Pulse Crops Expo

Jan. 7, 2019 (9:00 AM - 5:00 PM)

Holiday Inn, 110 S. 2nd Avenue, Kearney, NE, 68847

REGISTER FOR FREE (by Jan. 2)

Call or text: 402-318-1124 | **Email**: at sstepanovic2@unl.edu
Online: https://cropwatch.unl.edu/pulse-expo-registration

N EXTENSION

The Nebraska Environmental Trust
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PULSES

TOPICS WE WILL COVER:

Keynote: Management of Field Peas at Critical Growth Stages

- Field Peas Growth and Development - Lucas Haag, K-State University

Pulse Crop in Western NE:

- Field Pea as Fallow Replacement – Water Use, Yield, and Soil Health (**Sam Koeshall, UNL**)
- Response of Field Pea to Planting Date and Seeding Rates (**Cody Creech, UNL**)
- Are High-performing Pea Cultivars Different Across Regions in NE? (**Dipak Santra, UNL**)
- Tillage Effects on Pulse Crop Germination and Yield (**Strahinja Stepanovic, UNL**)
- How to Grow Chickpeas – Challenges and Opportunities (**Steve Tucker, Farmer**)

Pulse Crops in Central and Eastern NE and Under Irrigation

- Double Cropping Pulses with Cover Crops, Forages, and Short Season Crops (**Alex Rosa**)
- Cover Crop Grazing After Field Peas (**Farmer, TBA**)
- Irrigated Field Pea and Chickpea Production (**Strahinja Stepanovic, UNL**)

General Sessions Discussions

- Marketing Panel – Representatives of Pulse Grain Processing Industry
- Promoting the Pulse Crops Industry in Nebraska – Should Nebraska have a Pulse Crops Checkoff?

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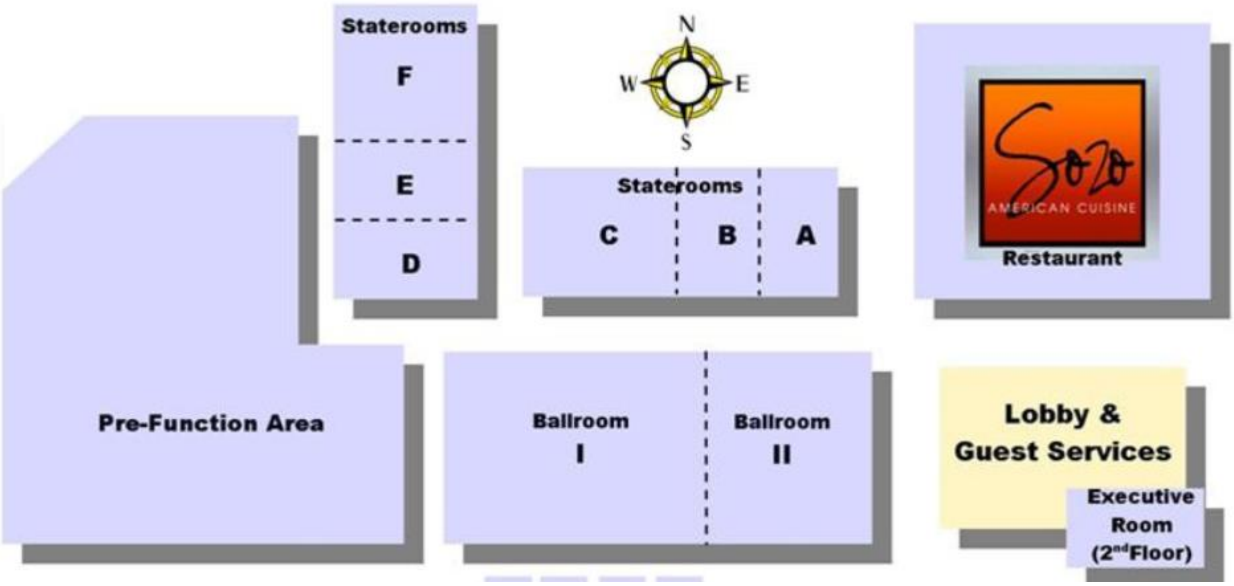
Table of contents

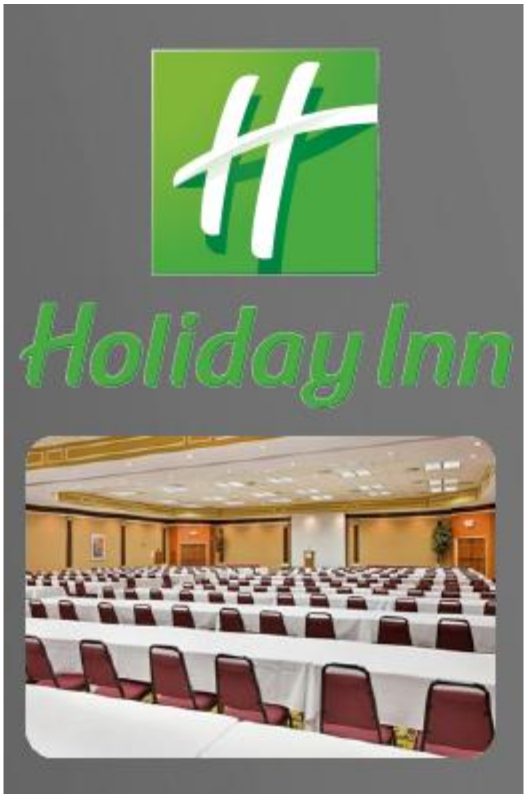
AGENDA - Pulse Crops Expo Jan. 7, 2019 (8:00 AM - 3:30 PM)

Holiday Inn, 110 S. 2nd Avenue, Kearney, NE, 68847

Start	End	Ballroom	Room B	Room C	Room D
8:00	8:30	**Registration**			
8:30	9:00	**Welcome**			
9:00	9:50	**Keynote: Management of Field Peas at Critical Growth Stages (Lucas Haag, K-State University)**			
10:00	10:30	Double Cropping Pulses with Cover Crops, Forages, and Short-Season Crops (**Alex Rosa, UNL**)	Are High-performing Pea Cultivars Different Across West-Central NE? (**Dipak Santra, UNL**)	Field Pea as Fallow Replacement – Water Use, Yield, and Soil Health (**Sam Koeshall, UNL**) Field Pea Planting Dates and Seeding Rates in western NE (**Sam Koeshall, UNL**)	Tillage Effects on Pulse Crop ‘Germination and Yield (**Strahinja Stepanovic, UNL**) Comparing Water Balance of Field Peas, Chickpeas and Soybeans vs Fallow (**Strahinja Stepanovic, UNL**)
10:30	11:00	**Networking Session**			
11:00	11:30	Producer Panel: Cover Crop Grazing After Field Peas **(Jim Campbell, Kearney & Tom Schwarz - organic farmer, Bertrand area)**	Tillage Effects on Pulse Crop Germination and Yield (**Strahinja Stepanovic, UNL**) Comparing Water Balance of Field Peas, Chickpeas and Soybeans vs Fallow (**Strahinja Stepanovic, UNL**)	Are High-performing Pea Cultivars Different Across West-Central NE? (**Dipak Santra, UNL**)	Field Pea as Fallow Replacement – Water Use, Yield, and Soil Health (**Sam Koeshall, UNL**) Field Pea Planting Dates and Seeding Rates in western NE (**Sam Koeshall, UNL**)
11:30	12:00		Water Use of Field Peas and Chickpea Under Irrigation (**Strahinja Stepanovic, UNL**)	**Gavilon Grain** **Farmers Business Network**	**Canidae Pet Food** **Luhrs Certified Seed**
12:00	1:00	**Lunch Break and Sponsor Presentations (lunch room)**			
1:00	1:30	Water Use of Field Peas and Chickpea Under Irrigation (**Strahinja Stepanovic, UNL**)	Double Cropping Pulses with Cover Crops, Forages, and Short-Season Crops (**Alex Rosa, UNL**)	**Luhrs Certified Seed** **Canidae Pet Food**	**Farmers Business Network** **Gavilon Grain**
1:30	2:00	**Networking Session**			
1:30	2:15	**How to Grow Chickpeas** – Challenges and Opportunities	Cover Crop Grazing After Field Peas **Jim Campbell, Kearney** & **Tom Schwarz - organic farmer, Bertrand area**		
2:15	3:00	**Marketing Panel - Clint Brauer (Canidae), Mason Nicklaus (Gavilon), Todd Scholz (US Dry Pea and Lentil Council)**			
3:00	3:30	**Should Nebraska have a Pulse Crops Checkoff? (Preliminary Survey Results and Discussion)**			

