How to Grow 200 Bushel Sorghum with Less Water

CHUCK BURR
NEBRASKA EXTENSION EDUCATOR - WCREC
Limited Water – Rainfed Principles

• Demonstration at Monsanto’s Water Utilization Learning Center near Gothenburg, NE
• Summer of 2012
• Side by side comparisons
Drought Management Demonstration

- Yield = 6.2 bu/ac
- Conventional Tillage
- 1” planting depth (too shallow)
- Poor Weed Control (Roundup on 20” weeds)
- Poor Hybrid for Drought Conditions
- No Insect Trait Technology
- Not a Genuity DroughtGard Hybrid
• Yield = 53 bu/ac
• No-Till (regulated)
• 2 inch Planting Depth
• Poor Weed Control (Roundup on 20” weeds)
• Poor Hybrid for Drought Conditions
• No Insect Trait Technology
• Not a Genuity DroughtGard Hybrid
• Yield = 95 bushels/ac
• No-Till
• 2 inch Planting Depth
• Residual Herbicide + Roundup Burndown
• Poor Hybrid for Drought Conditions
• No Insect Trait Technology
• Not a Genuity DroughtGard Hybrid
• **Yield = 92 bushels/acre**
• **No-Till**
• **2 inch Planting Depth**
• **Residual Herbicide + Roundup Burndown**
• **Proper Hybrid for Drought Conditions**
• **No Insect Trait Technology**
• **Not a Genuity DroughtGard Hybrid**
• Yield = 109 bushels/acre
• No-Till
• 2 inch Planting Depth
• Residual Herbicide + Roundup Burndown
• Proper Hybrid for Drought Conditions
• Insect Trait Technology YieldGard VT2
• Not a Genuity DroughtGard Hybrid
• Yield = 121 bushels/acre
• No-Till
• 2 inch Planting Depth
• Residual Herbicide + Roundup Burndown
• Proper Hybrid for Drought Conditions
• Insect Trait Technology YieldGard VT3
• Genuity DroughtGard Hybrid
Strategies to Maintain Yield with Limited Water

- Use efficient irrigation system – application efficiency
- Increase water use efficiency
- Limit evaporation
- Reduce non-yield producing transpiration
- Select hybrid with high water use efficiency and drought tolerance
• Increase Water Use Efficiency
• Make best use of rainfall
• Application Timing
• Soil sensors for first application
• Schedule last irrigation
• Use Efficient Irrigation Method
• Maintain Irrigation Equipment
• Check Pressure Regulators and Nozzles
• Apply Water Uniformly
Efficient Irrigation Application

- Properly designed sprinkler system
- Nozzles selected – uniform application
- Minimal runoff
- Apply larger irrigation amounts
  - 0.10 hangs up in canopy and evaporates
  - 0.5 inch application – 0.4 (80%) stored
  - 1.5 inch application – 1.4 (93%) stored
Uniform Application?
LIMITED CAPACITY?

Problem is likely due to matching of pump, well and power unit to center pivot needs.
Operating Pressure Does Not Match System Needs

- Measure pressure at end of center pivot pipeline at highest point in field.
- Pressure above regulator should be at least 5 PSI above regulator rating.
Uniform Application?

YIELD DECREASES LIKELY OTHER YEARS, JUST LESS VISIBLE THAN IN 2012

NEW NOZZLES AND REGULATORS COST APPROXIMATELY $3,000

COST OF YIELD REDUCTION FOR POOR UNIFORMITY CAN BE MUCH LARGER

PROBLEMS NOT ALWAYS SPRINKLERS, PUMPING PROBLEMS COMMON
Monitor Soil Moisture

- Watermark Soil
- Moisture Sensors
Crop Water App

- Free App
- Available for Apple and Android platforms
- Developed at the request of NAWMN
- Provides an easy way to estimate soil water status
- Will estimate water used as well as water available
- Log readings over time
- Enter Field Information
- Soil Texture
- Number of Sensors
- Allowable Water Depletion
CropWater

