan, WY

MATERIALS AND METHODS

Study site/ Location (factor 1)

- Irrigated studies
  - ➢SAREC: Lingle, WY
  - ➢PREC: Powell, WY
  - ~~➢ShREC: Sheridan, WY~~
- Dryland studies
  - ➢SAREC: Lingle, WY
  - ➢ShREC: Sheridan, WY

MATERIALS AND METHODS

Crops (Factor 2)

- Einkorn
- Emmer
- Spelt
- Wheat/Barley

Table. Crop Varieties in 2019 and 2020

Crop	Variety	
	2019	2020
Spelt	CDC origin	CDC origin
Emmer	‘Lucile’	‘Lucile’
Einkorn	‘Stoneage’	‘Stoneage’
Wheat	SY605(SAREC) Gunnison (ShREC)	Surpass HRS (SAREC) Fortuna (ShREC)
Barley	Moravian 170	Miller Coors BC100

Experimental design

- Split plot design in each location
- Three replications.
- Each replication had 3 blocks of nitrogen.
- Nitrogen was treated as main plot and crops randomized in subplots within the main plot

56 kg/ha N	
	Wheat
	Spelt
	Emmer
	Einkorn

90 kg/ha N	
	Emmer
	Einkorn
	Wheat
	Spelt

123 kg/ha N	
	Wheat
	Einkorn
	Spelt
	Emmer

90 kg/ha N	
	Emmer
	Einkorn
	Spelt
	Wheat

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Field site: SAREC irrigated, spring 2019

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Field site: SAREC irrigated, spring 2019

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- Each replication had 3 blocks of nitrogen.
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Factor 3: Nitrogen rates
(residual soil nitrate + 32-0-0 fertilizer)

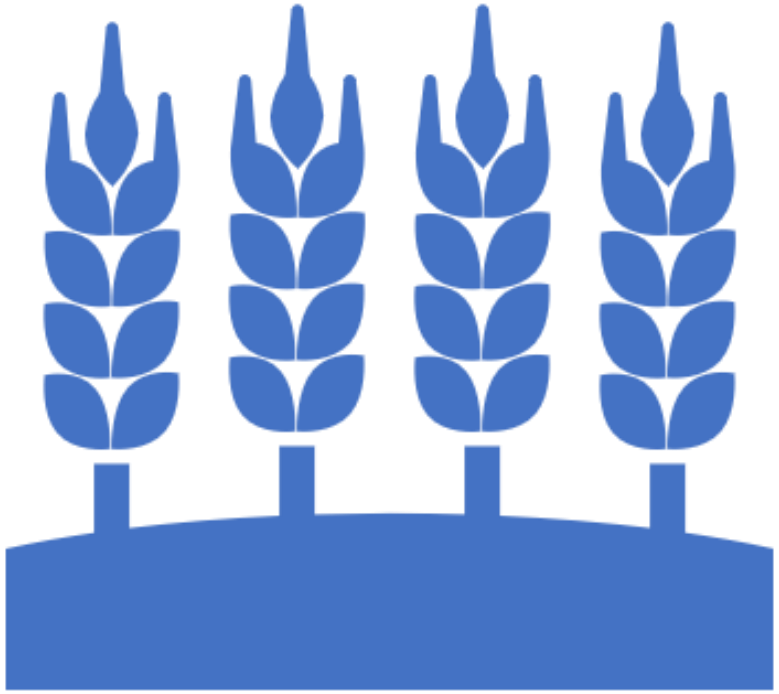
- High: 90 kg/ha N
- Medium: 56 kg/ha N
- Low: 28 kg/ha N
  - SAREC irrigated site:
    123, 90, and 56 kg/ha N

Soil sampling and nitrogen application:

- Soil sampled at 3 depths (0-20 cm, 20-60 cm, 60-90 cm) with Giddings.
- Samples sent to Midwest laboratories Inc., ohama, NE for analysis.
- N applied in each treatment blocks after deducting the residual soil N

Planting

- Seeding rate: 67 kg/ha (Dryland studies),
  112 kg/ha (Irrigated studies)
- Seeding depth: 3.8 cm



Data Collection

- Plant stands
- Growth stage
- NDVI (Normalized Difference Vegetation Index)
- Lodging
- Heading date and days to heading
- Hulled Yield and Grain Yield
- Test Weight
- Grain protein (%)
- Grain moisture (%)
- Grain N (kg/ha)= Yield (kg/ha)*Grain N
  Grain N =Protein/5.7
- Nitrogen use efficiency (NUE)= Grain Yield /(Residual N + applied N)
- Gravimetric water balance

Data analysis

- R Studio

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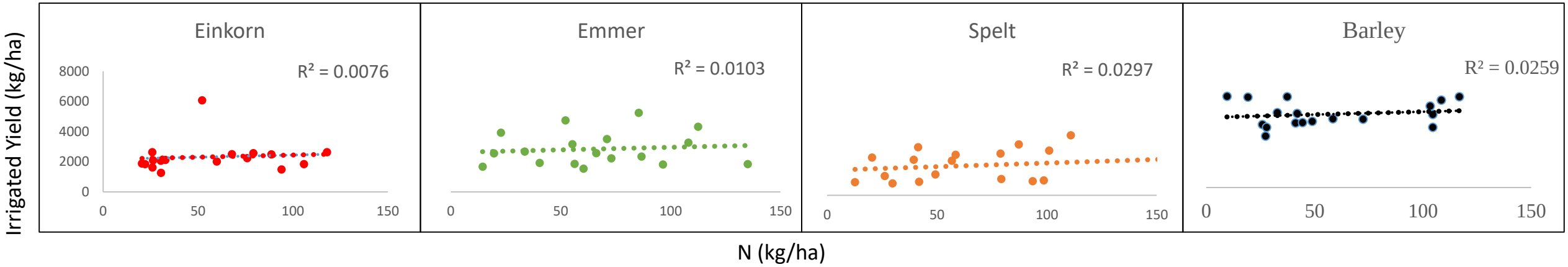
Chapter 1: Ancient Wheat Performance under Irrigation