Holiday Inn Meeting Rooms





Field Pea Growth and Development

Lucas Haag, Ph.D., Northwest Area Agronomist
Northwest Research-Extension Center, Colby, KS

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

Domestication

- Initial domestication occurred in the Near East and Mediterranean regions
- Cultivation of pea spread from the Fertile Crescent to modern Russia and westwards through the Danube valley into Europe, Greece and Rome, then spread into Northern and Western Europe
- Simultaneously, pea moved eastward to Persia, India, and China

Domestication – What Changed?

- Semi-drwaf growth habit *(le)*
- Wrinkled seed in garden types *(r)*
- Conversion of leaflets to tendrils *(af)*
- Absence of sclerenchymatic tissue in pods of edible types *(p/v)*
- Increased seed size
- Loss of germination inhibition
- Shoot basal branching
- Reduction/elimination of pod shattering

Defining Field Pea, It's Complicated

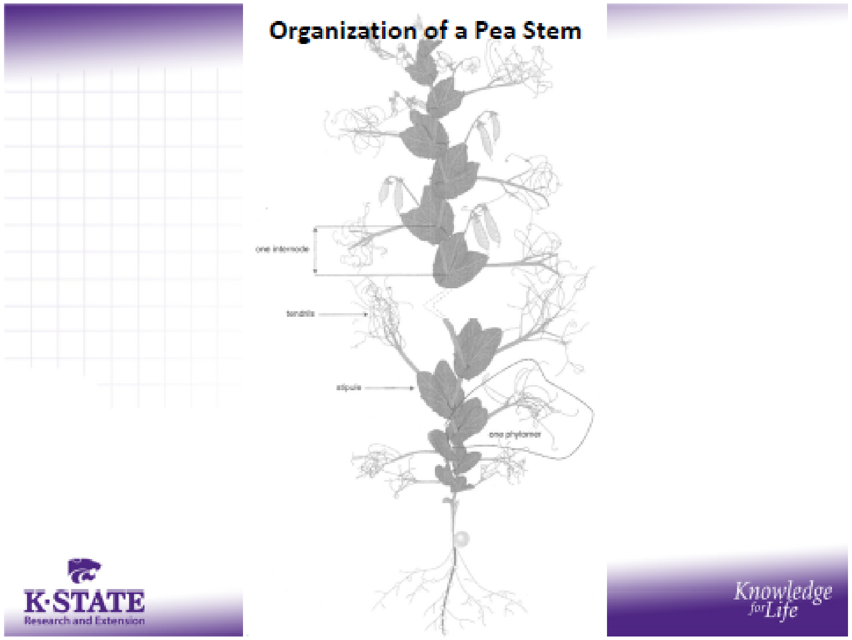
- Multiple Pisum Species
  - P. fulvum
  - P. elatius
  - P. abyssinicum
  - **P. sativum**
- Multiple Market Classes
  - Field Pea
    - Yellow (white), Green, Dunn, Blue, Morrowfat, Maple, Forage, Feed, Sprouts
  - Vegetable Pea
    - Freezer, Snow, Snap

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

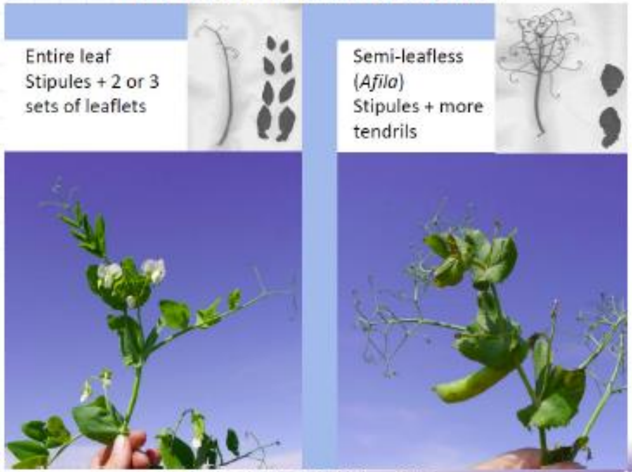
Winter vs. Spring Types

- 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



Organization of a Pea Stem

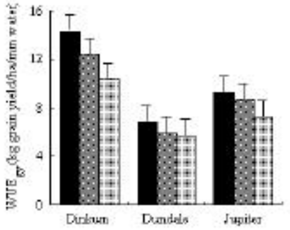
Plant Architecture

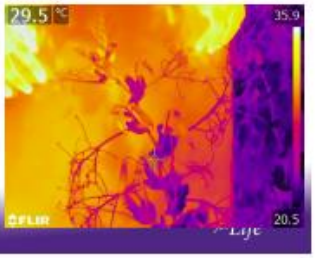


R. Bueckert et al., Univ. of Sask.

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

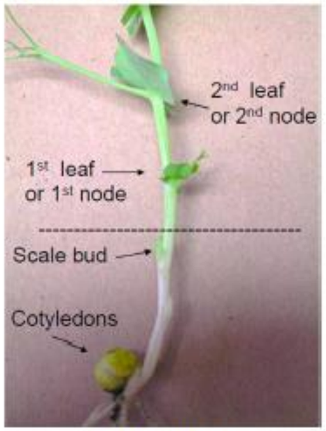
- Seed Size
  - Spring Pea 1600-2500 Seeds/Lb
  - Winter Pea 2200-3500 Seeds/Lb
- Seed doubles in volume in first 2 days of germination
- Requires 3x the moisture for germination compared to small grains
  - Management Note: Plant at least ½" into moisture

