Why peas in the central High Plains?

- Dryland rotations have transitioned from wheat-fallow to wheat-sorghum or corn-fallow in the past decades
- Economics of summerfallow wheat
  - Herbicide resistance in Kochia and Palmer Amaranth
  - Increasing rental rates
  - Decreasing commodity wheat prices
- Our dryland rotations lack diversity

Can peas improve PUE?

- We know that there is being water left on the table
  - Fallow period from row-crop to wheat
    - 15.5” precipitation x 25% efficiency = 11.6” lost
- We know that reducing soil water at planting will negatively impact subsequent crop yields
- Can we strike a balance?
Locations

- 2010 Pilot Study
  - KSU NWREC-Colby
  - KSU SWREC-Tribune

- 2011-2012 Additions
  - KSU SWREC-Garden City
  - USDA-ARS Bushland

Funded by:
USDA-ARS Ogallala Aquifer Program
Improving Dryland Production Systems

Water Use by Field Peas vs. No-Till Fallow
SWREC-Tribune and NWREC-Colby

<table>
<thead>
<tr>
<th></th>
<th>15-May</th>
<th>1-Jun</th>
<th>1-Jul</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peas</td>
<td>2.18</td>
<td>5.42</td>
<td>9.30</td>
<td></td>
</tr>
<tr>
<td>Fallow</td>
<td>1.81</td>
<td>3.94</td>
<td>5.92</td>
<td></td>
</tr>
<tr>
<td>Fallow Efficiency</td>
<td>23.3%</td>
<td>31.1%</td>
<td>25.9%</td>
<td></td>
</tr>
</tbody>
</table>

Peas effectively used 3.38" of water

Revisiting Water Use and Wheat Yield Potential

- Long term datasets at Tribune and Akron show that each inch of available soil water at wheat planting results in 3.7-4.7 bu ac⁻¹ of grain yield.

- Average difference in profile soil water between chemfallow and pea stubble at wheat planting studies (8 site-years) is around 2"

- A wheat yield reduction of 9.4 bu ac⁻¹ would be predicted using the results of this study and previous yield-water relationships. This closely matches our observations

- However we must keep a cropping systems perspective
Field Pea Growth and Development

Origin
- One of the first domesticated crops and grown in most temperate regions of the world
- Member of Leguminosae plant family
- Evidence of pea back to 10,000 BC in the Near East and Central Asia
- Accompanied cereals and was important in early civilizations of the Middle East and Mediterranean
- Cultivated in Europe since the stone and bronze ages and India from 200 BC

Defining Field Pea, It’s Complicated
- Multiple Pisum Species
  - P. fulvum
  - P. elatius
  - P. abyssinicum
  - P. sativum
- Multiple Market Classes
  - Field Pea
    - Yellow (white), Green, Dunn, Blue, Morrowfat, Maple, Forage, Feed, Sprouts
  - Vegetable Pea
    - Freezer, Snow, Snap

Development Basics
- Indeterminate, cool season crop
- Growth Temperatures
  - Optimum 17°C / 63°F
  - Minimum 10°C / 50°F
    - RUE reduced at <12°C / 54°F and PSII at < 15°C / 59°F
  - Maximum 23°C / 73°F
  - Damaging 28-32°C / 82-90°F
  - Damage to Pollen and Ovule 36°C / 95°F
Winter vs. Spring Types

- Winter types tend to be more photoperiod sensitive
- The Hr gene blocks floral initiation when the days are short (13.5 hours, April 25 @ Colby)
- Lower temperatures begin the cold acclimation process
  - Accumulation of solutes, changes in membrane lipid composition
  - Higher proportion of biomass accumulation to below-ground

Plant Architecture

- Entire leaf
  - Stipules + 2 or 3 sets of leaflets
- Semi-leafless (Afio)
  - Stipules + more tendrils

Why Semi-Leafless

- Harvestability / Standability
- Better Water Use Efficiency
- Lodged canopies are warmer than air temperature
- Wax reflects heat
- Less leaf area, more petioles and tendrils, thicker wax on petioles
Pea Seed and Germination

- **Seed Size**
  - Spring Pea 1600-2500 Seeds/Lb
  - Winter Pea 2200-3500 Seeds/Lb
- Seed doubles in volume in first 2 days of germination
- Requires 3x the moisture for germination compared to small grains
  - Management Note: Plant at least ½” into moisture

---

Pea Germination

- 38° F minimum temperature for germination
- Soil Temperature has a large effect on days and/or cumulative heat units to emergence
  - 38°F - 45°F: 17 to 21 days to emerge
  - 45°F - 50°F: 14 to 17 days to emerge
  - 50°F - 55°F+: 10 to 14 days to emerge
- Hypogeal germination
  - Growing point/cotyledons stay with seed piece

---

Germination and Emergence

- Cotyledons and 1st node are with the seed piece
- 2nd and 3rd nodes usually are below the soil surface and act as axillary buds
- The 1st true leaf is technically the 3rd or 4th node, referred to as 1st vegetative node

---

Above Ground Growth

- 1st Node – usually around 14 days, related to soil temp effects on emergence
- Additional nodes, every 3 to 5 days, thermally driven process
Growth Staging

Each leaf stage can be identified as a node stage as well.