- Data filled in
- Ability to push arrow button to add GPS coordinates
- Click on “Calculate” button
CropWater

- Calculate average reading down to 4 feet
- Water depleted in inches/foot
- Calculate water depleted in soil profile
- Also displays total water available
CropWater

Calculations Output

Results for Sandy loam

Water depleted (inches/foot):

Ø1-foot: 0.38
Ø2-foot: 0.25
Ø3-foot: 0.28
Ø4-foot: 0.20

Total water depleted (inches): 1.11

Readily crop available soil water left at 50% of the field capacity as irrigation threshold

Inches/ft: 0.32
Inches/2-foot: 0.45
Inches/3-foot: 0.50
Inches/4-foot: 0.50

Total water available (inches): 2.00

Warning
Do you want to add this data to history?

Cancel OK
CropWater

- Log the data that you input throughout the year
Schedule the Last Irrigation

NEBGUIDE 1871, PREDICTING THE LAST IRRIGATION OF THE SEASON

* DRY DOWN PROFILE AT END OF SEASON
* ALLOWS FOR STORAGE OF OFF-SEASON PRECIPITATION
* CALCULATE HOW MUCH USEABLE WATER IN SOIL
* COMPARE TO HOW MUCH CROP WILL USE TO MATURITY
## Water/Days to Reach Maturity - Sorghum

<table>
<thead>
<tr>
<th>Stage</th>
<th>Growth Stage</th>
<th>Days to Maturity</th>
<th>Water Use to Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 6</td>
<td>Half Bloom</td>
<td>34</td>
<td>9.0</td>
</tr>
<tr>
<td>Stage 7</td>
<td>Soft Dough</td>
<td>23</td>
<td>5.0</td>
</tr>
<tr>
<td>Stage 8</td>
<td>Hard Dough</td>
<td>12</td>
<td>2.0</td>
</tr>
<tr>
<td>Stage 9</td>
<td>Physiological Maturity</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
CropWater

- Schedule last irrigation
CropWater

**Data Entry**

**Allowable Water Depletion (%)**

- 60%
- 50%
- 40%
- 30%
- 20%

**Do you want to enter Last Irrigation Info?**

- Yes
- No

---

**Last Irrigation**

- Sorghum
- Stage 7 - Soft Dough
- Approx. Days to Maturity: 23
- Predicted Maturity Date: 2/13/
- Water requirement (in.): 5

**Calculate**

---

*Select Crop Growth Stage*

- Stage 6 - Half Bloom
- Stage 7 - Soft Dough
- Stage 8 - Hard Dough
- Stage 9 - Physiological Maturity

*Done*
Water Conservation

REDUCE ET BY:
  * REDUCING TRANSPIRATION
  * REDUCING SOIL EVAPORATION
Evapotranspiration (ET)

$ET = EVAPORATION + TRANSPIRATION$

$T = 70-80\%$

$E = 20-30\%$
When the crop is small, almost all ET is EVAPORATION.
WHEN THE CROP FULLY SHADES THE GROUND,

90 - 98% OF ET IS TRANSPIRATION
REDUCE SOIL EVAPORATION

NO-TILL SYSTEMS LEAVE RESIDUE COVER ON SOIL SURFACE
SHIELDS SURFACE FROM ENERGY FROM SUN
REDUCES AIR MOVEMENT ABOVE SOIL SURFACE
Effect of crop residue on evaporation and crop yield

REDUCED TILLAGE WITH MORE CROP RESIDUE CONSERVES WATER, BUT HOW MUCH WATER IS NOT CLEAR

SIMON VON DONK, WCREC
Effect of crop residue on evaporation and crop yield
Limited Irrigation, 2007
2007 CORN YIELD ON BARE SOIL (AVG. 172 BU/AC) AND RESIDUE-COVERED SOIL (AVG. 197 BU/AC) ON SMALL PLOTS AT NORTH PLATTE
THIS 25 BU/AC YIELD DIFFERENCE MAY BE INTERPRETED AS AN ADDITIONAL AMOUNT OF WATER OF 2.5-3.5 INCHES AVAILABLE TO THE CROP IN THE RESIDUE-COVERED PLOTS.

