Water and Nitrogen Use Efficiencies of Spring Wheat Cultivars

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- Northwestern Montana is the highest yielding spring wheat region of the State (USDA-NASS, 2014).
- Water and nitrogen are major production inputs.
- Application of high N increases yield, thus assumed to increase water use efficiency (WUE).
- On average (27-yr), 228-mm precipitation is received from April to August.
- In 2015, only 68-mm precipitation was received from April to August.

Objectives:

1. To determine water (WUE) and nitrogen use efficiencies (WUE) of various spring wheat varieties under well-watered and extreme drought conditions.

2. To assess the relationship between WUE and NUE.

Methods:

Location: Creston, MT [48.19, -114.14]

Soil: Flathead fine sandy loam (coarse-loamy, mixed, Pachic Haploxeroll)

Sites: Irrigated and Dryland

Planting density: 222 plants m^{-2}

Planted: April 22, 2015

Emerged: May 5, 2015

Harvested: August 12, 2015

Experimental Design: Split-plot, N as the main plot and 8 hard red spring wheat cultivars randomly assigned to 4 N levels: 1) No added N, 2) 165, 3) 310, 4) 450 kg ha^{-1} total N (soil +fertilizer). Each of the sites were analyzed with ANOVA using proc mixed in SAS.

Water was applied using surface drip in the irrigate site. The plant available water (PAW) was maintained above 50% (60- and 90-cm depths at vegetative and heading, respectively). Irrigation was applied until milk stage.

Table 1. PROC MIXED analysis of variance of some agronomic traits for nitrogen and cultivar main effects and their interaction.

Source of Variation	df	Yield	Protein	Height	Seed size	Days to PM	Falling No.
Irrigated							
Nitrogen, N	3	0.0002	<0.0001	0.107	0.0088	0.003	0.291
Cultivar, C	7	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001
N x C	21	0.127	0.134	0.168	0.121	0.936	0.002
Dryland							
Nitrogen, N	3	0.357	0.0007	0.699	0.259	0.450	0.123
Cultivar, C	7	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
N x C	21	0.288	0.822	0.921	0.651	0.469	0.012

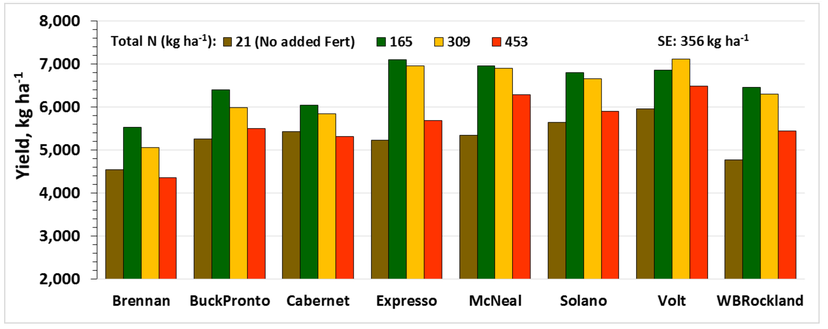

Fig 1. Irrigated Nitrogen x Cultivar yield response on Flathead fine sandy loam. Total plant available water: 342 mm; SE is the highest SE of N x C (proc mixed, tukey).

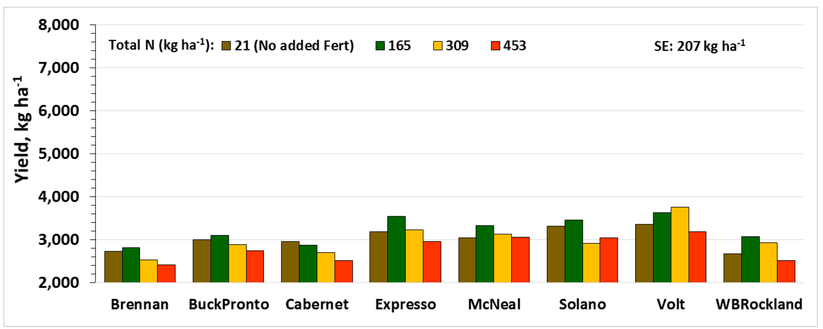

Fig 2. Dryland Nitrogen x Cultivar yield response on Flathead Fine sandy loam. Total plant available water: 120 mm; SE is the highest SE of N x C (proc mixed, tukey).

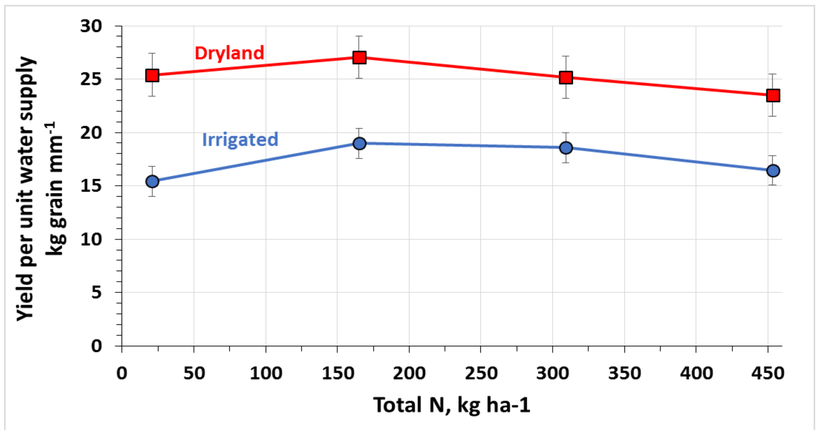

Fig 3. Water use efficiency of dryland and irrigated regimes with total N. Error bars were derived from the residuals of Type 3 ANOVA mixed procedure in SAS.