- Irrigated Research Plots
  - ➢PREC and SAREC

Irrigated Grain Yield

Nitrogen treatment had no effect on grain yield

PREC



SAREC

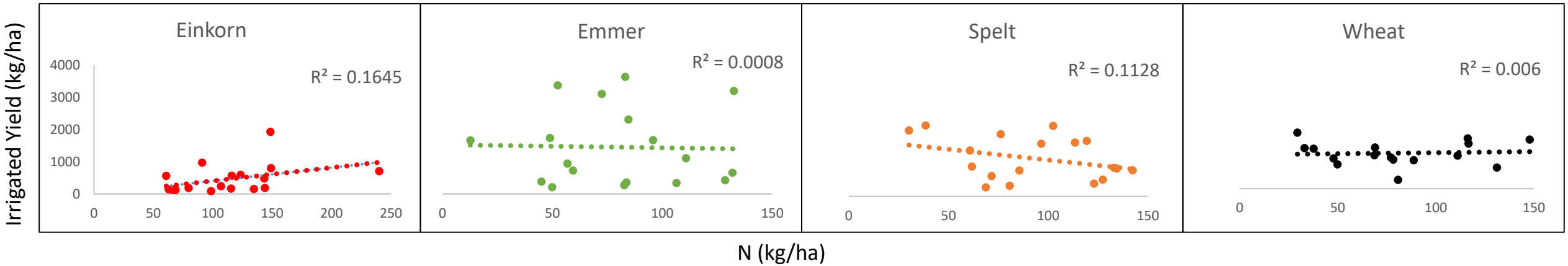
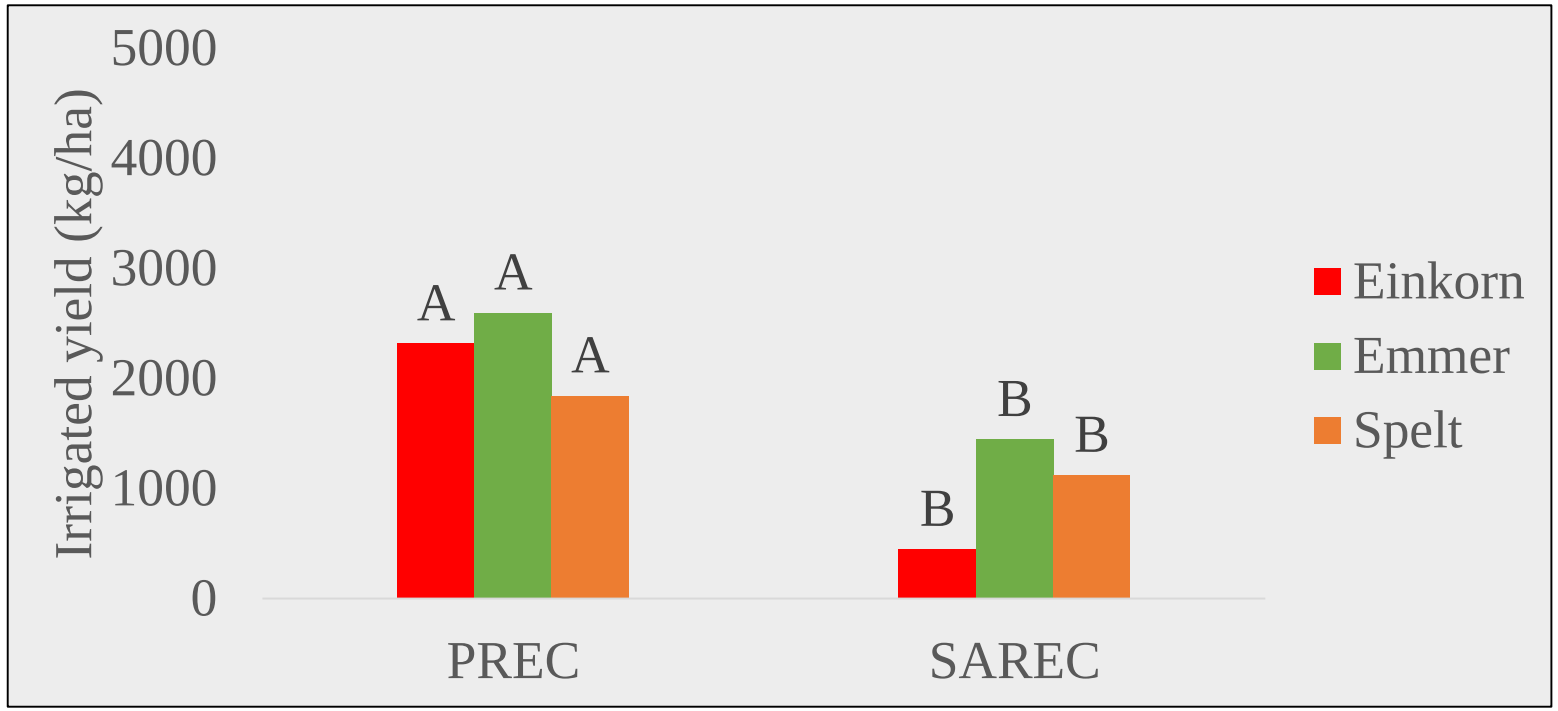


Fig: Effect of N (kg/ha) on grain yield (kg/ha) P-Value NS for N

Location treatment effected grain yield

Yield was higher at PREC than SAREC

Model: Grain yield~nitrogen+location+nitrogen*location+(1|year)



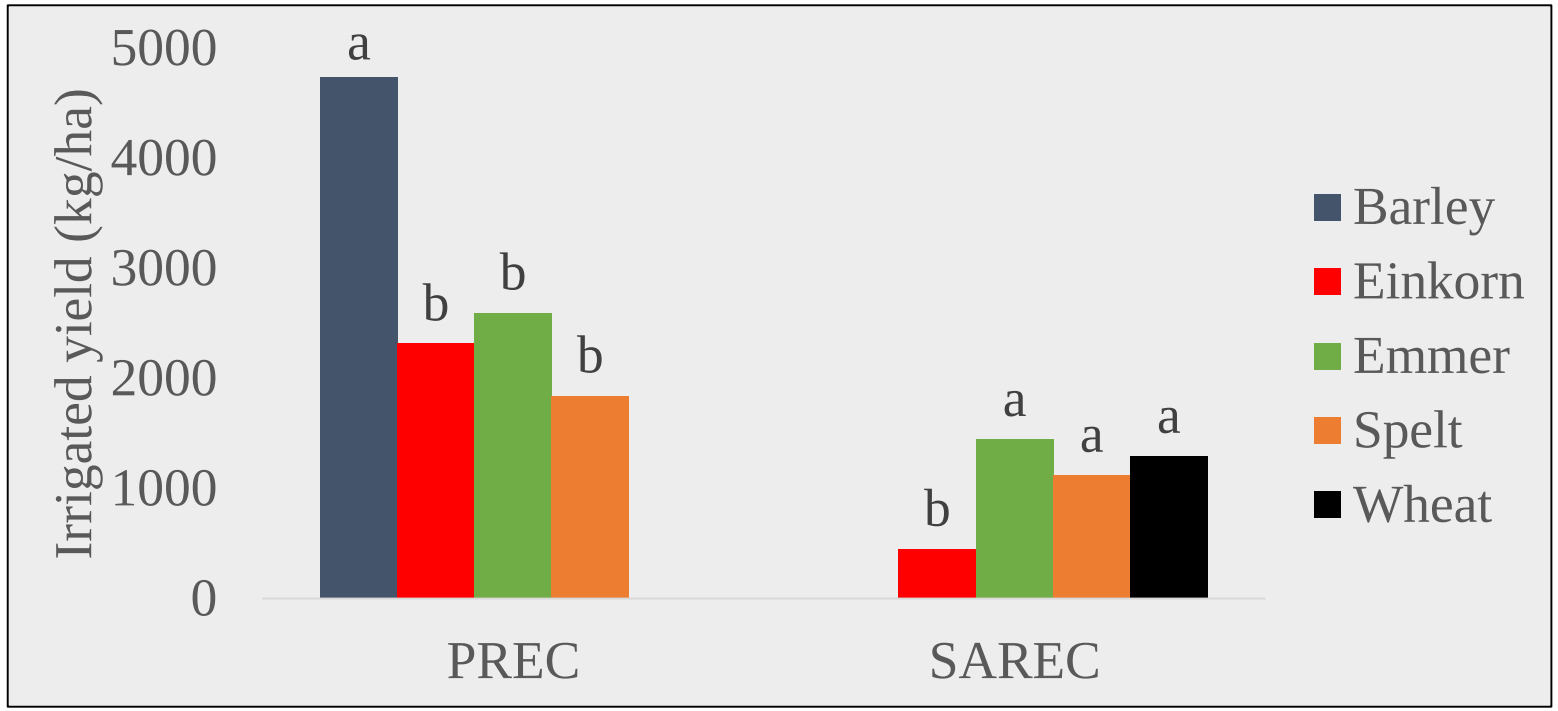
In the figure, upper case letters are used to compare the location. P-Value was significant for location and crop at 5% significance level. P-Value NS for nitrogen and interaction between nitrogen and location

Crops type effected yield within each location

At PREC, all 3 ancient wheats were the same but ½ of barley

At SAREC, einkorn performed poor emmer and spelt same as wheat

Model: Grain yield~crop+(1|year)



