Field Peas as Fallow Alternative

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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

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PUE – Precipitation Use Efficiency
lbs. of grain per inch of precipitation

- For dryland systems, the key to improved productivity and $$$ in the producer's pocket
- Principal ways of improving PUE
  - Improve fallow efficiency (No-till, more residue)
  - Grow a crop in place of fallow (W-F to W-S/C-F)
  - Next Step, W-S/C-Pea ?

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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 = <u>11.6" lost</u>
- We know that reducing soil water at planting will negatively impact subsequent crop yields
- Can we strike a balance?

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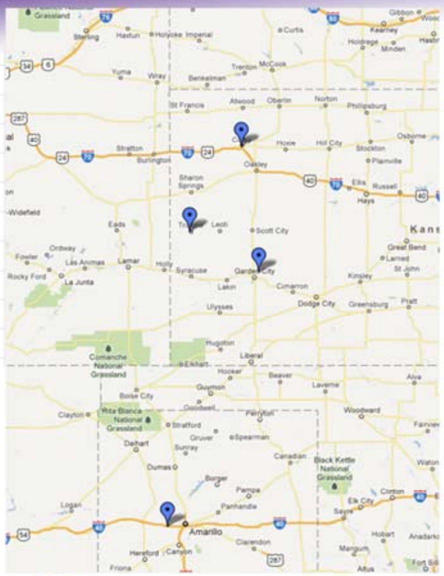


Locations

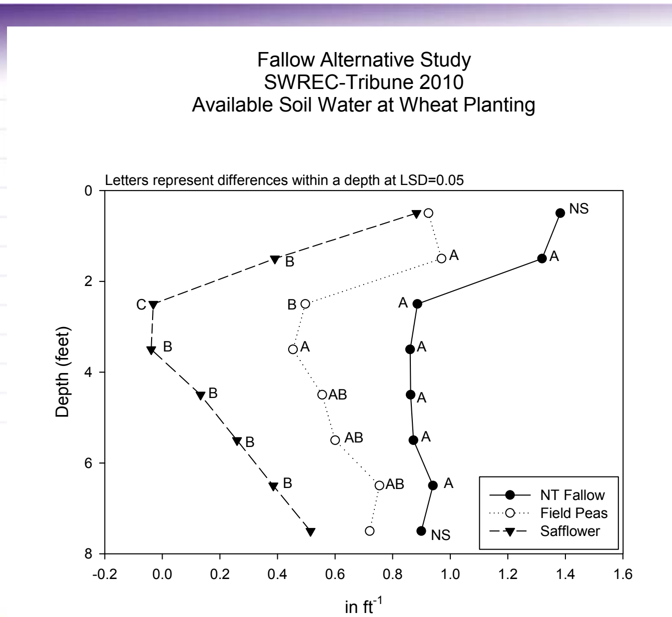
- 2010 Pilot Study
  - KSU NWREC-Colby
  - KSU SWREC-Tribune
- 2011-2012 Additions
  - KSU SWREC-Garden City
  - USDA-ARS Bushland

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

Peas effectively used 3.38" of water

	Water Use to Date (Inches)		
	15-May Termination	1-Jun Termination	1-Jul Harvest
Peas	2.18	5.42	9.30
Fallow	1.81	3.94	5.92
Fallow Efficiency	23.3%	31.1%	25.9%



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 ECONOMICS

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

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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

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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