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

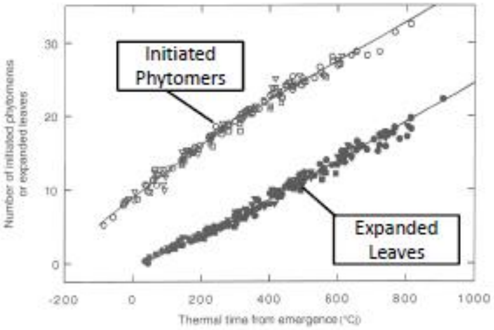
- Cotyledons and 1st node are with the seed piece
- 2nd and 3rd nodes usually are below the soil surface and act as axillary buds
- The 1st true leaf is technically the 3rd or 4th node, referred to as 1st vegetative node



K. McKay, NDSU

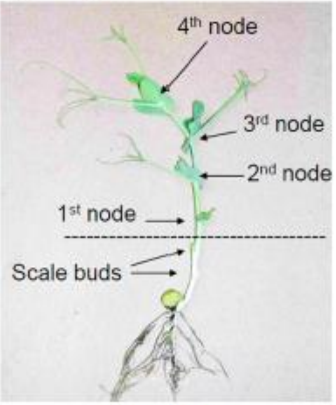
Above Ground Growth

- 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

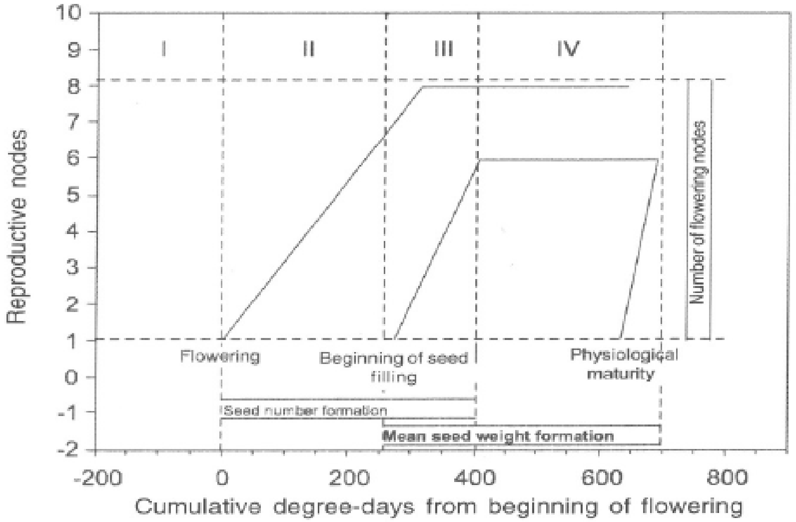


K. McKay, NDSU

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



Transition Points-Floral Initiation and Beginning of Flowering

- Many interactive genes control first flowering node, as well as floral initiation and flowering
- The process is driven by many factors
  - Thermal, Photoperiod, Plant size and age
- For most commercial pea varieties photoperiod is a quantative trait with respect to flowering (there are exceptions – forage and winter peas)
  - i.e. the longer the daylength experienced by the plants after emergence, the earlier floral initiation will begin

Floral Initiation and Flowering

- IT'S COMPLICATED!
- Physiologically – a flowering signal (not well understood), is produced by the leaves in response to photoperiod, temperature, age of plant and transmitted by sap to the terminal meristem
- Many (but not likely all) of the genes involved in this process have been identified, there is genetic variability

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

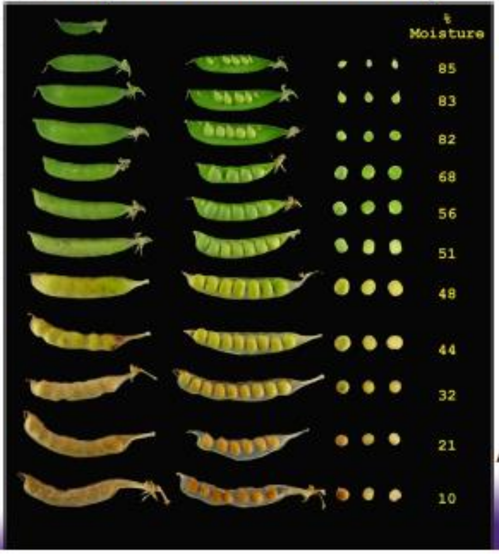
Reproductive Development
Seed Abortion

- 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

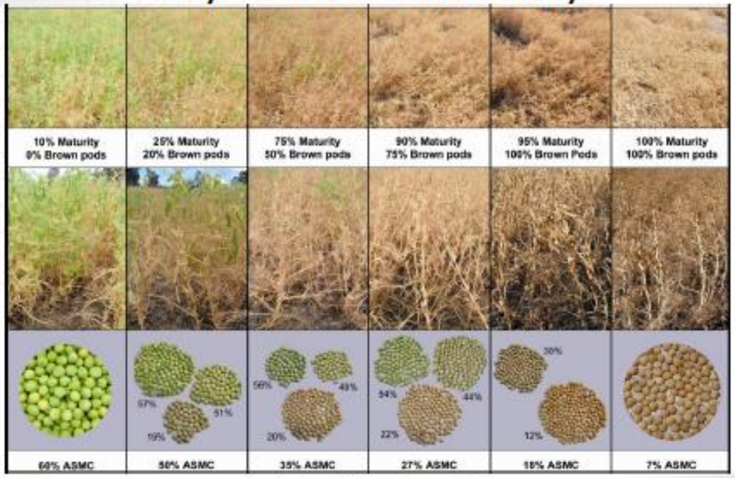
- End of phytomere production
  - Assimilate demand of seed filling becomes high relative to availability, the supply at the apical tip ceases

Drydown to Maturity



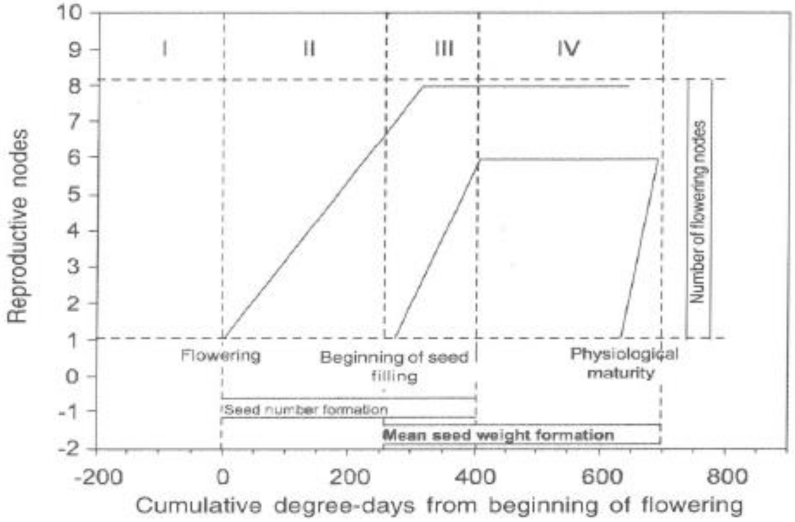
Australia GRDC

Drydown to Maturity



Australian Grains Research & Development (GRDC)

This also drives yield components



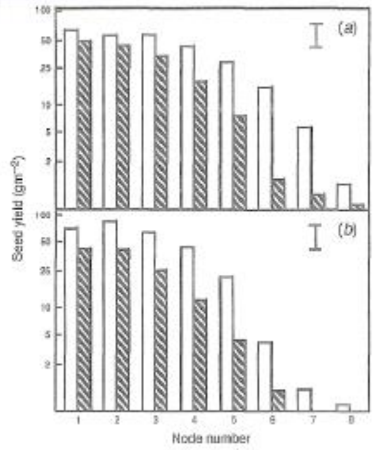


Fig. 3. Contribution of each reproductive node to seed yield in Derrimut (*a*) and Dundale (*b*) peas at Bruce Rock in 1986. ▨ first time of sowing. □ fourth time of sowing. Data for second and third times of sowing omitted for clarity. Vertical bar is l.s.d. ($P = 0{\cdot}05$).

