Effect of Nitrogen Source, Method and Timing of Application, and Irrigation on Corn in a Water Limited Environment

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Introduction

- With the demand for corn increasing, production has spread into more water limited, semi-arid regions. Couple this with increasing nitrogen (N) fertilizer costs and environmental concerns, the need for proper N fertilizer management practices has increased.

Objective

- The objective of this experiment was to evaluate the effect of N fertilizer sources, method and timing of application, and irrigation on corn grain yield, grain N content, N use efficiency (NUE), and water use efficiency (WUE).

Materials & Methods

Research Sites

- Lake Carl Blackwell, Oklahoma (LCB-2012, LCB-2013)
  - Port-Oscar complex, 0 to 1 percent slopes
- Stillwater, Oklahoma (STW-2012)
  - Easpur loam, 0 to 1 percent slopes
- Stillwater, Oklahoma (STW-2013)
  - Norge loam, 3 to 5 percent slopes

Treatments

- Irrigated vs. Rain-fed
  - Irrigation applied with drip irrigation
  - Irrigation ceased once crop reached R6 growth stage
- Fertilizer Treatments
  - 1. unfertilized check
  - 2. 90 kg N ha^{-1} as UAN pre-plant
  - 3. 90 kg N ha^{-1} as AS pre-plant
  - 4. 45 kg N ha^{-1} as UAN pre-plant/45 kg N ha^{-1} foliar
  - 5. 45 kg N ha^{-1} as AS pre-plant/45 kg N ha^{-1} foliar
  - 6. 180 kg N ha^{-1} as UAN pre-plant
  - 7. 180 kg N ha^{-1} as AS pre-plant
  - 8. 90 kg N ha^{-1} as UAN pre-plant/90 kg N ha^{-1} foliar
  - 9. 90 kg N ha^{-1} as AS pre-plant/90 kg N ha^{-1} foliar
  - 10. 90 kg N ha^{-1} as UAN pre-plant/90 kg N ha^{-1} as UAN surface
    - UAN=urea-ammonium nitrate (28-0-0)
    - AS = ammonium sulfate (21-0-0)
    - Foliar treatments split applied at V8/V10 in 2012 and at V10/V12 in 2013.

Measurements

- Grain yield (kg ha^{-1})
  - Adjusted to 155 g kg^{-1}
- Grain N content (percent)
  - Dry combustion
- NUE (percent)
  - Difference method
- WUE (kg ha^{-1} mm^{-1})
  - 2012-Included irrigation and rainfall
  - 2013-Included irrigation, rainfall, and soil profile moisture

Statistical Analysis

- Randomized complete block design
- Replications and fertilizer treatments nested with irrigation
- Site-years analyzed separately
- Single degree of freedom contrasts used to test differences
  - Alpha level 0.10 used to determine differences

Table 1. Analysis of variance and single degree of freedom contrast results for the four site-years analyzed in this trial.

	----------2012 STW----------				----------2013 STW----------				----------2012 LCB----------				----------2013 LCB----------			
	Grain Yield	Grain N	NUE	WUE	Grain Yield	Grain N	NUE	WUE	Grain Yield	Grain N	NUE	WUE	Grain Yield	Grain N	NUE	WUE
Parameter																
Irrigation	**	***	NS	NS	***	***	NS	***	***	**	NS	**	***	NS	NS	***
Fert. Treatment	NS	***	NS	NS	NS	NS	NS	NS	**	**	***	NS	***	***	***	***
Irrigation X Fert. Treatment	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	**	NS	**	**
Contrasts†																
UAN vs. AS	NS	**0.08**	NS	NS	**924**	NS	NS	**1.4**	NS	NS	NS	NS	NS	NS	NS	NS
UAN all pre vs. split	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**-28.0**	NS
AS all pre vs. UAN split	NS	NS	NS	NS	**-1531**	NS	**-26.4**	**-2.7**	NS	**0.12**	NS	NS	NS	NS	**-25.3**	NS
All pre vs. foliar	NS	**0.08**	NS	NS	NS	NS	**-10.0**	NS	**899**	NS	**9.3**	**0.4**	NS	NS	**-31.9**	NS
45 vs. 90 kg N ha^{-1} foliar	NS	NS	NS	NS	NS	NS	**13.0**	NS	NS	NS	**10.0**	NS	NS	NS	**15.6**	NS
Foliar vs. UAN split	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**1496**	NS	NS	NS
Irr-UAN vs. AS	NS	NS	NS	NS	**1462**	NS	NS	**2.1**	NS	NS	NS	NS	NS	NS	NS	NS
Rf-UAN vs. AS	NS	**0.10**	NS	NS	NS	NS	NS	NS	NS	NS	**-10.1**	NS	NS	NS	NS	NS
Irr-UAN all pre vs. split	NS	NS	NS	NS	**2110**	NS	NS	**3.5**	NS	NS	NS	NS	NS	NS	**-39.1**	NS
Rf-UAN all pre vs. split	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irr-AS all pre vs. split	NS	NS	NS	NS	NS	NS	**-29.7**	NS	NS	NS	NS	NS	NS	NS	**-32.0**	NS
Rf-AS all pre vs. split	NS	NS	NS	NS	**-1957**	NS	NS	**-3.8**	NS	**0.19**	NS	NS	NS	NS	NS	NS
Irr-All pre vs. foliar (45 kg N ha^{-1})	NS	NS	**15.4**	NS	NS	NS	NS	NS	NS	NS	**9.1**	NS	NS	NS	**-26.8**	NS
Rf-All pre vs. foliar (45 kg N ha^{-1})	**-1865**	**0.18**	**-11.3**	**-0.8**	NS	NS	NS	NS	**1259**	NS	**11.3**	**0.6**	NS	NS	**-38.8**	NS
Irr-All pre vs. foliar (90 kg N ha^{-1})	NS	NS	NS	NS	NS	NS	NS	NS	**1407**	NS	**11.9**	**0.5**	**-2741**	NS	**-54.6**	**-3.9**
Rf-All pre vs. foliar (90 kg N ha^{-1})	NS	**0.15**	NS	NS	NS	NS	NS	NS	NS	**0.10**	NS	NS	NS	NS	NS	NS
Irr-45 vs. 90 kg N ha^{-1} foliar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**12.0**	NS	**-2202**	NS	NS	**-3.1**
Rf-45 vs. 90 kg N ha^{-1} foliar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**7.9**	NS	NS	**-0.20**	**46.3**	NS
Irr-foliar vs UAN split	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rf-foliar vs UAN split	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**-3893**	NS	NS	**-5.4**