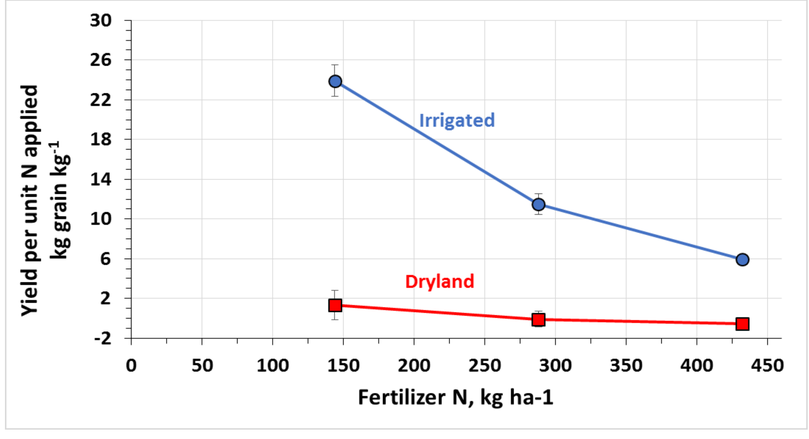

Fig 4. Nitrogen use efficiency of dryland and irrigated regimes with fertilizer N input. Error bars were derived from the residuals of Type 3 ANOVA mixed procedure in SAS.

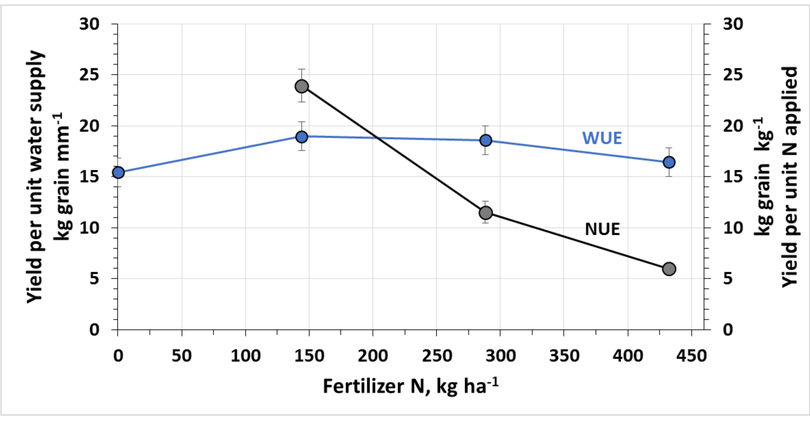

Fig 5. Relationship between nitrogen and water use efficiencies of irrigated spring wheat with fertilizer N input. Error bars were derived from the residuals of Type 3 ANOVA mixed procedure in SAS.

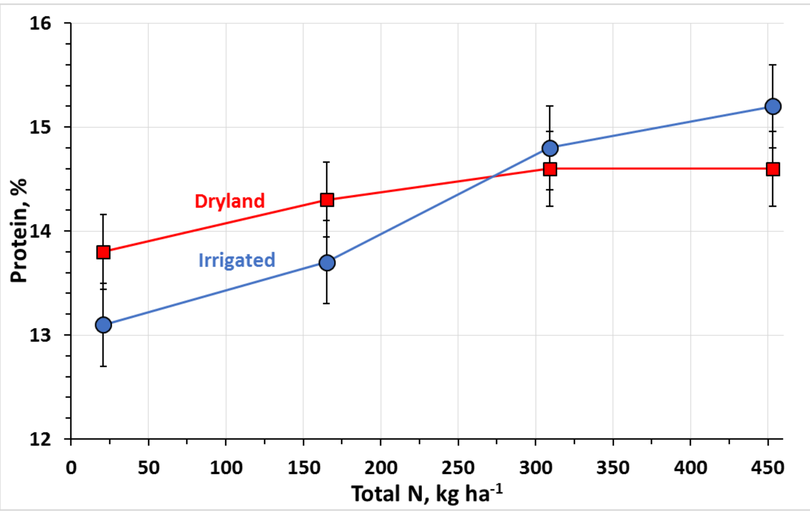

Fig 6. Percent protein of spring with total N for irrigated and dryland water regimes . Error bars were derived from the residuals of Type 3 ANOVA mixed procedure in SAS.

Summary:

- N response was significant for irrigated spring wheat.
- No N response was observed for dryland spring wheat.
- Application of N was consistently significant for protein in both water regimes.
- In both water regimes, N application increases water productivity (WUE), but, WUE declined as total N approached ~200 kg ha^{-1}.
- Increased N fertilization decreased NUE but increased WUE until ~150 kg ha^{-1}, then diminished thereafter (Fig. 5).
- For irrigated spring wheat, adjusted gross returns diminished with N application of ~150 kg ha^{-1} or greater.
- For dryland spring wheat with only 120-mm plant transpirable water, N applications did not provide any economic advantage.
- The crossover point between NUE and WUE (Fig. 5) maybe useful in determining economically-risky fertilization program for spring wheat in Northwestern MT.

References:

USDA–National Agricultural Statistics Service (NASS). 2014. Crops U.S. state and county databases, Washington, DC [online WWW]. Available from:http://www.nass.usda.gov/index.asp (accessed June 1, 2015).

Acknowledgement:

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