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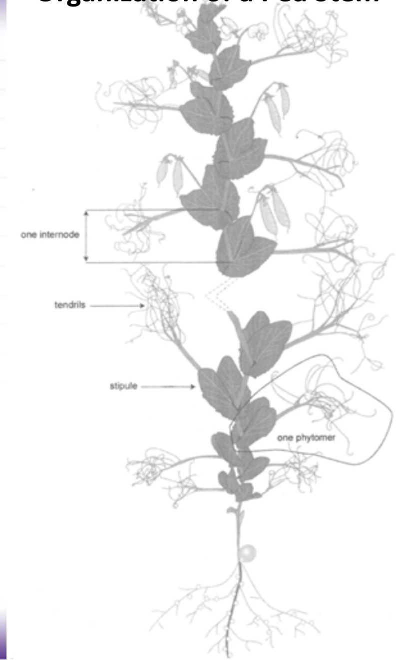
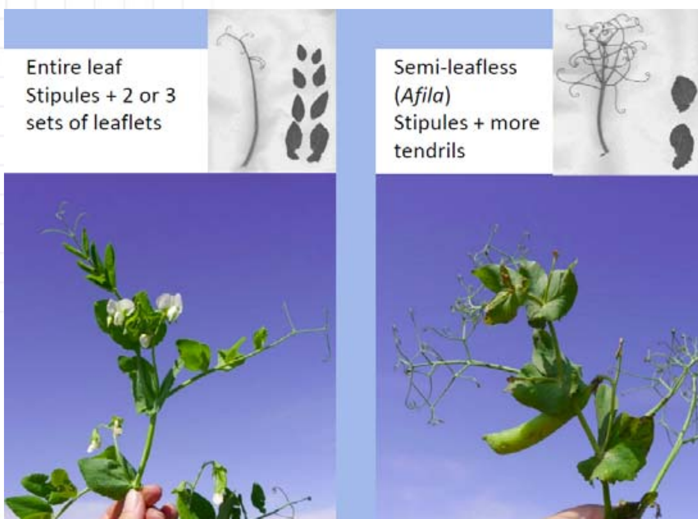
Winter vs. Spring Types

- 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

Organization of a Pea Stem



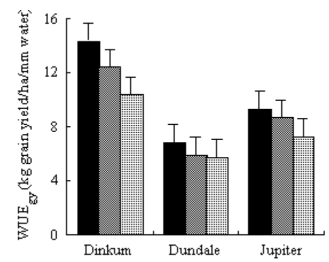
Plant Architecture



R. Bueckert et al., Univ. of Sask.

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



M. Khan et al.; R. Bueckert et al.

Pea Seed and Germination

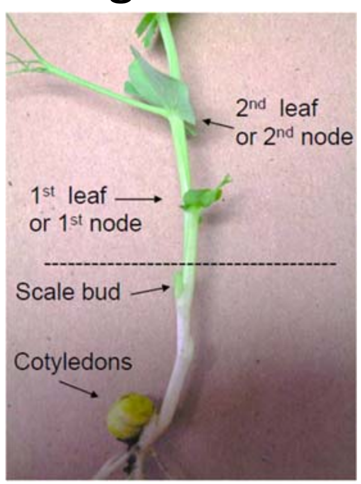
- Seed Size
  - Spring Pea 1600-2500 Seeds/Lb
  - Winter Pea 2200-3500 Seeds/Lb
- Seed doubles in volume in first 2 days of germination
- Requires 3x the moisture for germination compared to small grains
  - Management Note: Plant at least ½” into moisture

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

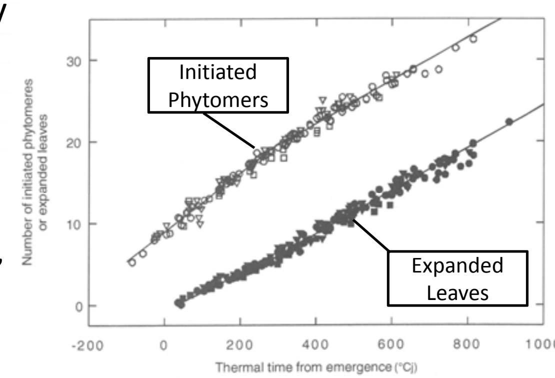
- Cotyledons and 1st node are with the seed piece
- 2nd and 3rd nodes usually are below the soil surface and act as axillary buds
- The 1st true leaf is technically the 3rd or 4th node, referred to as 1st vegetative node