***, **, * significant at the 0.01, 0.05, and 0.10 level, respectively.

† Numbers in bold represent the difference between contrast groups that are significant at the 0.10 level. Units for measured dependent variables: grain yield, kg ha^{-1}; grain N, percent; NUE, percent; WUE, kg ha^{-1} mm^{-1}.

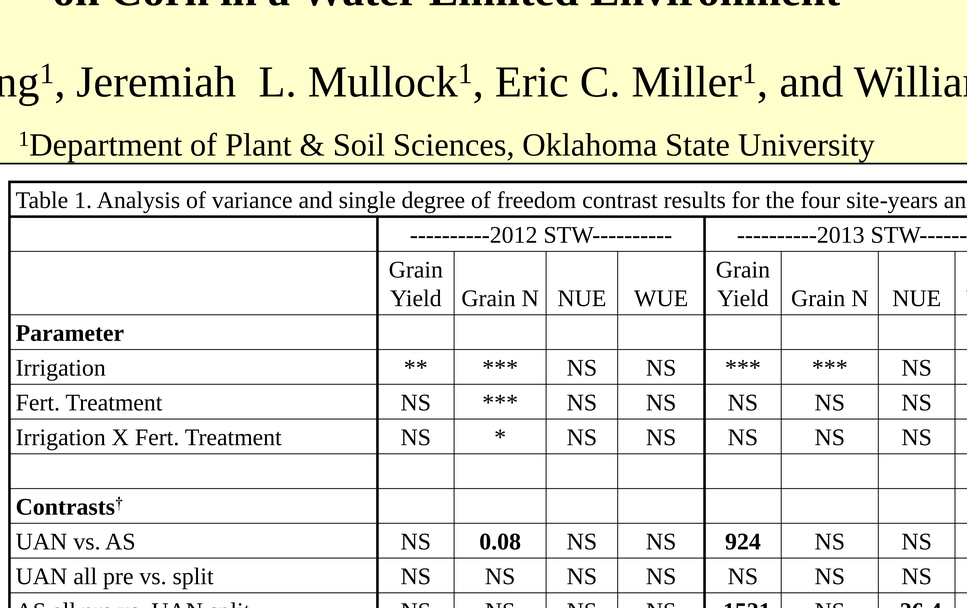

Figure 1. Average grain yield, nitrogen use efficiency (NUE), and water use efficiency (WUE) values for LCB, 2013.

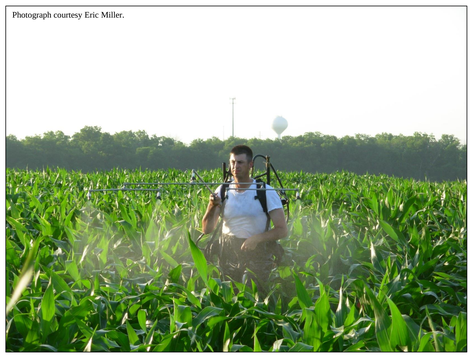

Figure 2. Application of foliar fertilizer treatments conducted using CO2 backpack sprayer (left). Mid-season surface fertilizer treatments applied in-between rows with streamer drop nozzles (right).

Results & Conclusions

- Results varied too much from site-year to site-year to determine if AS or UAN was more preferable as a preplant N fertilizer. This was likely due to the major differences in environmental conditions for each site-year.
- Split applications of UAN typically increased grain yield and NUE, regardless of irrigated or rain-fed conditions.
- For STW-2012, compared to the treatments receiving all the N at preplant, an increase in grain yield, grain N, NUE, and WUE for the rain-fed site receiving the 45 kg N ha^{-1} foliar rate was observed. The inverse of this was observed for the same rate in the irrigated site.
- For LCB-2012, significantly lower yields were observed for foliar treatments. This was likely due to extreme burn damage from treatments applied at this site.
- For LCB-2013, mid-season foliar and surface applied fertilizer treatments increased grain yields and NUE. This was likely due to the potential increased loss of preplant N because of significant periods of soil saturation early in the growing season.
- Foliar N application treatments have the potential to increase grain yields and NUE in lower yielding environments when the crop N demand is low and leaf burn can be minimized.

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