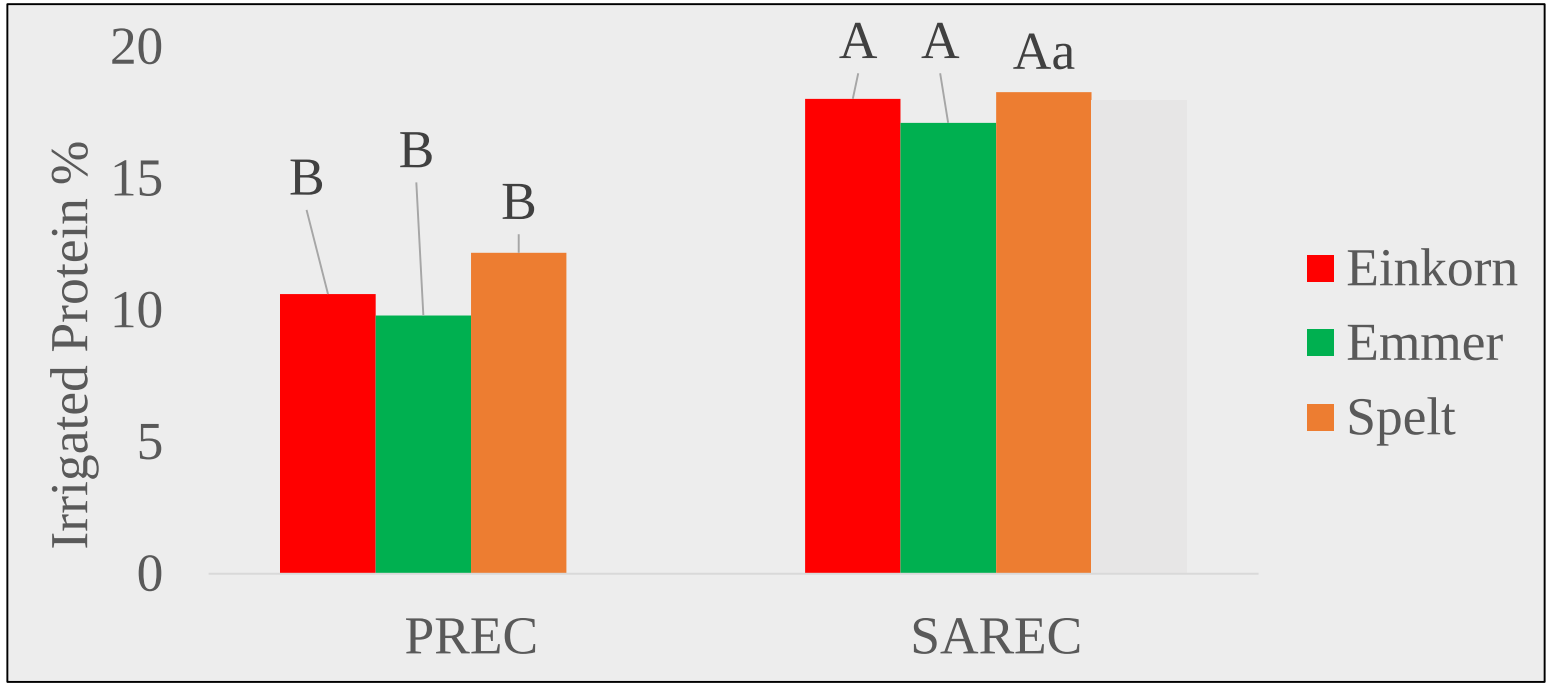
In the figure, Lower case letters are used to compare crops. P-Value was significant for crop at 5% significance level.

Irrigated Grain Protein

Location treatment effected grain protein

For all 3 crops, grain protein(%) was higher at SAREC than PREC

Model: Grain protein %~nitrogen+location+nitrogen*location+(1|year)



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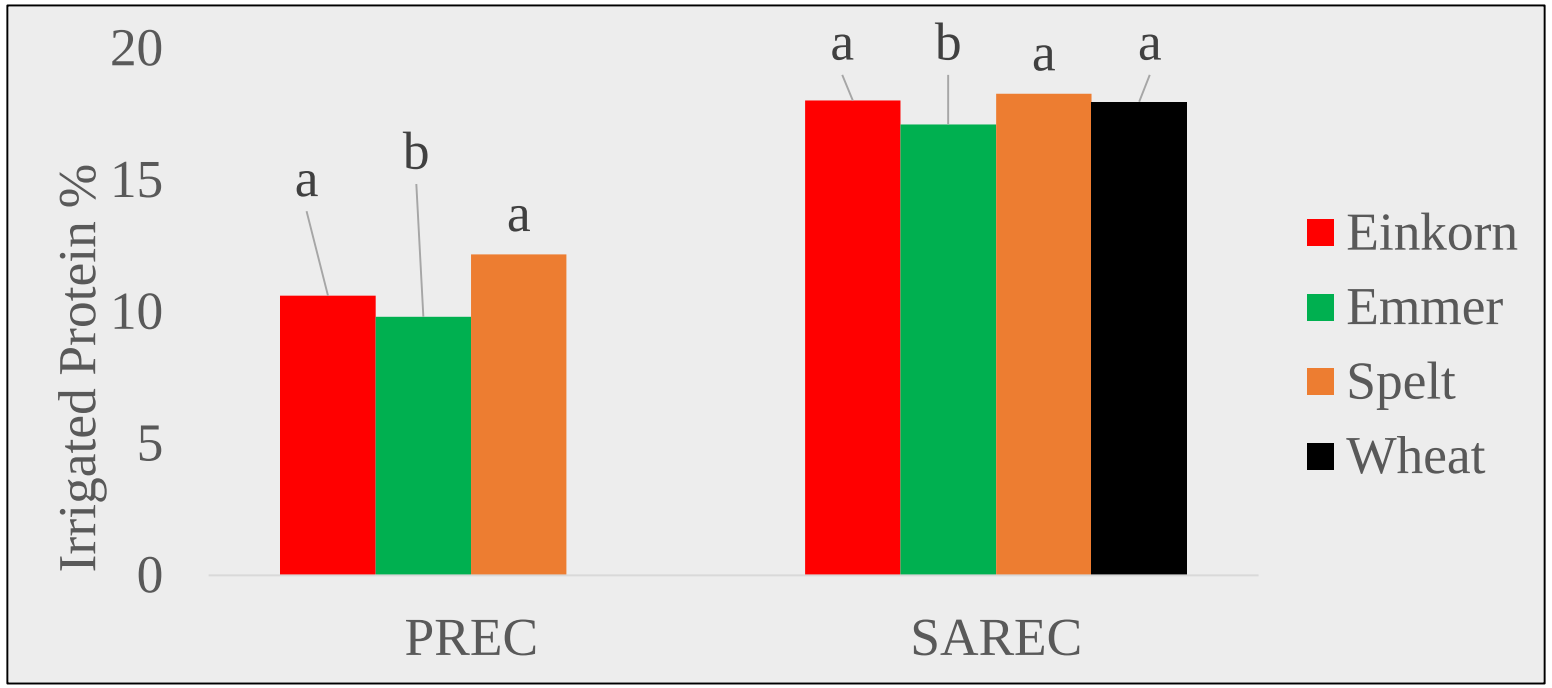
Crop type effect grain protein within each location

Emmer had lower grain protein(%) in both locations

Model: Grain protein %~crop+(1|year)

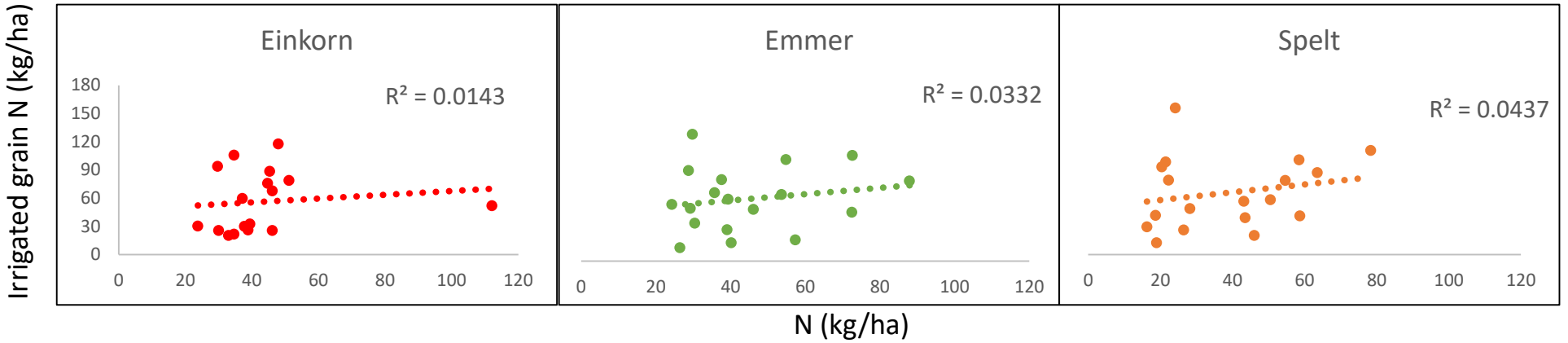


In the figure, Lower case letters are used to compare crops. P-Value for crop was significant crop at 5% significance level

Grain Nitrogen (kg/ha)= Grain N x Yield (kg/ha)
(Grain N = Protein /5.7)