K. McKay, NDSU

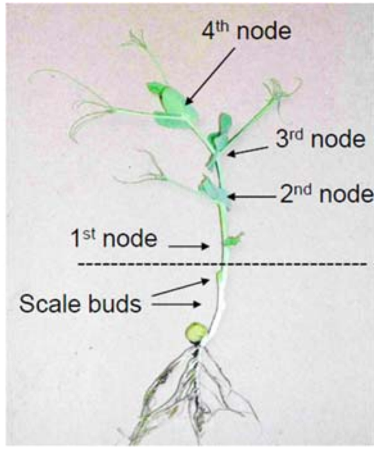
Above Ground Growth

- 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

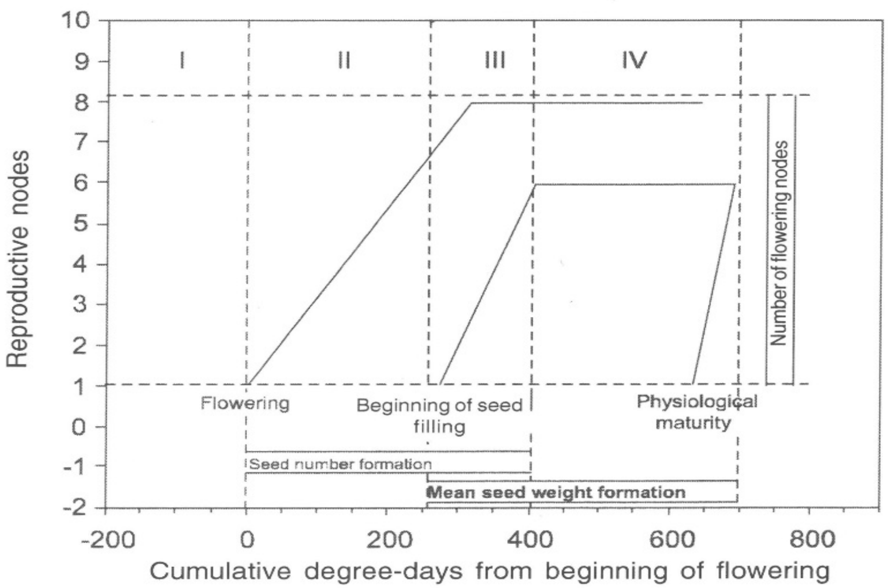


K. McKay, NDSU

Growth Staging

- 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

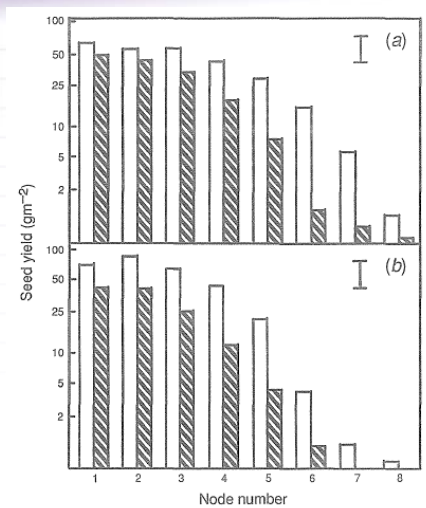
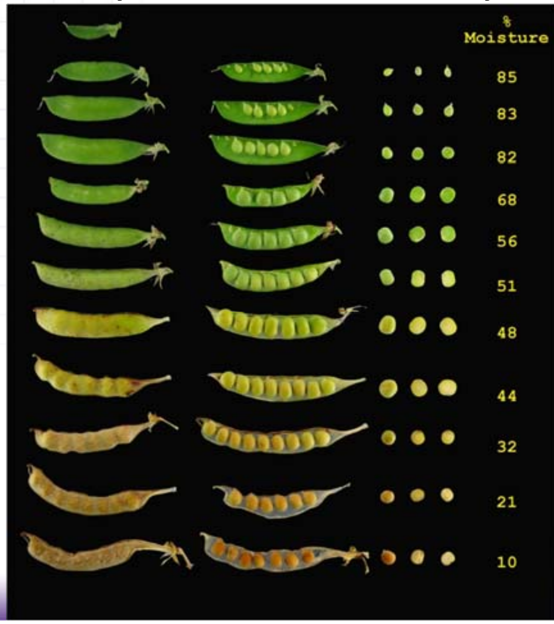