Example from herbicide labels:
- One to six true leaf stage
- Up to and including six above-ground nodes
- Up to and including a total of eight total nodes including the two scale nodes

These all describe the same growth stage!

Vegetative and Reproductive Stages

Number of Reproductive Nodes

- Recall that peas are indeterminate
- Heavily influenced by environment and genotype
- For a given genotype the rank of the last reproductive node varies widely by environment, however the rank of the first reproductive node remains stable.
Reproductive Development

• Two Stages to Seed Development
• 1st Stage – Begins at fertilization, cell division occurs in the embryos without significant dry matter accumulation. At the end of this stage seeds are unlikely to abort
• 2nd Stage – Cell division stops and near-linear dry matter accumulation begins in the cotyledons of the seed and continues until physiological maturity

Reproductive Development
Seed Abortion

• The transition from Stage 1 to Stage 2 in the seed filling process occurs around 85% moisture content, it is unlikely that seed will be aborted once the moisture content drops below 85%
• This also corresponds to a seed size, seed abortion will typically not occur once the seed size exceeds 8.5 mm

Transition Points

• End of phytomere production
  – Assimilate demand of seed filling becomes high relative to availability, the supply at the apical tip ceases

Fig. 3: Contribution of each reproductive node to seed yield in Derrimut (a) and Donale (b) peas at Bruce Rock in 1996; b first time of sowing, b fourth time of sowing. Data for second and third times of sowing omitted for clarity. Vertical bars indicate LSD (0.05).
Drydown to Maturity

Maintaining Crop Growth Rate (Assimilate Supply) is Key!

Temperature Stress on Yield

- Temperature can reduce yield in two ways
  - Overall stress effect that reduces plant growth rate and assimilate supply to maintain seed filling
  - Direct negative effect on the fertilization process
    - Pollen Viability
    - Pollen Tube Length
Pollination germination (PG) & tube growth

- HS reduced PG and pollen tube growth.
- At 36°C, PG of CDC Sage was higher than CDC Golden, but pollen tube length did not differ between these two cultivars.


Effect of heat stress on seed set

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Pod length (mm)</th>
<th>Number of seeds per pod</th>
<th>Seed-ovule ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC Golden</td>
<td>51 b</td>
<td>3.8 b</td>
<td>71.9 a</td>
</tr>
<tr>
<td>CDC Sage</td>
<td>62 a</td>
<td>4.8 a</td>
<td>69.8 a</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75° F</td>
<td>24</td>
<td>62 a</td>
<td>73.3 a</td>
</tr>
<tr>
<td>81° F</td>
<td>27</td>
<td>61 ab</td>
<td>72.0 a</td>
</tr>
<tr>
<td>86° F</td>
<td>30</td>
<td>58 bc</td>
<td>76.5 a</td>
</tr>
<tr>
<td>91° F</td>
<td>33</td>
<td>57 c</td>
<td>76.4 a</td>
</tr>
<tr>
<td>97° F</td>
<td>36</td>
<td>46 d</td>
<td>56.0 b</td>
</tr>
</tbody>
</table>

P value
- Cultivar (C) *** ns
- Temperature (T) *** *** ns
- C*T ns ns

Means with a common letter are not significantly different at P < 0.05.


Yield vs. Crop ET

Adapted from Stone et al., 2006 and Nielsen 2001 by Lucas Haag, K-State

Water Use - Daily

Maximum water use of approx. 0.24”/day occurs just after flowering.
Field Pea Production management specific to the Central Great Plains

- **Planting Date**
  - Beat the heat
- **Seeding Rates**
  - We need more plants per acre to make the same yield
- **Fungicides**
  - Need is likely to vary tremendously W to E
  - Crop rotation is our biggest tool
    - Peas no more than 1 out of 3 or 4 years
- **Heat Stress Tolerance (our biggest issue)**