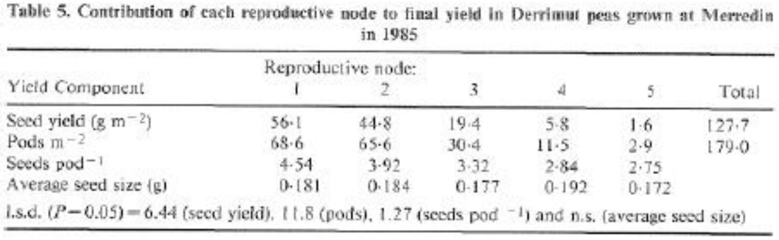
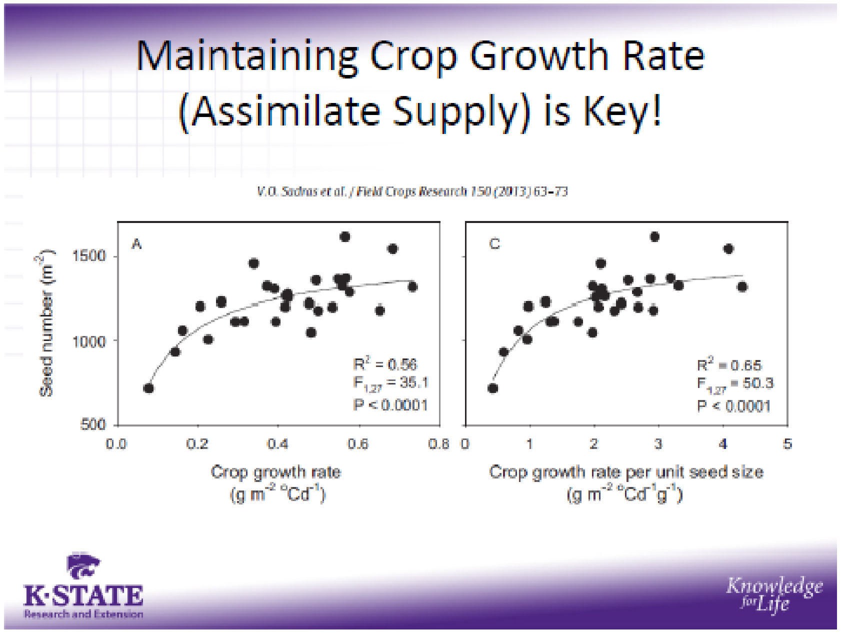


Table 5. Contribution of each reproductive node to final yield in Derrimut peas grown at Merredin in 1985

Yield Component	Reproductive node: 1	2	3	4	5	Total
Seed yield (g m^{-2})	56·1	44·8	19·4	5·8	1·6	127·7
Pods m^{-2}	68·6	65·6	30·4	11·5	2·9	179·0
Seeds pod^{-1}	4·54	3·92	3·32	2·84	2·75	
Average seed size (g)	0·181	0·184	0·177	0·192	0·172	

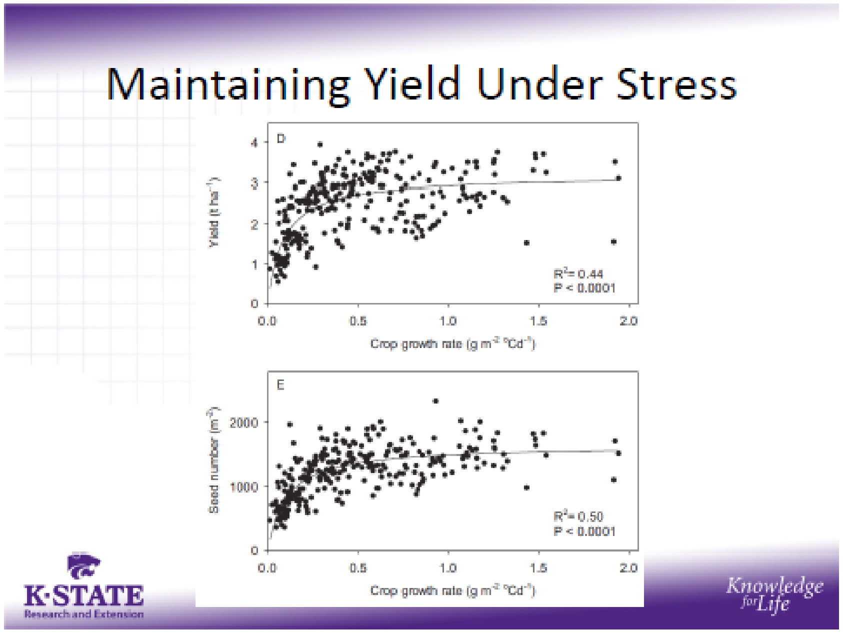
l.s.d. ($P = 0.05$) = 6.44 (seed yield), 11.8 (pods), 1.27 (seeds pod^{-1}) and n.s. (average seed size)

Maintaining Crop Growth Rate (Assimilate Supply) is Key!



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

Maintaining Yield Under Stress



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

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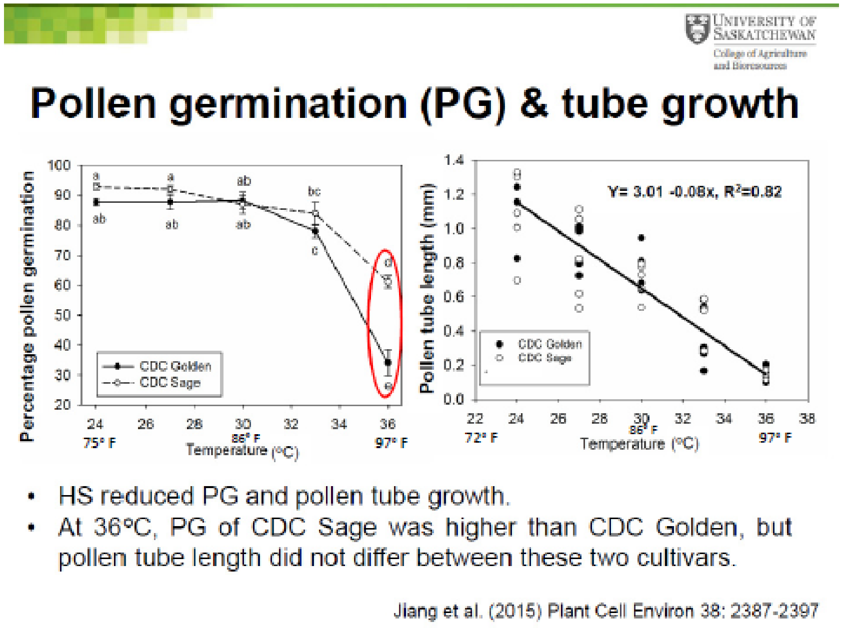
Pollen germination (PG) & tube growth



- 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.