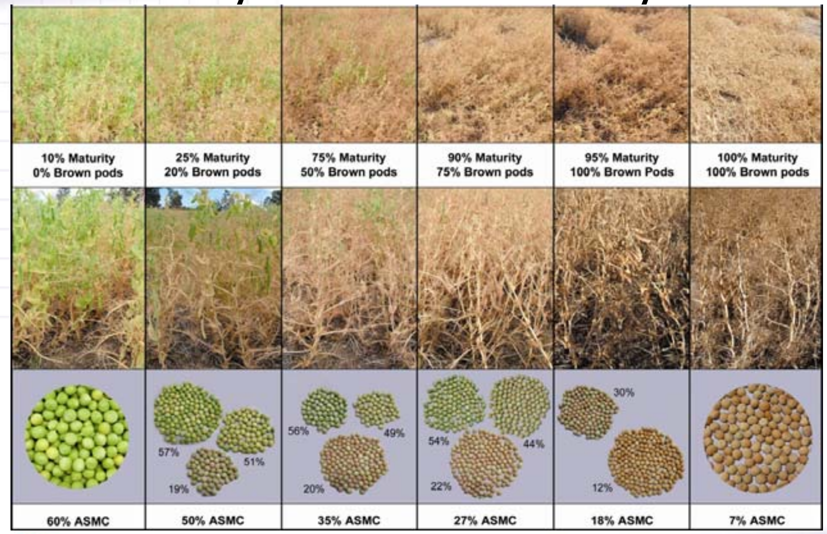
Fig. 3. Contribution of each reproductive node to seed yield in Derrimut (*a*) and Dundale (*b*) peas at Bruce Rock in 1986. □ first time of sowing. □ fourth time of sowing. Data for second and third times of sowing omitted for clarity. Vertical bar is l.s.d. (P = 0·05).

Drydown to Maturity



Australia GRDC

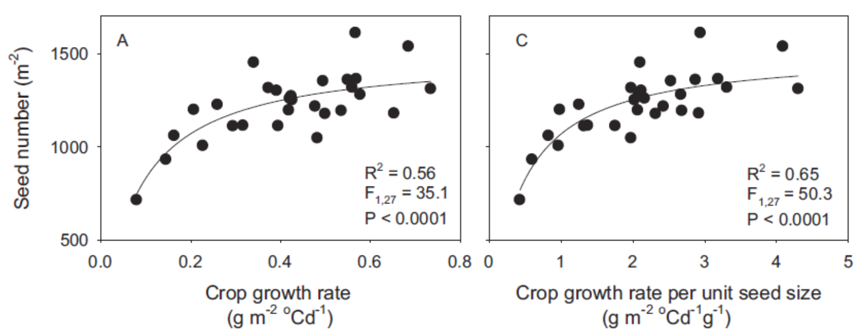
Drydown to Maturity



Australian Grains Research & Development (GRDC)

Maintaining Crop Growth Rate (Assimilate Supply) is Key!

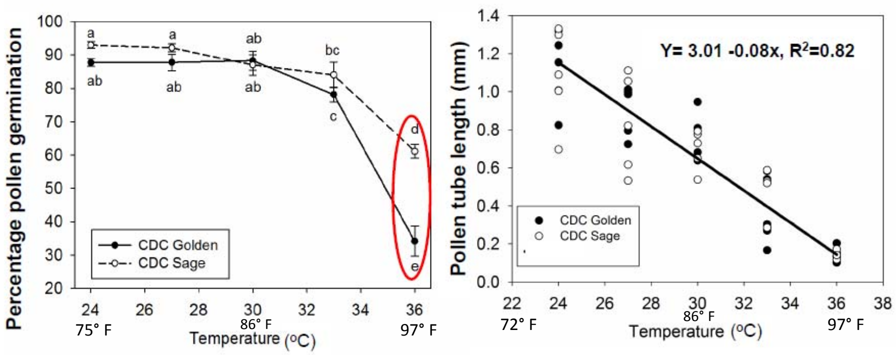
V.O. Sadras et al. / Field Crops Research 150 (2013) 63–73



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

Pollen 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.