Nitrogen treatment had no effect on grain N

PREC



SAREC

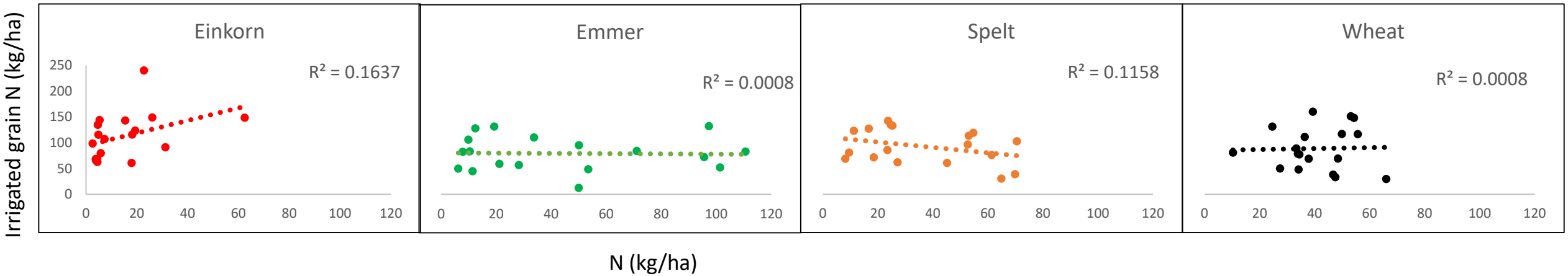
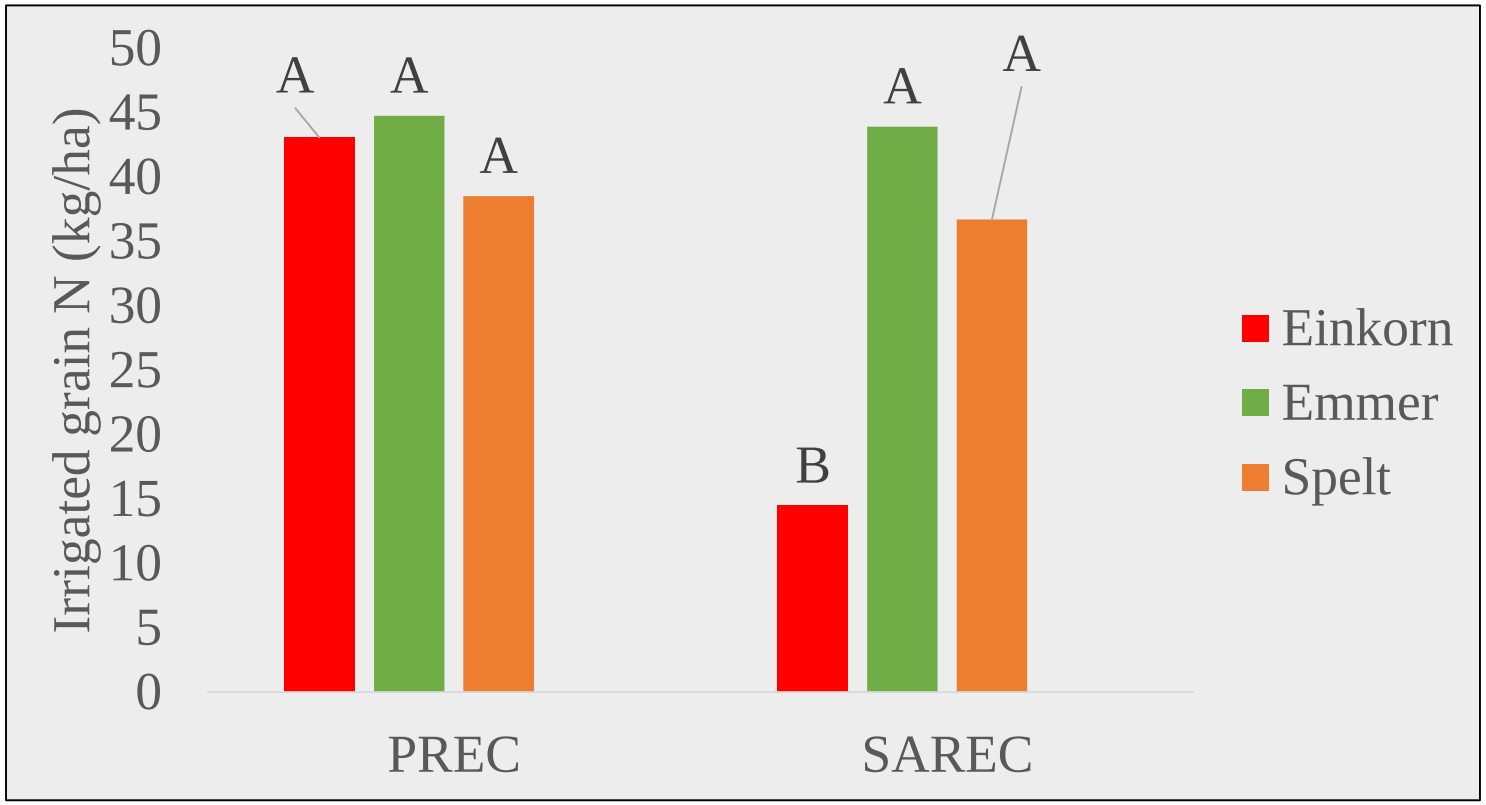


Fig: Effect of N (kg/ha) on grain N (kg/ha). P-Value NS

Location treatment effected grain Nitrogen (kg/ha)

Einkorn had lower grain N at SAREC. Emmer and Spelt had similar grain N in both locations

Model: GrainN(kg/ha)~nitrogen+location+nitrogen*location+(1|year)



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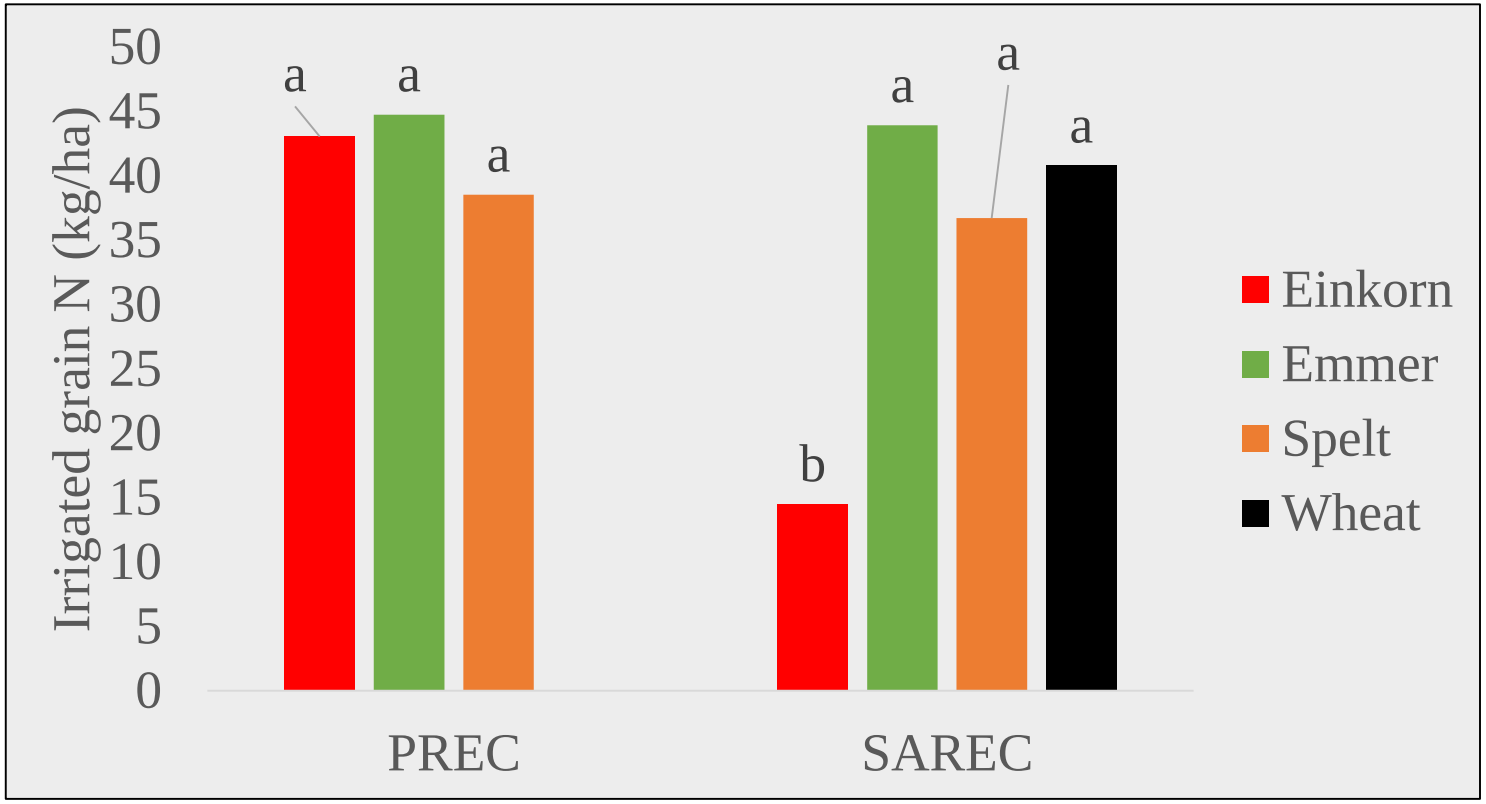
Crop type effected grain Nitrogen (kg/ha) at SAREC