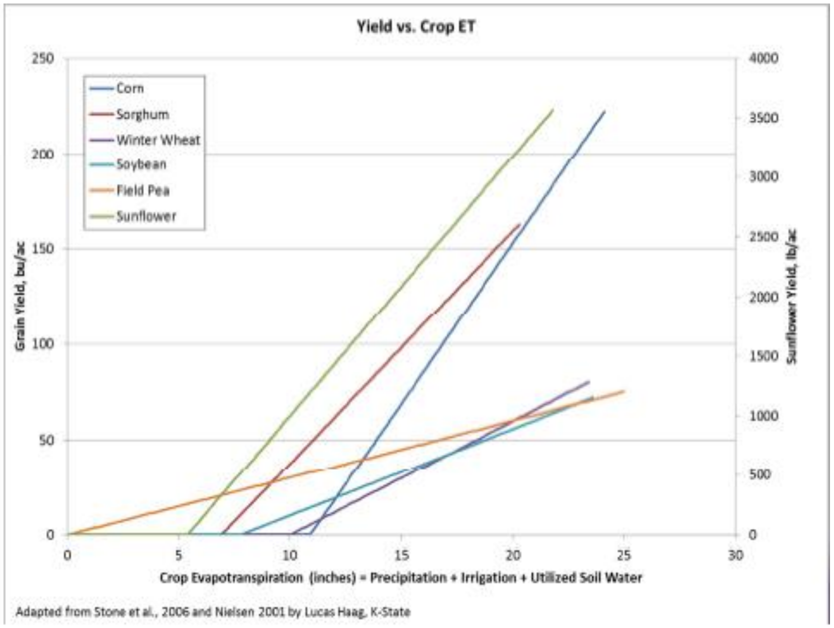
Jiang et al. (2015) Plant Cell Environ 38: 2387-2397

Effect of heat stress on seed set

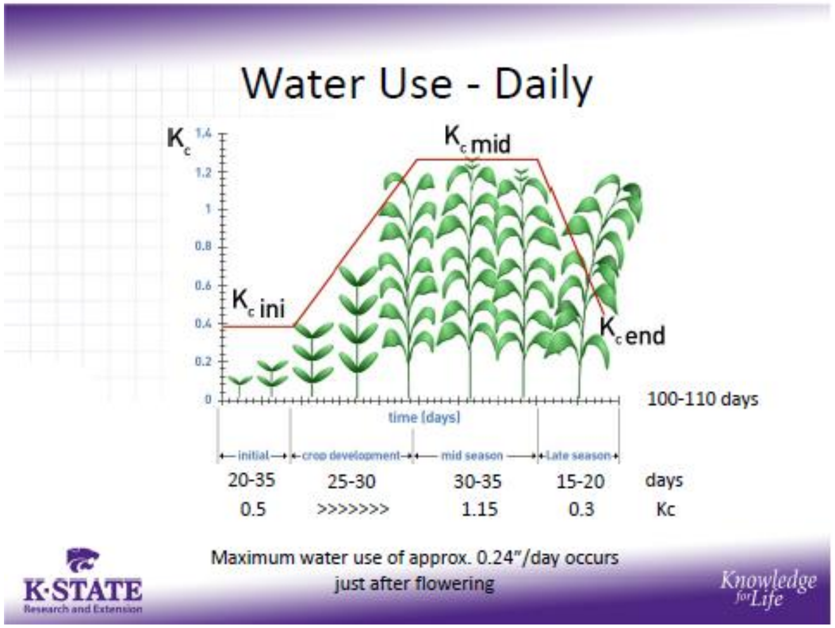
	Pod length (mm)	Number of seeds per pod	Seed-ovule ratio (%)
Cultivar			
CDC Golden	51 b	3.8 b	71.9 a
CDC Sage	62 a	4.8 a	69.8 a
Temperature (°C)			
75° F 24	62 a	4.6 a	73.3 a
81° F 27	61 ab	4.4 a	72.0 a
86° F 30	58 bc	4.6 a	76.5 a
91° F 33	57 c	4.6 a	76.4 a
97° F 36	46 d	3.4 b	56.0 b
P value			
Cultivar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



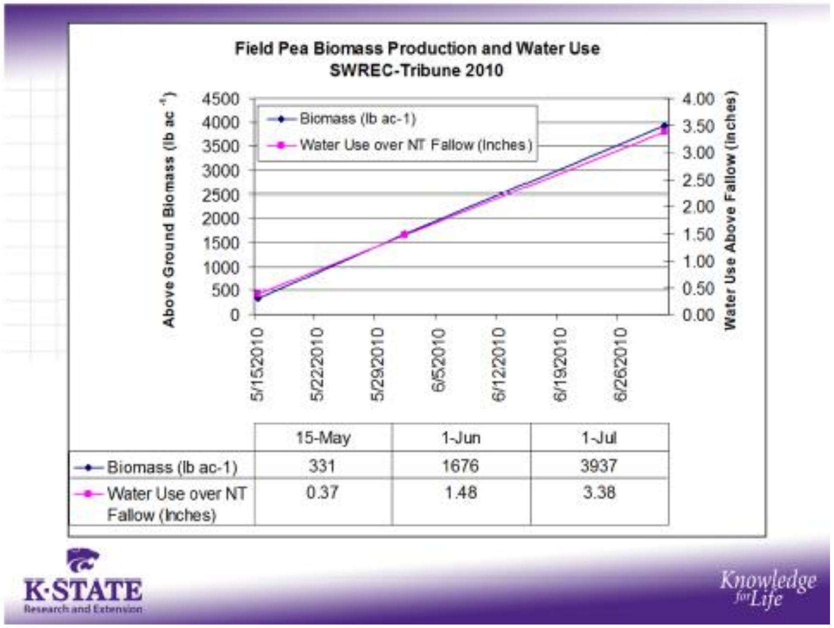
Adapted from Stone et al., 2006 and Nielsen 2001 by Lucas Haag, K-State



Water Use - Daily

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



	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

Water Use by Field Peas vs. No-Till Fallow

	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%

Peas effectively used 3.38" of water

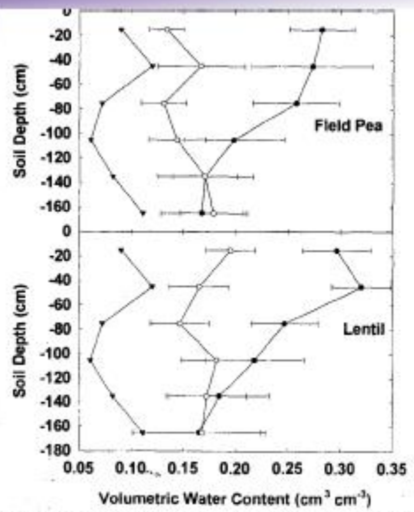


Fig. 4. Volumetric water content of rainfed plots (avg. across years) at planting and harvest for chickpea, field pea, and lentil; also, lower limit of volumetric water for winter wheat on Weld silt loam at Akron, CO. Bars are ± one standard deviation.