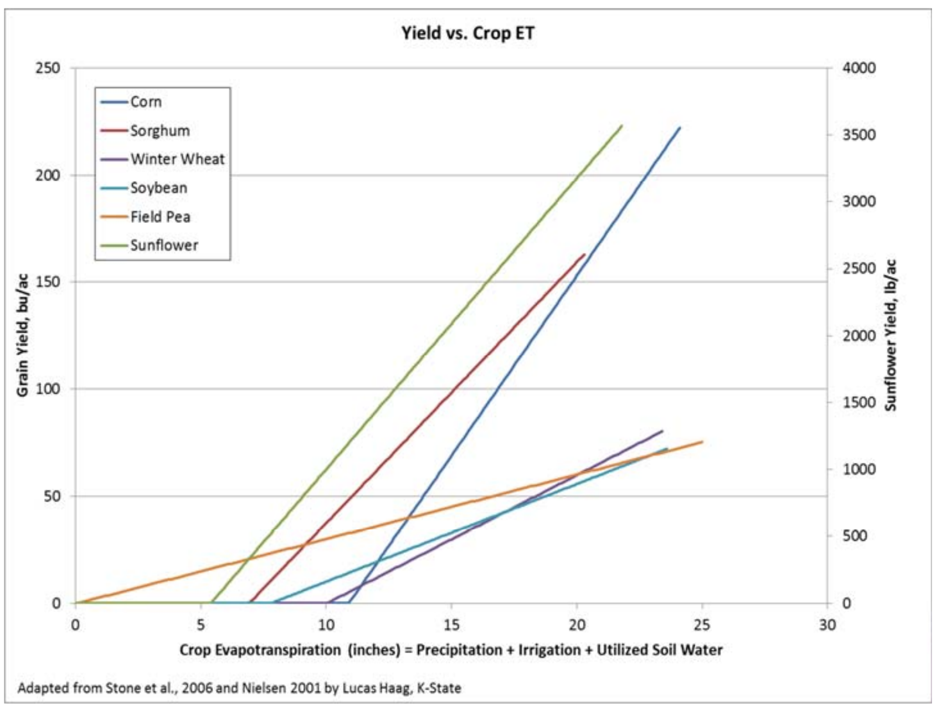
Jiang et al. (2015) Plant Cell Environ 38: 2387-2397

Effect of heat stress on seed set

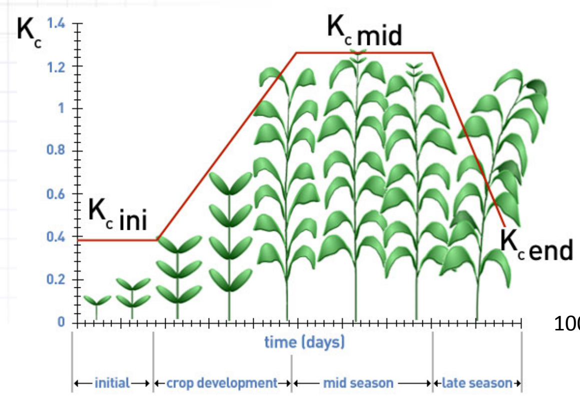
	Pod length (mm)	Number of seeds per pod	Seed-ovule ratio (%)
Cultivar			
CDC Golden	51 b	3.8 b	71.9 a
CDC Sage	62 a	4.8 a	69.8 a
Temperature (°C)			
75° F 24	62 a	4.6 a	73.3 a
81° F 27	61 ab	4.4 a	72.0 a
86° F 30	58 bc	4.6 a	76.5 a
91° F 33	57 c	4.6 a	76.4 a
97° F 36	46 d	3.4 b	56.0 b
P value			
Cultivar (C)	***	***	ns
Temperature (T)	***	***	***
C*T	ns	ns	ns

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

Jiang et al. (2015) Plant Cell Environ 38: 2387-2397



Water Use - Daily



100-110 days

initial	crop development	mid season	late season	
20-35	25-30	30-35	15-20	days
0.5	>>>>>>>	1.15	0.3	Kc