At SAREC, einkorn had lower grain N (~1/2) than other crops. No difference in grain N among crops at PREC

Model: Grain N (kg/ha)~crop+(1|year)



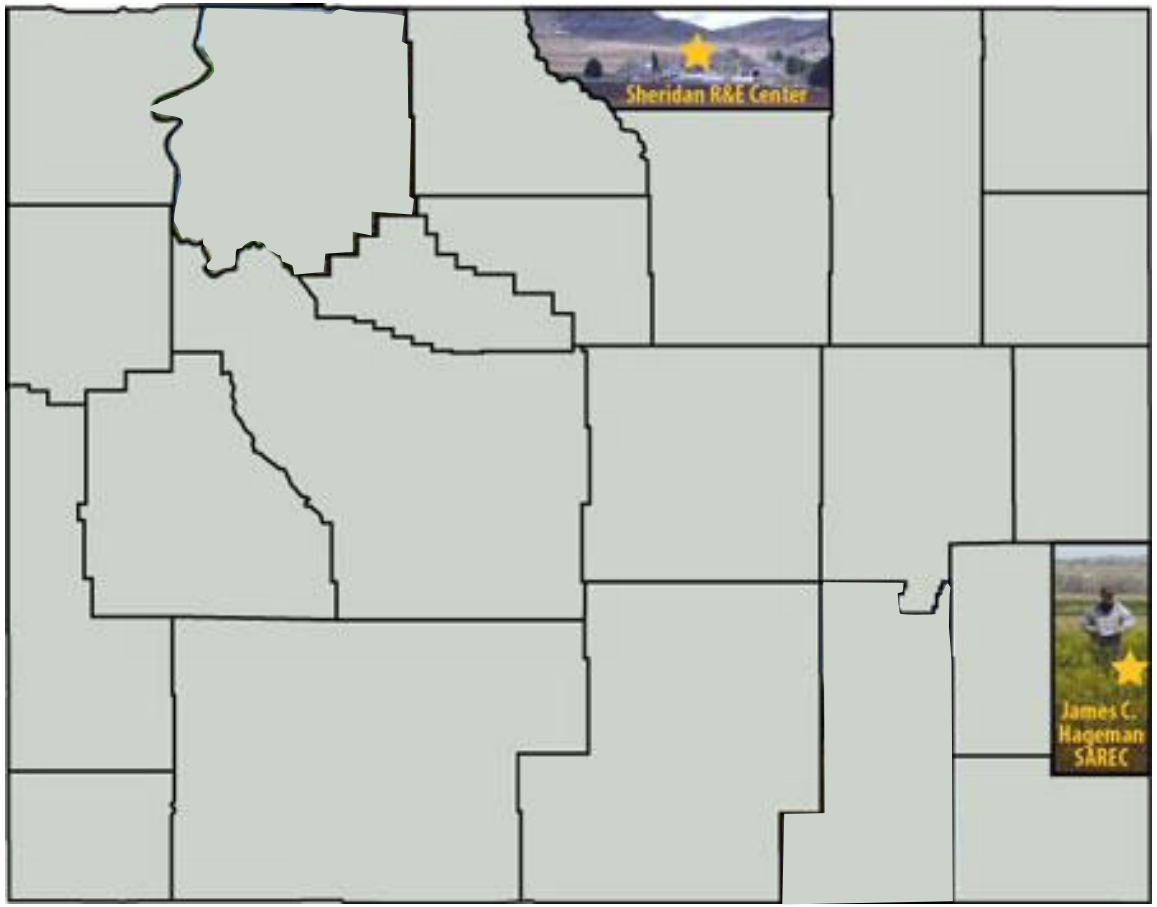
In the figure, Lower case letters are used to compare crops. P-Value was significant for crop type at SAREC at 5% significance level

Irrigated Conclusion

- For highest irrigated yield Powell is the preferred growing region
- Protein of all spring ancient wheat was higher in the Lingle growing region, but this was an effect of low yield.
- Emmer and spelt performed the same as modern wheat in the Lingle growing region.
- Increasing nitrogen did not improve yield or protein for any crop at either location.

Chapter 2: Ancient Wheat Performance in Dryland

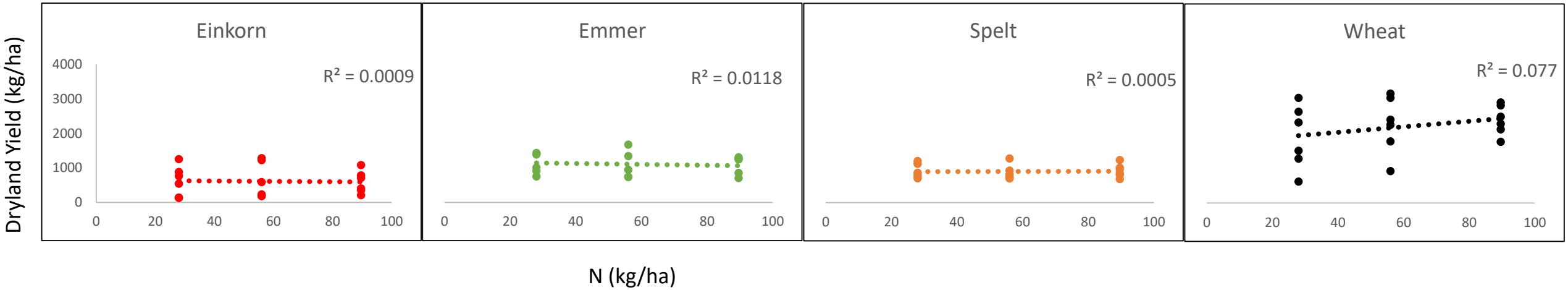
- Dryland Research Plots
  - ➢ShREC and SAREC