Nielsen et al., 2001. Agron. J.

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
- Heat Stress Tolerance (our biggest issue)

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

Double Cropping Pulses with Short Season Grain Crops, Forages, and Cover Crops in Eastern NE Research Update

Alexandre Tonon Rosa, Samuel Koeshall, Italo Kaye Pinho de Faria, Cody Creech, Keith Glewen and Strahinja Stepanovic

Cover photo. Overview of the study near Mead, NE. Left to right: Corn, soybean, grain sorghum, grain sorghum, proso millet, sunflower, and forage sorghum. Pictures taken on 09/03/2018.

Introduction

A research project is underway at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE to evaluate a double crop production system. The experiment was designed by University of Nebraska faculty and graduate students as a potential alternative to the prominent corn/soybean rotation that is commonly used in the area.

A corn/soybean rotation can often lead to soil degradation, over-reliance on pesticides and fertilizers, frequent outbreaks of diseases and insects, herbicide-resistance weeds, and increased financial risks associated with low market prices. Diversifying a crop production system by including additional crops or methods can help overcome many of these issues.

This experiment used yellow field peas as the first crop in the double crop system. Yellow field peas are typically planted in March and harvested in July. Although not evaluated in this experiment, winter wheat could be another cool season crop option and provide additional benefits by overwintering and protecting the soil. Wheat has the ability to perform well in Eastern NE.

The objectives of this ongoing research project are:

1. To evaluate the yield potential of pulse crops (field peas, lentils and chickpeas) in eastern NE. Current market prices for pulse crops can be found at https://www.ams.usda.gov/mnreports/gl_gr851.txt
2. To evaluate the feasibility of double cropping yellow field peas with short season crops (corn, soybean, grain sorghum, millet and sunflower) and annual forages (forage sorghum and sorghum-Sudangrass) by measuring crop production and performing an economic analysis.
3. To investigate the benefits of incorporating cover crops and livestock grazing into the cropping systems
4. To design the cropping system with extended growing season that will minimize pesticides and fertilizer inputs and will be more water use efficient.

Pulse Crops Variety Trial (Objective 1)

Figure 1. (L-R) Field peas, lentils, and chickpeas planted in a double cropping study at the Eastern Nebraska Research and Extension Center near Mead (Photos taken June 12).

Although the double crop experiment is ongoing, an important component was to conduct a pulse crop variety trial to identify which varieties are best adapted to the environment in eastern Nebraska (Figure 1). The variety trial (Figure 2) was conducted adjacent to the double crop experiment at ENREC. Yellow peas, green peas, lentils, and chickpeas were planted early in the spring and evaluated for their characteristics such as flowering, maturity, plant height, test weight and yield (Table 1).

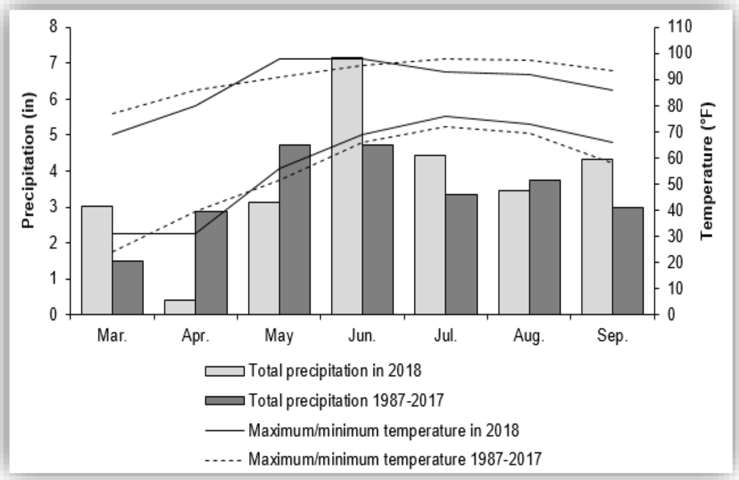


Figure 1. Total precipitation and temperature during the growing season of pulses in Mead, NE. Data collected from Mar 13th to Sep 4th 2018.

Location description:

- Location: Mead, NE - Saunders CO
- Weather info: see Figure 1
- Soil type: Silt Loam and Silt Clay Loam
- Tillage practice: no-till
- Previous crop: corn
- Herbicide program: Sharpen 2 oz + Prowl 2 pt

Seeding (date, rate, depth, inoculant):

- Yellow peas (04/05/2018, 310,000 live plants/acre, 1.5-2 inches deep, liquid and peat inoculant 2x rate)
- Green peas (03/30/2018, 310,000 live plants/acre, 1-1.5 inches deep, 2 peat-based pea inoculant)
- Lentils (03/30/2018, 310,000 live plants/acre, 1 inch deep, 2 peat-based pea inoculant)
- Chickpeas (04/12/2018, 300,000 for Orion and 220,00 live plants/acre for Frontier, 1.5 inch deep, diluted liquid inoculant plus a full rate of Verdesian N-Dure peat inoculant)

Harvest (date): yellow and green peas (07/12/2018); lentils (07/20/2018); chickpeas (08/13/2018)

Table1. 2018 Pulses Variety Trial at Mead, NE (Saunders County)

Variety	Brand	50% bloom (DAP) *	Flowering rating	Maturity (1-10)*	Plant height (in)	Moisture at harvest (%)	Test wt (lbs/bu)	Yield (bu/ac) *	Yield (lbs/ac)	Yield rank
Yellow Peas										
Agassiz	Meridian Seed	58	Early	8	20.1	13.7	62.9	48	2893	1
AAC Profit	Great Northern Ag	60	Late	6	27.6	23.2	60.8	45	2696	2
Jetset	Meridian Seed	58	Early	10	24	12.7	63.7	44	2637	3
AC Earlystar	Meridian Seed	58	Early	8	24.3	14.1	59.7	42	2516	4
CDC Inca	Meridian Seed	60	Late	6	21.3	15.8	62.8	42	2493	5
Hyline	Great Northern Ag	59	Mid	7	24.9	19.3	60.4	41	2468	6
AAC Carver	Meridian Seed	58	Mid	7	27.6	14.8	62.0	41	2459	7
Spider	Great Northern Ag	59	Mid	7	24.9	15.1	62.8	41	2452	8
CDC Saffron	Meridian Seed	59	Mid	8	23.7	15.5	63.9	41	2445	9
4193	Montech	57	Early	8	21	13.3	62.4	38	2303	10
SW Midas	Pulse USA	58	Mid	9	19.2	13.2	62.8	37	2231	11
LG Sunrise	Pulse USA	57	Early	4	27.6	19.9	59.5	37	2210	12
1057	Montana Integrigy	60	Late	8	29.4	13.7	64.0	37	2207	13
4152	Montech	58	Mid	7	23.7	15.5	62.3	36	2181	14
DS-Admiral	Pulse USA	57	Early	10	21.6	12.7	62.7	36	2137	15
CDC Amarillo	Meridian Seed	60	Late	5	27.6	22.7	59.4	36	2135	16
Nette 2010	Pulse USA	57	Early	10	18.9	12.2	62.6	36	2133	17
CDC Spectrum	Meridian Seed	60	Late	3	29.4	24.8	58.7	35	2084	18
Bridger	Great Northern Ag	57	Early	8	23.1	14.6	63.0	35	2084	19
Navarro	Great Northern Ag	56	Early	6	25.5	14.8	62.3	34	2063	20
Salamanca	Great Northern Ag	59	Mid	7	29.4	15.9	62.4	34	2027	21
LG Amigo	Pulse USA	58	Mid	5	26.1	16.4	62.1	33	2001	22
Partner	NS Seed	58	Mid	8	22.8	14.2	48.7	28	1693	23
Durwood	Pulse USA	58	Mid	6	30.9	16.6	61.7	26	1555	24
Dukat	NS Seed	56	Early	10	12.3	13.5	62.8	22	1318	25
Average of all Varieties		**58**	**Mid**	**7**	**24.3**	**15.9**	**61.4**	**37**	**2217**	
Difference required for significance at 5%				3	4	5	8	12	716	
Green Peas										
CDC Striker	Pulse USA			9	25.8	13.6	63.7	46	2740	1
Shamrock	Great Northern Ag			10	17.7	13.4	62.4	44	2665	2
SW Arcadia	Pulse USA			10	21.3	12.1	63.7	43	2556	3
CDC Greenwater	Meridian Seed			9	27.6	13.0	63.4	41	2471	4
AAC Comfort	Meridian Seed			3	30.3	26.2	58.1	39	2319	5
Empire	Great Northern Ag			4	35.7	17.6	62.7	29	1761	6
Junior pea	NS Seed			6	26.1	18.2		27	1650	7
Average of all Varieties				7	26.4	16.3	62.3	38	2309	
Difference required for significance at 5%				2	5	4	2	10	648	