Maximum water use of approx. 0.24"/day occurs just after flowering

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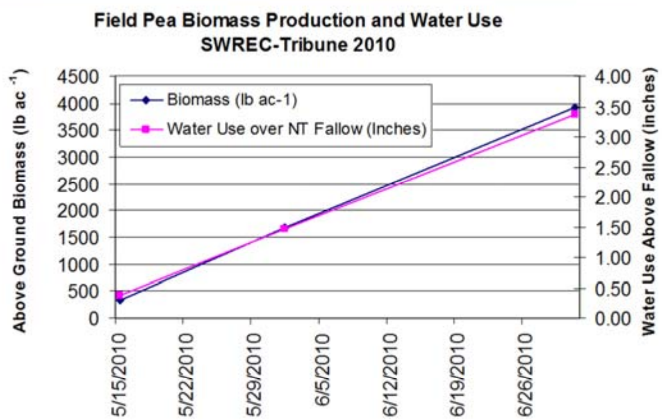


	15-May	1-Jun	1-Jul
Biomass (lb ac-1)	331	1676	3937
Water Use over NT Fallow (Inches)	0.37	1.48	3.38

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
  - <u>Crop rotation is our biggest tool</u>
    - 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

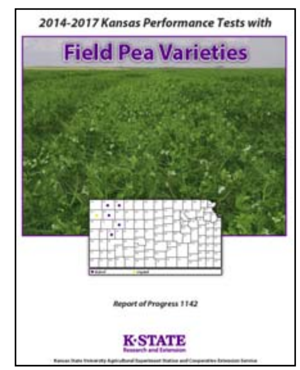


Table 1. Across-years yield averages for field pea varieties at four locations in northwest Kansas.

Company	Variety	Location			
		Rawlins		Thomas	
		4 Year Avg. 2014-17	5 Year Avg. 2014-2018	4 Year Avg. 2014-17	5 Year Avg. 2104-2018
PulseUSA	SW Midas (Y)	31.9	35.3	26.4	26.0
PulseUSA	DS Admiral (Y)	31.3	34.0	30.2	29.9
PulseUSA	Nette 2010 (Y)	32.7	35.7	29.6	29.4
Meridian Seeds	Earlystar (Y)	32.5	34.7	28.1	27.4
Meridian Seeds	AAC Carver (Y)	35.2	-	28.9	-
CDC / Meridian_Seeds	CDC Saffron (Y)	32.3	-	26.1	-
CDC / Meridian_Seeds	CDC Amarillo (Y)	31.4	-	27.1	-