Dryland Grain Yield

N treatments had no effect on yield in dryland fields

ShREC



SAREC

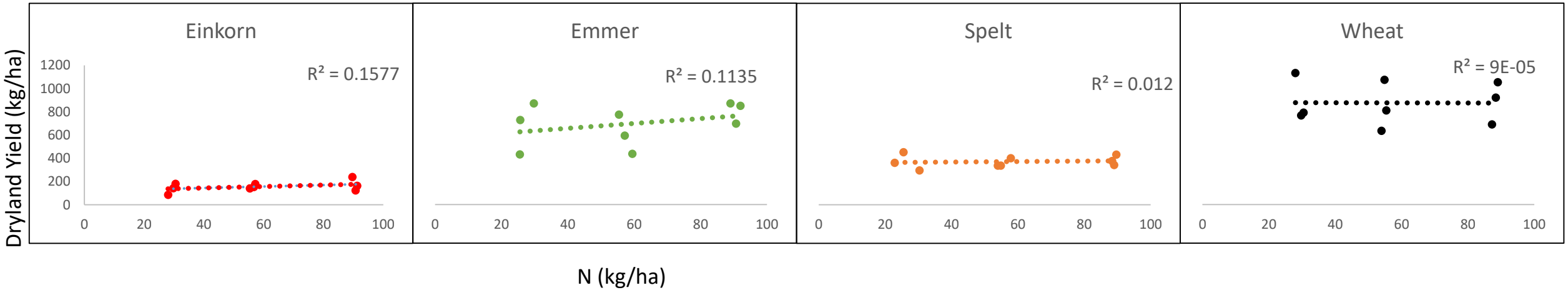
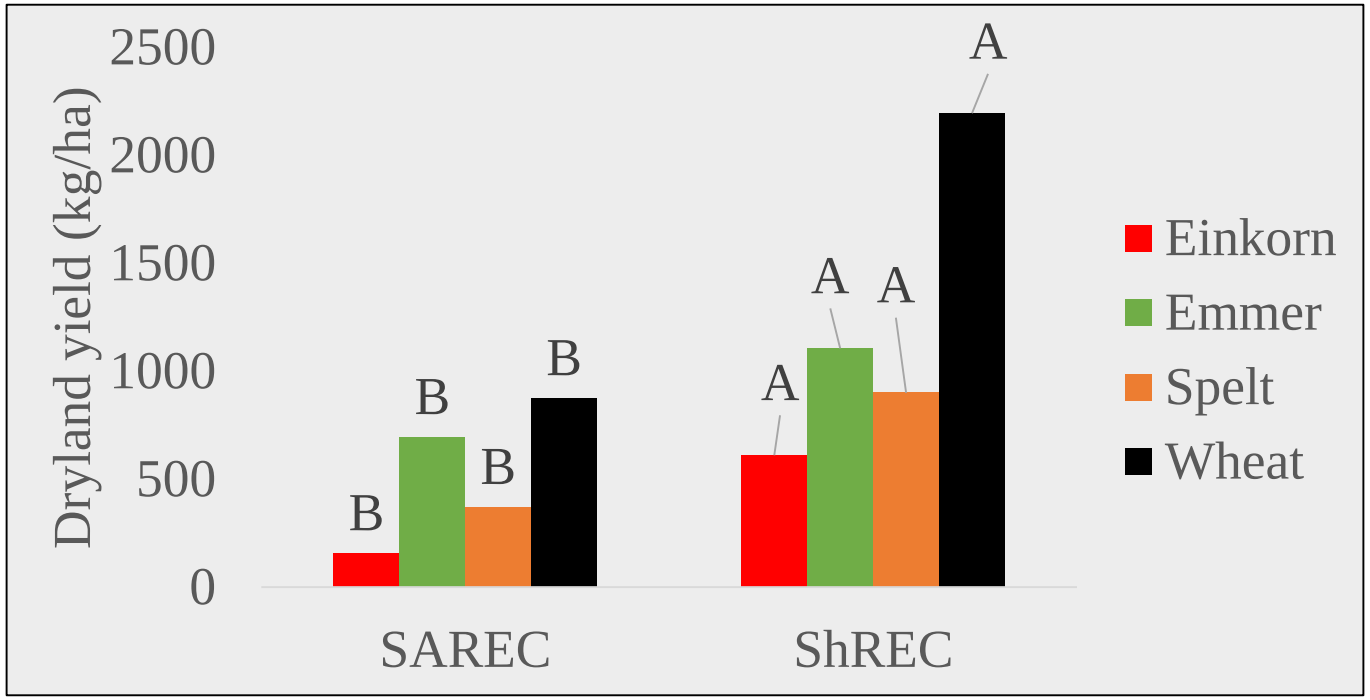


Fig: Effect of N (kg/ha) on grain yield (kg/ha). P-Value NS.

Location treatment effected grain yield

Grain yield was higher at ShREC than SAREC

Model: Grain yield~nitrogen+location+nitrogen*location+(1|year)

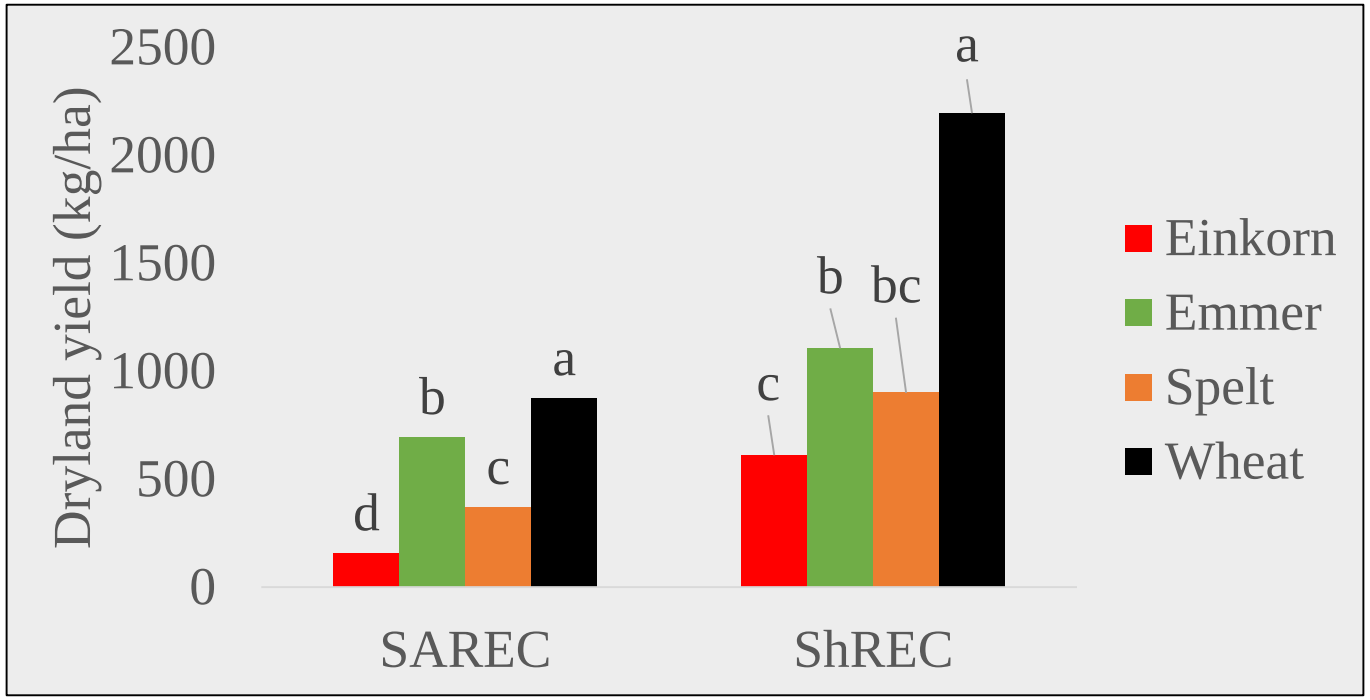


In the figure, upper case letters are used to compare the location. P-Value was significant for location at 5% significance level. P-Value NS for nitrogen and interaction between nitrogen and location

Crops type effected yield within each location

In both locations, wheat had the highest and einkorn had the lowest yield

Model: Grain yield~crop+(1|year)



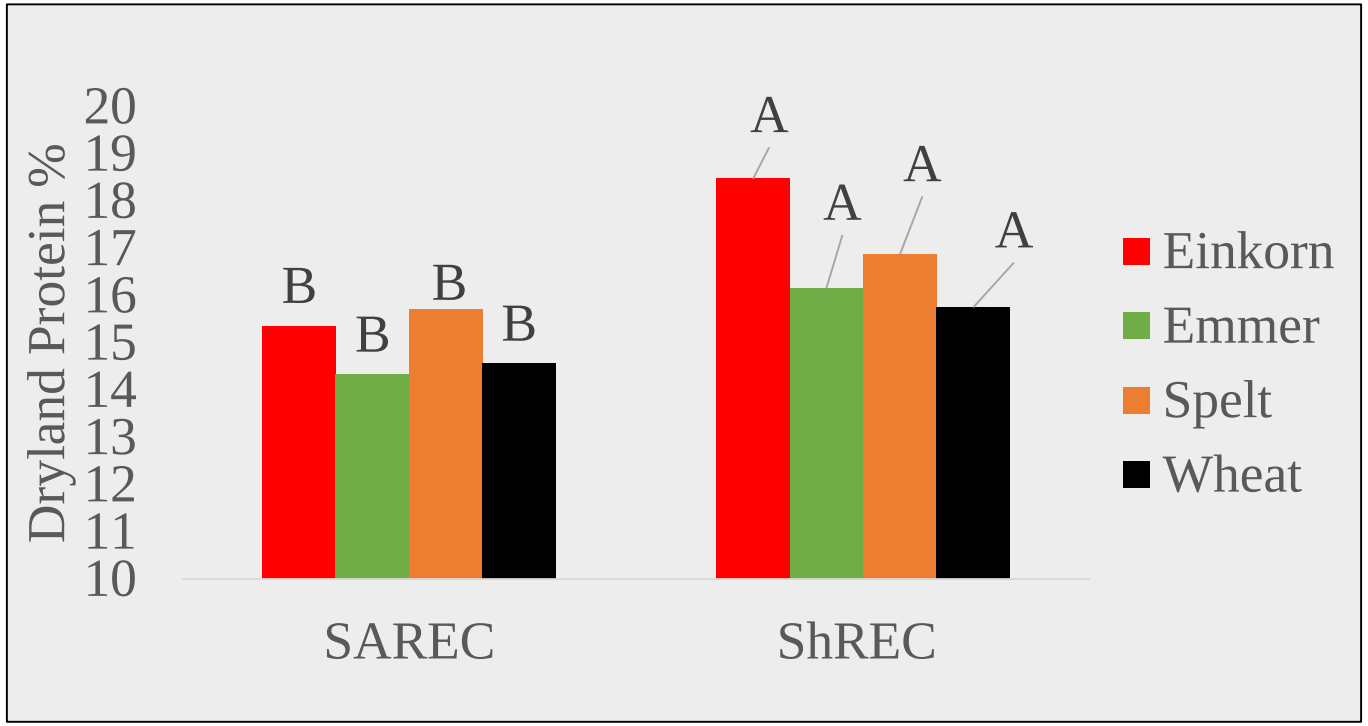
In the figure, Lower case letters are used to compare crops. P-Value was significant for crop at 5% significance level.