Lentils						
CDC Maxim CL	Pulse USA	10		31	1835	1
CDC Invincible CL	Pulse USA	10		29	1738	2
Chickpeas						
CDC Orion	Meridian Seed	12.2	53.9	40	2418	1
CDC Frontier	Meridian Seed	12.7	55.4	35	2088	2

* DAP, Days after planting

* 1 = late maturing, 10 = early maturing

* Yield at 60 lbs/bu and 13% moisture

Feasibility of Double Cropping (Objective 2)

Two separate studies were conducted to evaluate the feasibility of double cropping.

The first study evaluated short season cash crops harvested for grain (corn, soybean, sunflower, millet and milo) and annual forages (forage sorghum). Each double crop was planted in strips 7.5-10 ft wide by 150 ft long and replicated four times. Plating date was July 15, which was 7 days after field pea harvest.

The second study was planted to three different cover crop mixes including sorghum sudan, winter sensitive mix and winter sensitive + winter hardy mix. The cover crops were planted in strips 30 ft wide by 300 ft long (for grazing purposes). Planting date was early August.

Table 2. Grain yield and seeding practices used in double crops and grazing cover crop study.

Double Crop	Brand	Equipment	Seed size (#/lb)	Target population (pl/ac)	Seeding rate (lbs/ac)	Seeding depth (in)	Yield (bu/ac)	Yield (lbs/ac)
corn (CN)	P7213R	planter	NA	25,000	NA	1.5	26	1,535
soybean 2.0 (SB)	RX1827	drill	2150	250,000	120	1.5	11	622
milo 1 (M1)	NK2212	drill	15,000	75,000	5	1	87	4,863
milo 2 M2)	SP 25C10	drill	15,000	75,000	5	1	104	5,837
proso millet PM)	Huntsman	drill	80,000	280,000	35	1	36	1,725
sunflower (SF)	MY8H456CL	planter	NA	20,000	NA	1.5	54	1,725
forage sorghum (FS)	CaneX	drill	15,000	NA	30	1		11,606
Grazing Cover Crop								
sorghum sudan (CC1)	Honey Grazed BMR	drill	NA	NA	40	1		NA
winter sensitive (CC2)	Roberts Seed	drill	NA	NA	120	1		NA
winter sensitive + winter hardy (CC3)	Roberts Seed	drill	NA	NA	120	1		NA

Are High-performing Pea Cultivars Different Across West-Central NE?

Dipak Santra

Panhandle Four Years Average: Eight site-years

2018: Cheyenne and Box Butte Co

2017: Cheyenne, Box Butte and Scotts Bluff Co

2016: Cheyenne Co

2015: Cheyenne and Scotts Bluff Co

Brand	Variety	Entry	Yld rank	Yield (bu/a)	Test wt (lbs/bu)	Flowering 50% (DAP)	Plant height (inch)	Seed protein %
Meridian Seeds	AAC Carver	1	1	34	61	70	19	23
Meridian Seeds	CDC Amarillo	7	2	33	61	72	19	24
Meridian Seeds	AC Earlystar	4	3	32	61	69	17	23
Meridian Seeds	Jetset	15	4	31	61	69	17	24
Meridian Seeds	CDC Saffron	10	5	31	61	69	17	24
Pulse USA	Nette 2010	20	6	30	62	68	17	24
Pulse USA	SW Midas	23	7	29	60	70	17	23
Great Northern Ag.	Salamanca	21	8	28	61	69	20	24
Pulse USA	DS-Admiral	12	9	28	61	69	19	24
Great Northern Ag.	Spider	22	10	28	60	69	17	25
Av. of all entries				**30**	**61**	**69**	**19**	**23**
Diff. req. at 5% sig. (LSD)				**ns**	**1**	**2**	**2**	**1**
CV				**18**	**1**	**2**	**9**	**3**

West Central Four Years Average: Seven site-years

2018: Perkins and Custer Co

2017: Perkins Co

2016: Perkins and Lincoln Co

2015: Perkins and Lincoln Co

Brand	Variety	Entry	Yield rank	Yield (bu/a)	Test wt (lbs/bu)	Flowering 50% (DAP)	Plant height (inch)	Seed protein %
Meridian Seeds	CDC Saffron	4	1	34	62	68	19	25
Pulse USA	Durwood	6	2	33	62	66	21	24
Pulse USA	Nette 2010	8	3	32	62	66	21	24
Great Northern Ag	Salamanca	9	4	32	61	66	20	26
Pulse USA	DS-Admiral	5	5	32	62	65	19	24
Great Northern Ag	Spider	10	6	31	62	67	19	26
Great Northern Ag	Bridger	2	7	31	63	65	18	25
Meridian Seeds	Jetset	7	8	30	62	65	20	25
Pulse USA	SW Midas	11	9	28	62	67	19	24
Meridian Seeds	AC Earlystar	1	10	28	62	65	17	24
Av. of all entries				**31**	**62**	**66**	**19**	**25**
Diff. req. at 5% sig. (LSD)				**4**	**ns**	**1**	**1**	**1**
CV				**10**	**2**	**1**	**2**	**3**