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

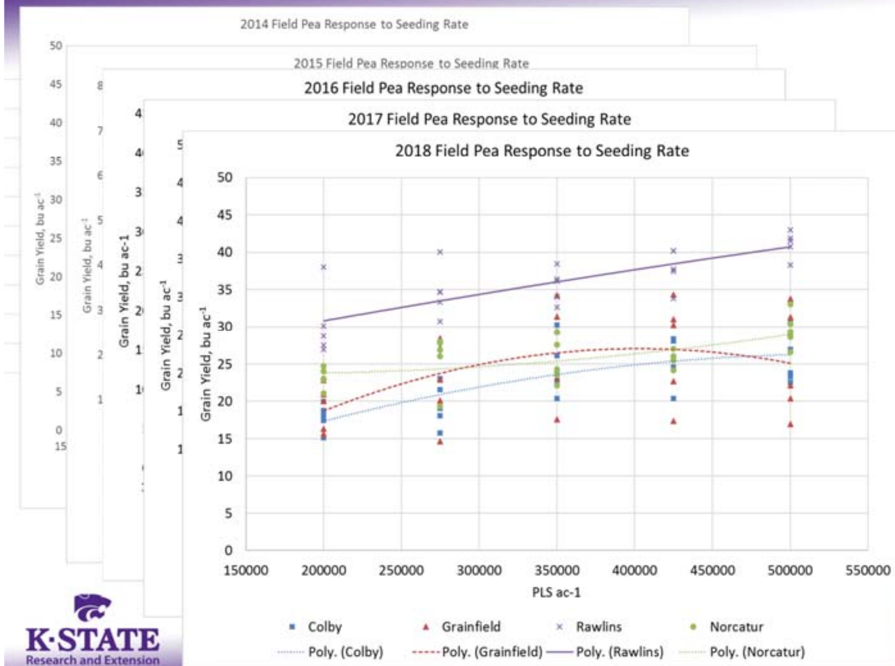
Inoculant

- 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

Site Year		Inoculant Type			
		Check	Liquid	Granular	
		Grain Yield, bu/ac			
1997	Canora	37.9	39.9	43.4	
1997	**Indian Head**	**26.8**	**26.0**	**29.9**	
1997	Melfort	60.2	57.8	60.5	
1997	Outlook	72.4	71.8	72.4	
1997	**Redvers**	**28.4**	**37.3**	**41.2**	
1997	**Scott**	**15.5**	**16.2**	**19.6**	
1997	**Swift Current**	**33.3**	**33.2**	**38.7**	
1998	Canora	46.5	46.5	47.1	
1998	Indian Head	49.8	49.2	50.1	
1998	Melfort	36.7	40.0	40.7	
1998	Outlook	76.0	77.2	79.1	
1998	**Scott**	**29.6**	**28.3**	**31.2**	
1998	**Swift Current**	**30.9**	**34.3**	**36.0**	
Statistically Significant Sites		27.4	29.2	32.8	5.4
All Sites		41.9	42.9	45.4	3.5

H.R. Kutcher et al., Canadian J. of Plant Science



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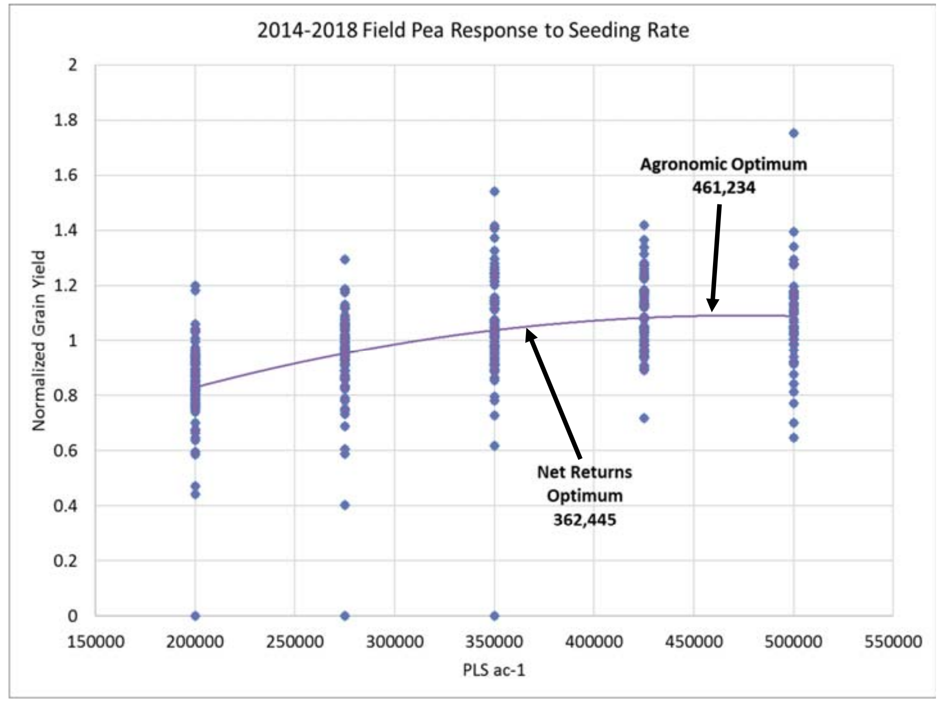

Seeding Rate Summary

- 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

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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

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Knowledge for Life

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

	Rawlins	Gove	Thomas	
		-- bu/ac --		
Untreated	28.4	19.9	26.2	b
Obvious	28.5	19.6	28.4	a
VibranceMaxx	31.0	19.0	29.4	a
Apron Maxx RTA	.	.	28.2	ab
		ANOVA		
P>F	0.5945	0.8694	0.049	
LSD	NS	NS	2.18	