IT WOULD TAKE AN ADDITIONAL 2.5-3.5 INCHES OF WATER ON THE BARE-SOIL PLOTS TO REACH THE SAME YIELD AS OBTAINED IN THE RESIDUE-COVERED PLOTS.
2008 CORN YIELD ON BARE SOIL (AVG. 169 BU/AC) AND RESIDUE-COVERED SOIL (AVG. 186 BU/AC) ON SMALL PLOTS AT NORTH PLATTE.
IT WOULD TAKE AN ADDITIONAL 1.5 – 2.5 INCHES OF WATER ON THE BARE-SOIL PLOTS TO REACH THE SAME YIELD AS OBTAINED IN THE RESIDUE-COVERED PLOTS.

ALSO, THE RESIDUE-COVERED PLOTS HELD MORE WATER TOWARDS THE END OF THE SEASON (1.5 INCHES MORE THAN BARE-SOIL PLOTS IN TOP 4 FT).

TOTAL OF 3-4 INCHES OF WATER SAVINGS.
<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>Residue Bu/ac</th>
<th>Bare Bu/ac</th>
<th>Diff. Bu/ac</th>
<th>Yield* Inch</th>
<th>Soil** Inch</th>
<th>Total inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Corn</td>
<td>197</td>
<td>172</td>
<td>25</td>
<td>3.0</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>2008</td>
<td>Corn</td>
<td>186</td>
<td>169</td>
<td>17</td>
<td>2.0</td>
<td>1.5</td>
<td>3.5</td>
</tr>
<tr>
<td>2009</td>
<td>Soyb.</td>
<td>68</td>
<td>58</td>
<td>10</td>
<td>3.0</td>
<td>2.0</td>
<td>5.0</td>
</tr>
<tr>
<td>2010</td>
<td>Soyb.</td>
<td>61</td>
<td>53</td>
<td>8</td>
<td>2.5</td>
<td>0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*Additional irrigation water needed on the bare-soil plots to produce same yield as on residue-covered plots.

**Additional soil water (in the top 4 ft of soil, at the end of the growing season) in the residue-covered plots compared to the bare-soil plots.
Residue Cover Increases Infiltration

- Prevents sealing of soil surface
- Maintains infiltration rate
- Slows water movement across surface
* Use water conservation practices that reduce transpiration and maintain yield
* Limit irrigation during non-critical growth stages
* Grow crops that require less water
* Adjust population to water available
* Use appropriate crop rotation
Gross System Capacity \( (C_g) \)

System Capacity = \( \frac{\text{System Flow Rate}}{\text{Field Area}} \)

= gpm / acre

\[ C_g = \frac{750 \text{ gpm}}{125 \text{ acres}} = 6 \text{ gpm / acre} \]
Determine how much flow is needed for system.

MINIMUM NET SYSTEM CAPACITY REGIONS

Region 1

Region 2
# Nebraska Net System Capacity Recommendations

## Net Capacity (to Fully Meet Needs 9 of 10 Years)

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Available Water (in/ft)</th>
<th>Region 1 (GPM/AC)</th>
<th>Region 2 (GPM/AC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silty Clay Loam</td>
<td>2.5</td>
<td>3.9</td>
<td>4.6</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>2.0</td>
<td>4.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>2.0</td>
<td>4.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>1.6</td>
<td>4.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>1.4</td>
<td>4.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>1.1</td>
<td>4.8</td>
<td>5.4</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>1.0</td>
<td>5.0</td>
<td>5.9</td>
</tr>
<tr>
<td>Peak ET</td>
<td>5.7</td>
<td></td>
<td>6.6</td>
</tr>
</tbody>
</table>
Pump Capacity Needed