Dryland Grain Protein

Location treatment effected grain protein %

Protein was higher at ShREC than SAREC

Model: Grain protein %~nitrogen+location+nitrogen*location+(1|year)



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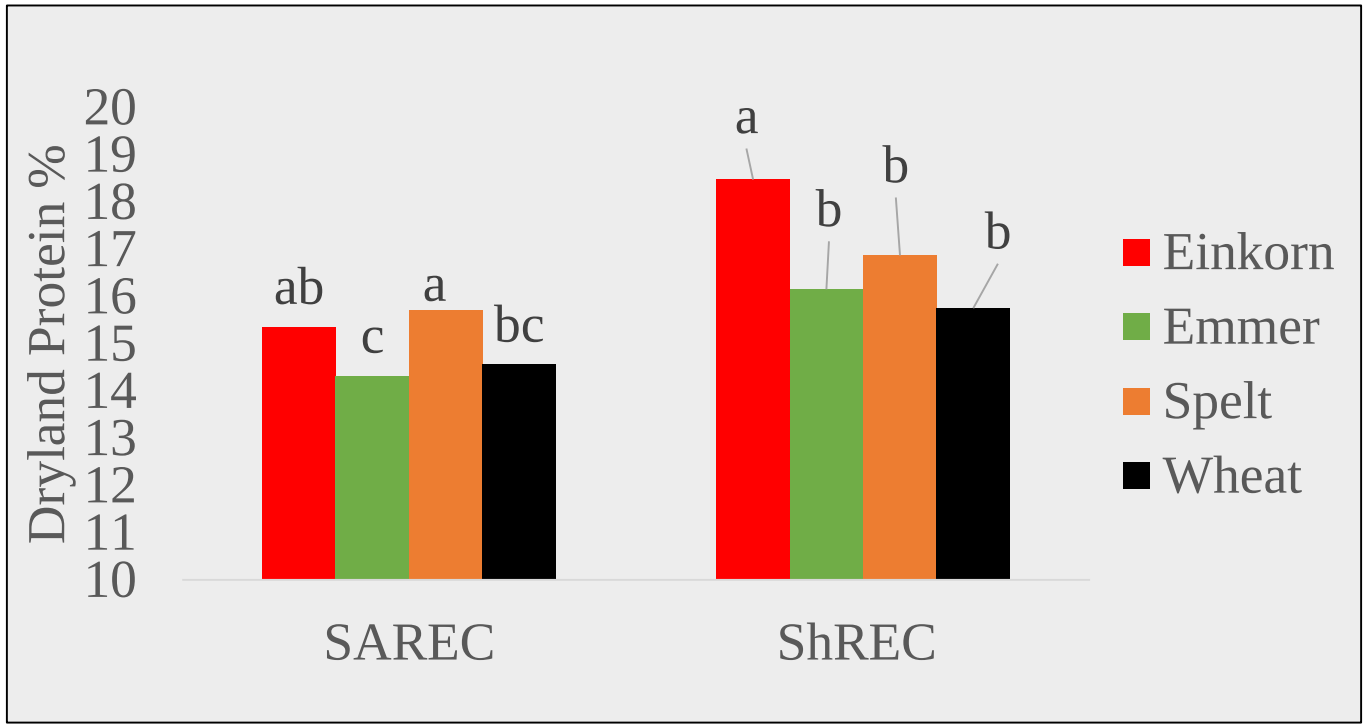
Crop type effected grain protein % in dryland

Protein was the highest in einkorn at ShREC and Spelt at SAREC

Model: Grain protein %~crop+(1|year)



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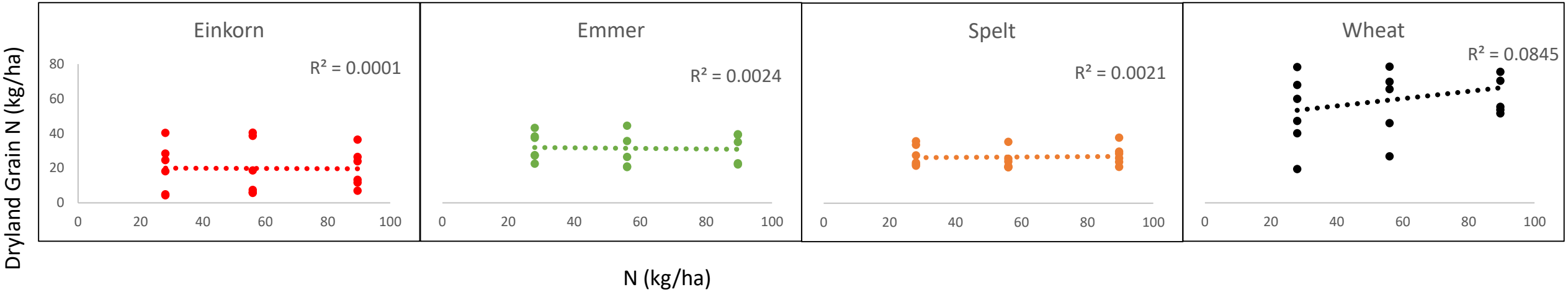
Dryland Grain Nitrogen (kg/ha) = Grain N x Yield (kg/ha)
(Grain N= Protein/5.7)

Nitrogen had no effect on grain N

ShREC



SAREC

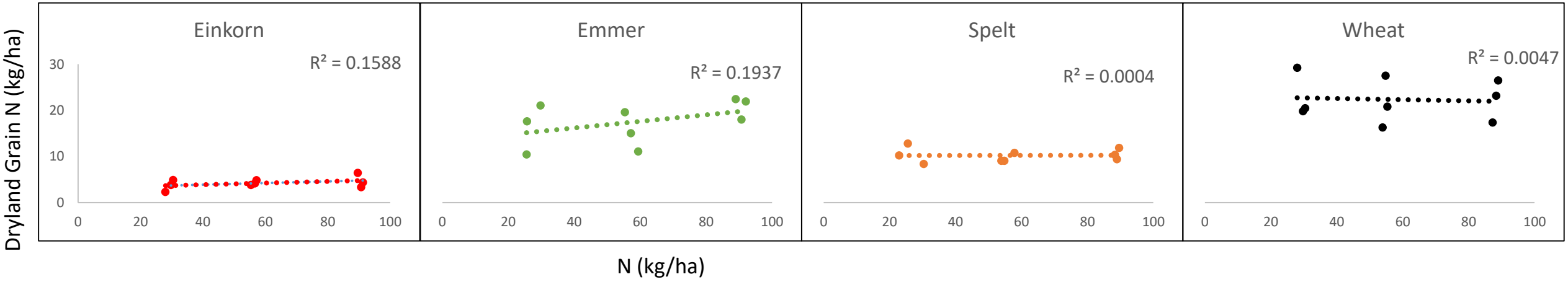
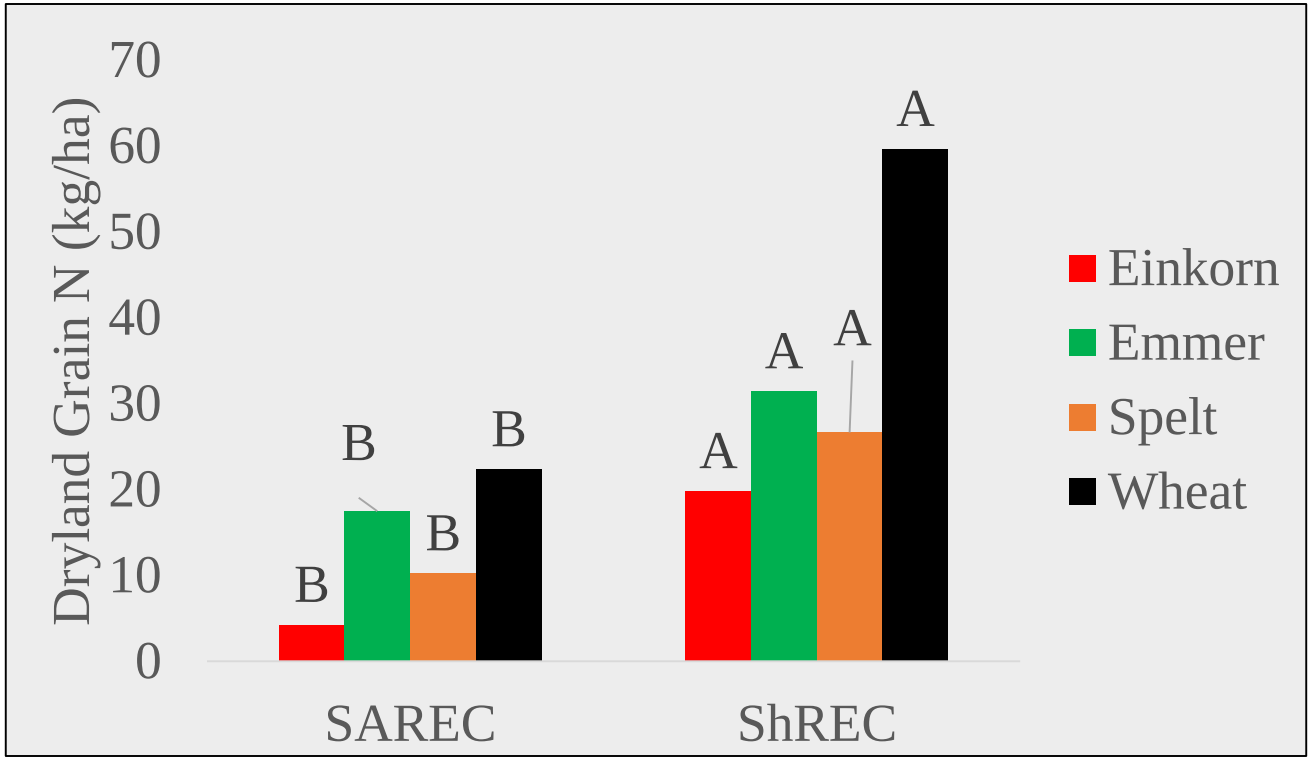