Farm Management Guide MF-xxxx

Dry Field Pea Cost-Return Budget (W-C-P Rotation) in Northwest Kansas

Department of Agricultural Economics - www.AgManager.info

Kansas State University Agricultural Experiment Station and Coooperative Extension Service

Lucas Haag
Crops and Soils, NW

INCOME PER ACRE	Yield Level, bu/ac			Your Farm
A. Yield per acre	15	30	45	
B. Price per bushel	$6.40	$6.40	$6.40	
C. Net government payment	$0.00	$0.00	$0.00	
D. Indemnity payments	$0.00	$0.00	$0.00	
E. Miscellaneous income	$0.00	$0.00	$0.00	
F. Returns/acre ((A x B) + C + D + E)	$96.00	$192.00	$288.00	
COSTS PER ACRE				
1. Seed	$28.75	$28.75	$28.75	
2. Herbicide	17.60	17.60	17.60	
3. Inocculant	5.80	5.80	5.80	
4. Fertilizer and Lime	4.32	9.12	13.44	
5. Crop Consulting	0.00	0.00	0.00	
6. Crop Insurance	7.38	7.38	7.38	
7. Drying	0.00	0.00	0.00	
8. Miscellaneous	5.50	5.50	5.50	
9. Custom Hire / Machinery Expense	62.01	65.01	68.01	
10. Non-machinery Labor	7.50	7.50	7.50	
11. Irrigation				
a. Labor	0.00	0.00	0.00	
b. Fuel and Oil	0.00	0.00	0.00	
c. Repairs and Maintenance	0.00	0.00	0.00	
d. Depreciation on Equipment / Well	0.00	0.00	0.00	
e. Interest on Equipment	0.00	0.00	0.00	
12. Land Charge / Rent	52.08	52.08	52.08	
G. SUB TOTAL	$190.94	$198.74	$206.06	
13. Interest on 1/2 Nonland Costs	3.30	3.48	3.66	
H. TOTAL COSTS	$194.24	$202.22	$209.72	
I. RETURNS OVER COSTS (F - H)	**($98.24)**	**($10.22)**	**$78.28**	
J. TOTAL COSTS/BUSHEL (H/A)	**$12.95**	**$6.74**	**$4.66**	
K. RETURN TO ANNUAL COST (I+13)/G	**-49.72%**	**-3.39%**	**39.77%**	

* Reflects expected net premium paid

Economics – Evaluate the entire system!

Wheat-Corn/Sorghum-**Pea**

- \+ Land Cost
- \+ Herbicide Cost
- \+ Machinery Cost
  planting/harvest
- \- Pea grain revenue

Wheat-Corn/Sorghum-Fallow

- \- Land Cost
- \- Herbicide Cost
- \- Machinery Cost
  reduced sprayer passes
- \- Wheat 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

Economics – Think about how you allocate land cost

Rotation	Start	End	Days	Share	Cost
W-C-P					
Wheat	7/1/2016	6/25/2017	359	0.98	$ 49.18
Corn	6/26/2017	9/10/2018	441	1.21	$ 60.41
Pea	9/11/2018	6/30/2019	292	0.80	$ 40.00
W-C-F					
Wheat	9/11/2015	6/25/2017	653	1.79	$ 89.45
Corn	6/26/2017	9/10/2018	441	1.21	$ 60.41
W-C-C-P					
Wheat	7/1/2016	6/25/2017	359	0.98	$ 49.18
Corn1	6/26/2017	9/10/2018	441	1.21	$ 60.41
Corn2	9/11/2018	9/10/2019	364	1.00	$ 49.86
Pea	9/11/2019	6/30/2020	293	0.80	$ 40.14
W-C-C-F					
Wheat	9/11/2015	6/25/2017	653	1.79	$ 89.45
Corn1	6/26/2017	9/10/2018	441	1.21	$ 60.41
Corn2	9/11/2018	9/10/2019	364	1.00	$ 49.86

Example is $50/ac cash rent

Questions?

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

Spring Field Peas at the Colby Branch Experiment Station, 1915