EAST
PEAK - 5.7 GPM * 130 AC/85% = 871 GPM
SANDY LOAM – 4.5 GPM * 130 AC/85% = 688 GPM
SILT LOAM – 3.9 GMP * 130 AC/85% = 596 GPM

WEST
PEAK - 6.6 GPM * 130 AC/85% = 1,010 GPM
SANDY LOAM – 5.2 GPM * 130 AC/85% = 795 GPM
Know how much water you are applying

<table>
<thead>
<tr>
<th>System Capacity, gpm/acre</th>
<th>System Flow Rate for Land Acres of:</th>
<th>Depth Applied per Day, inches/day</th>
<th>Depth Applied per Week, inches/week</th>
<th>Time to Apply one-inch, days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120</td>
<td>130</td>
<td>160</td>
<td>240</td>
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<tr>
<td>3.0</td>
<td>360</td>
<td>390</td>
<td>480</td>
<td>720</td>
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<tr>
<td>3.5</td>
<td>420</td>
<td>455</td>
<td>560</td>
<td>840</td>
</tr>
<tr>
<td>4.0</td>
<td>480</td>
<td>520</td>
<td>640</td>
<td>960</td>
</tr>
<tr>
<td>4.5</td>
<td>540</td>
<td>585</td>
<td>720</td>
<td>1080</td>
</tr>
<tr>
<td><strong>5.0</strong></td>
<td><strong>600</strong></td>
<td><strong>650</strong></td>
<td><strong>800</strong></td>
<td><strong>1200</strong></td>
</tr>
<tr>
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<td>880</td>
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<tr>
<td>7.0</td>
<td>840</td>
<td>910</td>
<td>1120</td>
<td>1680</td>
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<tr>
<td>7.5</td>
<td>900</td>
<td>975</td>
<td>1200</td>
<td>1800</td>
</tr>
<tr>
<td>8.0</td>
<td>960</td>
<td>1040</td>
<td>1280</td>
<td>1920</td>
</tr>
<tr>
<td>8.5</td>
<td>1020</td>
<td>1105</td>
<td>1360</td>
<td>2040</td>
</tr>
</tbody>
</table>
Crop Response to Water Stress – Sensitive Stages

MOST SUSCEPTIBLE – TRANSITION FROM VEGETATIVE TO REPRODUCTIVE GROWTH OR FLOWERING TO FRUIT SET (EC 2007, CORN IRRIGATION MANAGEMENT UNDER WATER-LIMITING CONDITIONS).

CORN
(VT) TO BLISTER (R2) – MOST CRITICAL
PRIOR TO TASSELING – MID-CRITICAL
GRAIN FILL – LESS CRITICAL

SOYBEANS
FLOWERING AND FRUITING STAGE
Crop Response to Water Stress – Sensitive Stages

GRAIN SORGHUM
SECONDARY ROOTING & TILLERING TO BOOT – MOST CRITICAL
HEADING, FLOWERING AND GRAIN FORMATION – MID-CRITICAL
GRAIN FILL – LESS CRITICAL

WHEAT
BOOTING - HEADING & 2 WEEKS BEFORE POLLINATION

ALFALFA
FOLLOWING CUTTING
Limited Irrigation Strategies – How to Distribute Stress

DISTRIBUTE SEASONALLY AVAILABLE WATER WITH FIXED AMOUNTS THROUGHOUT SEASON INDEPENDENT OF CROP GROWTH STAGE
EXAMPLE: REPLACE OF 75% FULL IRRIGATION DEPTH EACH WATERING
GRADUAL PROGRESSION OF STRESS AS SOIL WATER IS MINED
DEGREE OF ULTIMATE STRESS DEPENDS ON RAIN AND SOIL