Production Practices

**Production Practice Recommendations**

- **KNOW YOUR HERBICIDE HISTORY!**
  - Check labels for products used on the field in the last 18-24 months
- Variety Selection, see K-State and UNL variety performance testing results
- Seeding Rate, minimum 365,000 live seed acre⁻¹,
- Peas will germinate at soil temps > 40° F
- Seeding depth: 1-3” is acceptable. Seed at least ½” into moisture, never on the dry/wet soil interface

Variety Selection Considerations

- **Yield**
- **Yield Stability**
  - Especially important an in emerging crop
- **Height, lodging, harvestability**
- **Market Class**
- **Spread the Risk**
- [www.northwest.ksu.edu/agronomy](http://www.northwest.ksu.edu/agronomy)
Table 1. Across-years yield averages for field pea varieties at four locations in northwest Kansas.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PulseUSA</td>
<td>SW Midas (Y)</td>
<td>Rawlins</td>
<td>31.9</td>
<td>35.3</td>
<td>26.4</td>
<td>26.0</td>
</tr>
<tr>
<td>PulseUSA</td>
<td>DS Admiral (Y)</td>
<td>Thomas</td>
<td>31.3</td>
<td>34.0</td>
<td>30.2</td>
<td>29.9</td>
</tr>
<tr>
<td>PulseUSA</td>
<td>Nette 2010 (Y)</td>
<td>Rawlins</td>
<td>32.7</td>
<td>35.7</td>
<td>29.6</td>
<td>29.4</td>
</tr>
<tr>
<td>Meridian Seeds</td>
<td>Earlystar (Y)</td>
<td>Thomas</td>
<td>32.5</td>
<td>34.7</td>
<td>28.1</td>
<td>27.4</td>
</tr>
<tr>
<td>Meridian Seeds</td>
<td>AAC Carver (Y)</td>
<td>Rawlins</td>
<td>35.2</td>
<td>-</td>
<td>28.9</td>
<td>-</td>
</tr>
<tr>
<td>CDC / Meridian_</td>
<td>CDC Saffron (Y)</td>
<td>Thomas</td>
<td>32.3</td>
<td>-</td>
<td>26.1</td>
<td>-</td>
</tr>
<tr>
<td>Seeds</td>
<td>CDC Amanillo (Y)</td>
<td>Rawlins</td>
<td>31.4</td>
<td>-</td>
<td>27.1</td>
<td>-</td>
</tr>
</tbody>
</table>

Production Practices

Production Practice Recommendations

• Weed Control
  (you have to really dig through the herbicide labels)
  - Dark is one of the best herbicides
  - Field pea is a week competitor with weeds early in the season
  - Preemerge residual herbicide: Spartan, Metribuzin, Dual, Treflan, Command, Sharpen
  - Post options: Raptor, Basagran, Clethodim, Assure II

Inoculant

• Inoculation at every planting is recommended
  - If your rotation is short enough you don’t need inoculant then you’re likely developing other disease issues
• Not the same as soybean inoculant, not all pulse crops use the same inoculant
  - Peas and Lentils vs. Chickpea
• Multiple product forms on the market
  - Liquid, peat, dry granular

Inoculant – Product Forms vs. Performance

<table>
<thead>
<tr>
<th>Site Year</th>
<th>Inoculant Type</th>
<th>Check</th>
<th>Liquid</th>
<th>Granular</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Canora</td>
<td>37.9</td>
<td>39.9</td>
<td>43.4</td>
</tr>
<tr>
<td>1997</td>
<td>Indian Head</td>
<td>26.8</td>
<td>26.0</td>
<td>29.9</td>
</tr>
<tr>
<td>1997</td>
<td>Melfort</td>
<td>60.2</td>
<td>57.8</td>
<td>60.5</td>
</tr>
<tr>
<td>1997</td>
<td>Outlook</td>
<td>72.4</td>
<td>71.8</td>
<td>72.4</td>
</tr>
<tr>
<td>1997</td>
<td>Redvers</td>
<td>28.4</td>
<td>37.3</td>
<td>41.2</td>
</tr>
<tr>
<td>1997</td>
<td>Scott</td>
<td>15.5</td>
<td>16.2</td>
<td>19.6</td>
</tr>
<tr>
<td>1997</td>
<td>Swift Current</td>
<td>33.3</td>
<td>33.2</td>
<td>38.7</td>
</tr>
<tr>
<td>1998</td>
<td>Canora</td>
<td>46.5</td>
<td>46.5</td>
<td>47.1</td>
</tr>
<tr>
<td>1998</td>
<td>Indian Head</td>
<td>49.8</td>
<td>49.2</td>
<td>50.1</td>
</tr>
<tr>
<td>1998</td>
<td>Melfort</td>
<td>36.7</td>
<td>40.0</td>
<td>40.7</td>
</tr>
<tr>
<td>1998</td>
<td>Outlook</td>
<td>76.0</td>
<td>77.2</td>
<td>79.1</td>
</tr>
<tr>
<td>1998</td>
<td>Scott</td>
<td>29.6</td>
<td>28.3</td>
<td>31.2</td>
</tr>
<tr>
<td>1998</td>
<td>Swift Current</td>
<td>30.9</td>
<td>34.3</td>
<td>36.0</td>
</tr>
</tbody>
</table>