Fig: Effect of N (kg/ha) on grain N (kg/ha). P-Value NS

Location effected grain N (kg/ha)

Grain N was higher at ShREC than SAREC

Model: Grain N (kg/ha)~nitrogen+location+nitrogen*location+(1|year)



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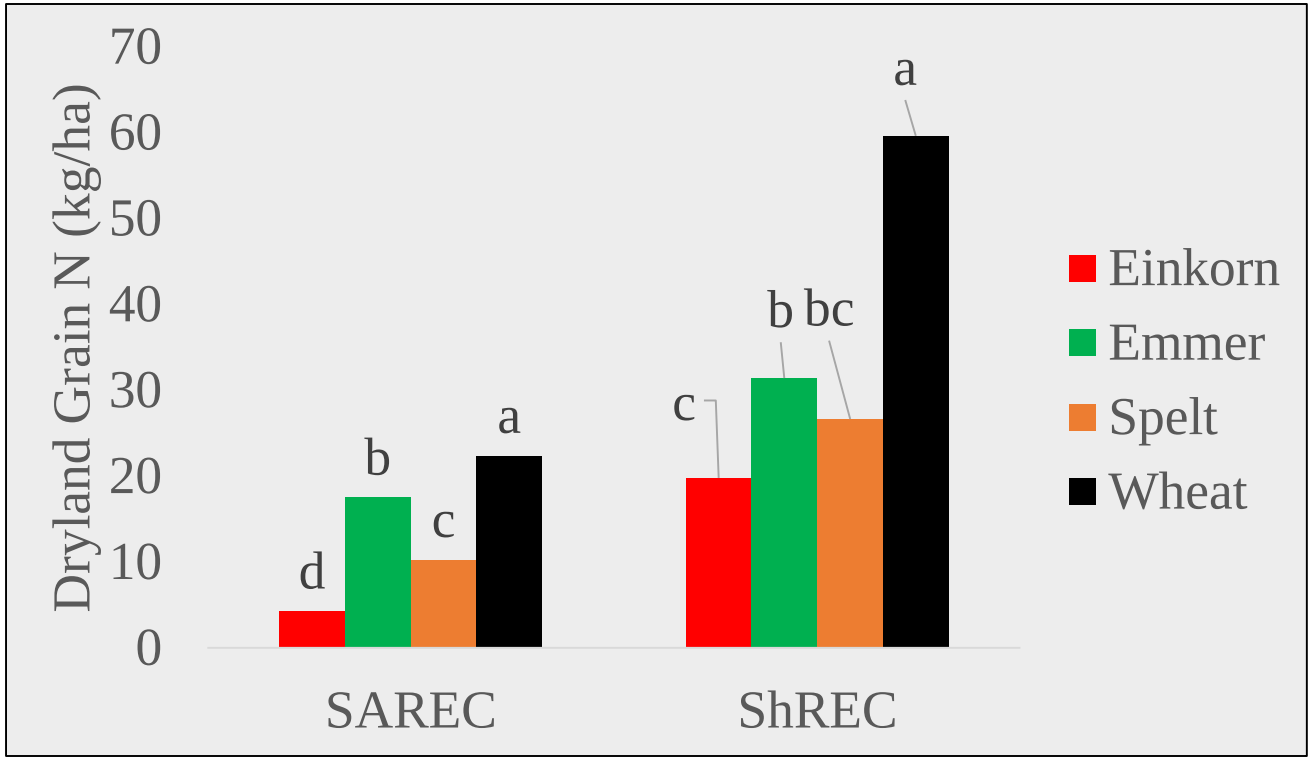
Crop type effected grain N (kg/ha)

Wheat had the highest, and einkorn the lowest grain N

Model: Grain N (kg/ha)~crop+(1|year)



In the figure, Lower case letters are used to compare crops. P-Value was significant for crop at 5% significance level.

Dryland Conclusion

- ShREC is the preferred growing region for dryland
- For both regions, modern wheat outperformed ancient wheats
- Einkorn and spelt had higher grain protein than the modern wheat in SAREC and ShREC respectively
- Emmer and spelt performed better than the einkorn.
- Increasing nitrogen did not improve yield or protein for any crop at either location.

Overall Conclusion

- Spring ancient wheats are better adapted to northern Wyoming locations.
- SAREC irrigated and ShREC dryland locations produced ancient wheat with high protein content.
- Over all treatments emmer and spelt had higher yield than einkorn.
- Einkorn is best suited for irrigated production in the Powell region
- For the range of nitrogen used, ancient wheats and barley/modern wheat can maintain yield and quality even at low N input

Future Work

- Future research on higher and lower nitrogen rates and timing of nitrogen application should be performed to find out appropriate N requirement for these wheats.
- Performance of other varieties of ancient wheats should be evaluated in the different growing region to identify the range of performance potential of ancient wheats in WY.
- Evaluation of the economics of ancient grain production in Wyoming will be critical to establishing spelt, emmer, or einkorn as a crop for the state.

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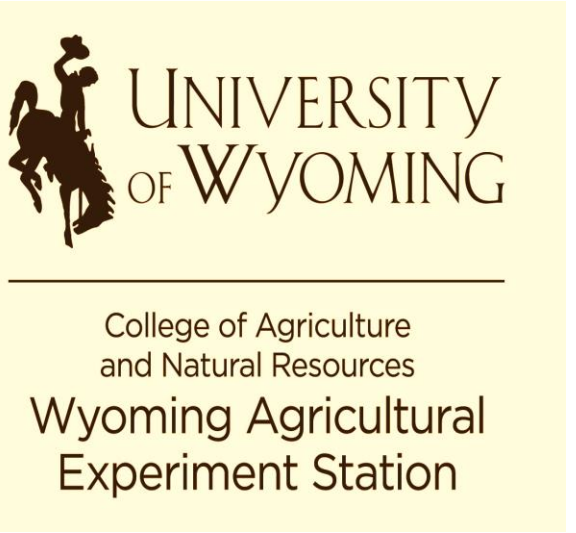
Federal Hatch Funds, Y-Cross Ranch Scholarship
University of Wyoming Ag Experiment Station



THANK YOU
ANY QUESTIONS?

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