WITHHOLD WATER AT CROP GROWTH STAGES THAT ARE LESS SENSITIVE TO WATER STRESS
ACCOUNTS FOR SENSITIVE CROP GROWTH STAGES
USUALLY PRACTICED WHEN UNDER A WATER ALLOCATION
REQUIRES CAPACITY TO RELIEVE STRESS DURING CRITICAL STAGES
Limited Water Management Strategies

REDUCE IRRIGATION TO ENTIRE FIELD
REDUCE IRRIGATED ACREAGE
IRRIGATE ONLY A PORTION OF LAND & REMAINDER IN DRYLAND PRODUCTION
PLANT PART OF THE FIELD TO:
LOWER WATER USE CROPS THAT ARE MORE DROUGHT TOLERANT AND ONLY IRRIGATE THEM IF WATER BECOMES AVAILABLE

PLANT PORTIONS OF FIELD TO CROPS WITH CRITICAL GROWTH STAGES AT DIFFERENT TIMES OF YEAR TO AVOID CAPACITY LIMITATIONS
Know how much water you are applying.

Schneekloth et al., 1991.
Flow Meters

- Can also use the flow meter as a management tool.

- If flows are tracked over the course of several years, trends could be seen such as pump/power unit performance.
MeterCalc

- Cost - $3.99
- Available in Apple (iPhone only, iPad version coming soon) and Android platforms
- This app calculates the amount of water applied by irrigation over time.
MeterCalc

- Begin by selecting a meter type
- Input field information
- Input meter information
- Are you in a NRD that have allocations?
- Enter your beginning and ending meter reading
- Click “Next” arrow to view calculations
MeterCalc

- Acre inches pumped displayed
- Inches per acre displayed
- Total inches pumped during growing season displayed
MeterCalc

- Calculates inches per acre and total for the year
Check Pumping Plant Efficiency

• Keep track of water pumped for season
• Keep track of energy consumed for season
• Compare to Nebraska Pumping Plant Criteria
  • Diesel – 12.5 whp-hr/gal
  • Gas – 8.86 whp-hr/gal
  • Propane – 6.89 whp-hr/gal
  • Natural Gas – 61.7 whp-hr/1000 ft3
  • Electricity – 0.885 whp-hr/kW-hr
Gallons of diesel to pump 1 acre-in

<table>
<thead>
<tr>
<th>Lift</th>
<th>10 psi</th>
<th>20 psi</th>
<th>30 psi</th>
<th>40 psi</th>
<th>50 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.21</td>
<td>0.42</td>
<td>0.63</td>
<td>0.84</td>
<td>1.05</td>
</tr>
<tr>
<td>25</td>
<td>0.44</td>
<td>0.65</td>
<td>0.86</td>
<td>1.07</td>
<td>1.28</td>
</tr>
<tr>
<td>50</td>
<td>0.67</td>
<td>0.88</td>
<td>1.09</td>
<td>1.30</td>
<td>1.51</td>
</tr>
<tr>
<td>75</td>
<td>0.89</td>
<td>1.11</td>
<td>1.32</td>
<td>1.53</td>
<td>1.74</td>
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<tr>
<td>100</td>
<td>1.12</td>
<td>1.33</td>
<td>1.54</td>
<td>1.75</td>
<td>1.97</td>
</tr>
<tr>
<td>125</td>
<td>1.35</td>
<td>1.56</td>
<td>1.77</td>
<td>1.98</td>
<td>2.19</td>
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<td>150</td>
<td>1.58</td>
<td>1.79</td>
<td>2.00</td>
<td>2.21</td>
<td>2.42</td>
</tr>
</tbody>
</table>
## Conversions for other Energy Sources

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Units</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>Kilowatt-hours</td>
<td>14.12</td>
</tr>
<tr>
<td>Propane</td>
<td>Gallons</td>
<td>1.814</td>
</tr>
<tr>
<td>Gasoline</td>
<td>Gallons</td>
<td>1.443</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1000 cubic feet</td>
<td>0.2026</td>
</tr>
</tbody>
</table>
For more information:

- Pumping Efficiency App available now.
- Android and iPad versions
IrrigatePump

- Cost - $3.99
- Available in Apple and Android platforms
- Figure how well your pumping plant stacks up against the Nebraska Pumping Plant Criteria (NPC)
- Should be a reasonable target for most pumping plants
IrrigatePump

- App will allow you to:
- Input energy source
- Price/unit of energy
- Acres irrigated
- Water applied
IrrigatePump

- App will allow you to:
  - Input well specifications
  - Fuel used for test period
IrrigatePump

- Results:
- Click on the “Calculate” button to figure your performance rating
- Figures potential savings if you could bring the unit up to NPC standard
- Also figures payback years if repairs/improvements are made
Irrigation Water Use Efficiency

\[
\text{IWUE} = \frac{\text{Irrigated Yield} - \text{Rainfed Yield}}{\text{Gross Irrigation Depth}}
\]

\[
= \frac{220 \text{ bu/acre} - 120 \text{ bu/acre}}{12 \text{ inches}} = 8.3 \text{ bushels / acre - inch}
\]

Measure of Water Productivity for Management Practices

<table>
<thead>
<tr>
<th>Attainable Water Use Efficiencies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✅ Corn: 12 - 14 bushels/acre-inch</td>
</tr>
<tr>
<td>✅ Soybeans: 3 - 5 bushels/acre-inch</td>
</tr>
<tr>
<td>✅ Wheat: 4 - 6 bushels/acre-inch</td>
</tr>
<tr>
<td>✅ <strong>Sorghum:</strong> 8 – 10 bushels/acre-inch</td>
</tr>
</tbody>
</table>
Irrigation Water Use Efficiency

If Your IWUE Is Much Less Than Target Values:

- Monitor soil water to use precipitation or carryover soil water
- Leave room in soil profile to store irrigation/rainfall
- Schedule last irrigation to dry profile at end of season
- Improve application efficiency of system
- Use no-till systems to reduce evaporation and runoff
- Check application uniformity to maximize use of irrigation water
How to grow 200 bu sorghum with less water

THINK LIKE A RAINFED (DRYLAND, NON-IRRIGATED) PRODUCER
INCREASE APPLICATION EFFICIENCY
INCREASE WATER USE EFFICIENCY
LIMIT WATER EVAPORATION
REDUCE TRANSPIRATION
HYBRID SELECTION
LIMITED RESEARCH ON SORGHUM PRODUCTION IN RECENT YEARS NEW HIRES COULD CHANGE THAT...
Julie Peterson, entomologist
New Pest in Sorghum: Sugarcane Aphid

EXPANDED HOST RANGE FROM SUGARCANE TO SORGHUM
FORMS LARGE COLONIES ON SORGHUM LEAVES
LIGHT YELLOW APHID WITH BLACK LEG TIPS AND TAIL PIPES
Quickly Approaching Nebraska

RAPID MOVEMENT NORTH & EAST SINCE 2013, FOUND IN KANSAS FOR 1ST TIME IN 2015
SO FAR NOT FOUND IN NE; IF PRESENT, VERY IMPORTANT TO DOCUMENT FOR SECTION 18 APPROVALS—FEW INSECTICIDES WILL CONTROL IT
PLEASE SUBMIT SAMPLES TO UNL PLANT & PEST DIAGNOSTIC CLINIC
Survey Program for Nebraska

- Preliminary surveys by Julie Peterson in 2015 in Hitchcock, Red Willow, Furnas & Lincoln counties found no sugarcane aphid

- More thorough surveys in 2016 are needed for early detection to:
  - Warn producers about this potentially damaging pest
  - Petition EPA for Section 18 approval for insecticide use
  - Conduct research on IPM for this insect to understand how to protect sorghum yields in Nebraska
Daran Rudnick, irrigation
Rodrigo Werle, cropping systems
Questions?

• chuck.burr@unl.edu