Statistically Significant Sites: 27.4 29.2 32.8 5.4
All Sites: 41.9 42.9 45.4 3.5

H.R. Kucher et al., Canadian J. of Plant Science
Seeding Rate Summary

- K-State data would suggest our optimal seeding rate is likely higher than the 350,000 PLS/acre that we initially recommended to producers based on other pea growing areas.

- Agronomic optimum is over 400k PLS/ac. Economic optimum and current KSU recommendation is 365k PLS/ac.

Seeding Rate Summary

Some of my thoughts on this from a crop physiology perspective:

- Why might we need higher seeding rates than the Northern Plains?
  - As peas are moved south our conversion of yield components into actual grain yield is more limited.
    - Fewer flowers converted into pods
    - Fewer seeds per pod
  - Therefore it possibly takes more plants/acre to maximize yield potential.
Seed Quality

- Warm Germination is all that is required for seed to be certified
- Is that really enough information?
- What about farm saved seed?
- Proper handling is essential
  - Cold temps, overly dry seed, contact with steel
- Keep a sample back of what you plant

Seed Quality - Testing

- Having warm germ, cold germ, and accelerated aging test ran provides you more information
- Once you start with a lab, stick with it
- Talk to your lab, while test procedures are standardized, philosophies and interpretation are not
- Other potential tests of interest
  - Disease Assay
  - Conductivity (detects mechanical damage in seed coat)

Fungicide Seed Treatments

- Seed Treatments
  - Untreated
  - Obvious (BASF)
  - VibranceMaxx (Syngenta)
  - Apron Maxx RTA (Syngenta)
- Seeded at 350,000 PLS
- Three locations

2017 Yield Results

<table>
<thead>
<tr>
<th></th>
<th>Rawlins</th>
<th>Gove</th>
<th>Thomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>28.4</td>
<td>19.9</td>
<td>26.2 b</td>
</tr>
<tr>
<td>Obvious</td>
<td>28.5</td>
<td>19.6</td>
<td>28.4 a</td>
</tr>
<tr>
<td>VibranceMaxx</td>
<td>31.0</td>
<td>19.0</td>
<td>29.4 a</td>
</tr>
<tr>
<td>Apron Maxx RTA</td>
<td>.</td>
<td>.</td>
<td>28.2 ab</td>
</tr>
</tbody>
</table>

ANOVA

- P>F 0.5945 0.8694 0.049
- LSD NS NS 2.18
Economics – Evaluate the entire system!

**Wheat-Corn/Sorghum-Pea**
- + Land Cost
- + Herbicide Cost
- + Machinery Cost planting/harvest
- - Pea grain revenue

We’re basically making wheat cheaper to grow with the expectation that the cost reduction for wheat and revenue from peas will exceed (or at least offset) the reduced wheat revenue.

**Wheat-Corn/Sorghum-Fallow**
- - Land Cost
- - Herbicide Cost
- - Machinery Cost reduced sprayer passes
- - Wheat revenue

Economics – Think about how you allocate land cost

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Start</th>
<th>End</th>
<th>Days</th>
<th>Share</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-C-P</td>
<td>Wheat 7/1/2016</td>
<td>6/25/2017</td>
<td>359</td>
<td>0.98</td>
<td>$49.18</td>
</tr>
<tr>
<td></td>
<td>Corn 6/26/2017</td>
<td>9/10/2018</td>
<td>441</td>
<td>1.21</td>
<td>$60.31</td>
</tr>
<tr>
<td></td>
<td>Pea 9/11/2018</td>
<td>6/25/2019</td>
<td>292</td>
<td>0.80</td>
<td>$40.09</td>
</tr>
</tbody>
</table>

|       | Wheat 9/11/2015 | 6/25/2017  | 653   | 1.79  | $89.45|
|       | Corn 6/26/2017  | 9/10/2018  | 441   | 1.21  | $60.41|

Questions?

Phone (785) 462-6281, email: LHaag@ksu.edu,Twitter: @LucasAHaag
www.northwest.ksu.edu/agronomy

Example is $50/ac cash rent

Spring Field Peas at the Colby Branch Experiment Station, 1915