West Central 2018 Average: Two sites

2018: Perkins and Custer Co

Brand	Variety	Entry	Yield rank	Yield (bu/a)	Test wt (lbs/bu)	Flowering 50% (DAP)	Plant height (inch)	Seed Protein %
Legume Logic	CDC Dakota*	9	1	47	60	62	19	26
Great Northern Ag	AAC Profit*	12	2	42	59	63	18	25
Meridian Seeds	CDC Spectrum*	5	4	39	59	63	21	25
Meridian Seeds	CDC Saffron	8	5	39	60	63	18	24
Pulse USA	Durwood	23	6	38	61	61	18	24
Great Northern Ag	Spider	16	7	37	61	62	18	25
Meridian Seeds	AAC Carver	4	8	37	61	62	18	23
Meridian Seeds	CDC Inca	6	9	36	61	62	18	24
Meridian Seeds	CDC Amarillo	7	10	33	60	63	18	24
Arrowseed	Montech 4193	21	11	33	60	61	19	22
Great Northern Ag	Salamanca	15	12	33	60	62	19	26
Pulse USA	DS-Admiral	22	13	33	60	61	20	23
Pulse USA	Nette 2010	27	14	33	56	62	20	23
Pulse USA	LG Sunrise	25	15	31	62	61	18	23
Pulse USA	Korando	28	16	30	57	62	20	25
Meridian Seeds	Agassiz	1	17	28	60	62	17	24
Great Northern Ag	Bridger	13	18	28	63	61	20	24
Meridian Seeds	Jetset	2	19	28	59	62	19	24
Arrowseed	Montech 4152	20	20	27	61	61	19	24
Pulse USA	SW Midas	26	21	27	60	62	18	24
NS Seed	DUKAT*	35	22	25	61	61	17	25
Pulse USA	Pro 133-7410*	30	23	25	*59*	62	16	23
Meridian Seeds	AC Earlystar	3	24	24	59	62	19	22
Pulse USA	LG Amigo*	24	25	23	61	61	19	25
Pulse USA	Pro 133-6243*	29	26	23	61	61	21	25
NS Seed	PARTNER*	36	28	18	54	62	17	24
Av. of all entries				**31**	**60**	**62**	**19**	**24**
Diff. req. at 5% sig. (LSD)				**9**	**5**	**1**	**1**	**1**
CV				**16**	**6**	**2**	**2**	**3**

*New in 2018

Evaluating the feasibility of replacing Summer Fallow with Field Pea (*Pisum sativum* L.) in the semi-arid Central Great Plains

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R. Werle – Weed Scientist (UW-Madison)
S. Stepanovic – Cropping Systems Extension Educator

Objective

Water conservation and soil fertility are the two main limiting factors in dryland cropping systems throughout the Central Great Plains. Many cereal grain dryland cropping systems have incorporated summer fallow in wheat-based production systems as a management practice to conserve soil water content and improve precipitation management. Even though summer fallow does conserve soil water content, proper management of summer fallow demands effective management of weeds. Weed management can be a challenge in summer fallow due to herbicide-resistant weed populations increasing which limit cost-effective herbicide options. Yellow field pea (*Pisum sativum* L.) has become a popular pulse crop in the central Great Plains that could replace summer fallow because of its short growing season and a growing market demand. Yellow field pea has the ability to improve soil fertility, increase water productivity, and suppress summer annual weeds while producing a cash crop in place of a summer fallow period.

Methods

Two sites (Sidney & North Platte, NE) were established to determine the effect of yellow field pea versus summer fallow on soil fertility, water conservation, and land productivity in a wheat-corn-fallow rotation. Field pea plots were paired side-by-side with summer fallow for comparison throughout the growing seasons. Field peas were planted March 21 and March 23 at Sidney and North Platte. After field pea was emerged, a baseline soil test was taken on summer fallow and field pea plots. Soil water content was monitored every two weeks in field pea and summer fallow plots after field pea was emerged. Soil fertility was tested again after field pea plots were harvested on July 10 to test for differences in nitrates, phosphorus, potassium, organic matter, pH, and soil microbiome activity between summer fallow and field pea at 0-8 inches and 8-24 inches in the soil profile. Field pea plots were harvested for yield, test weight, and seed moisture.

Results and Conclusions

Volumetric water content (m^3 m^{-3}) did not differ between summer fallow and field pea until yellow field pea began the reproductive cycle of forming seed pods, however, after field pea harvest, soil water content of field pea began to come back into equilibrium with summer fallow water content. Summer fallow contained on average 47% more water over field pea across all observations. At Sidney, nitrate and soluble salt content was different with summer fallow expressing greater levels while microbial activity did not differ. At North Platte, field pea expressed a greater level of microbial activity and nitrogen mineralization over summer fallow. The effect of field pea may depend on environmental conditions as soil trends between Sidney and North Platte differ. Field pea yielded 22 bu. /acre and 30 bu. /acre at Sidney and North Platte respectively. Integration of field pea into crop rotations can be approached with a multi-year vision for improving ecological parameters such as soil water holding capacity, soil microbiome, and soil fertility. The use of field pea can be part of a long-term strategy to enhance ecological sustainability while producing a high-protein cash crop.

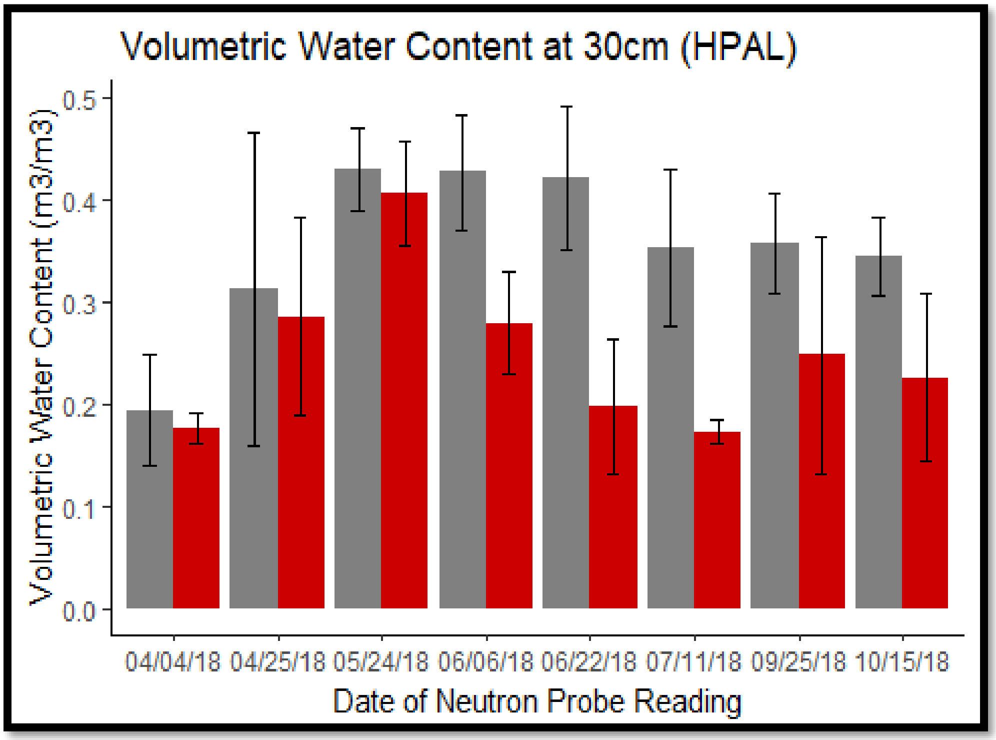


Figure 3. Volumetric Water Content (m^3 m^{-3}) over time from establishment of yellow field pea to recent establishment of hard red winter wheat (HRW) in summer fallow and previous yellow field pea plots.

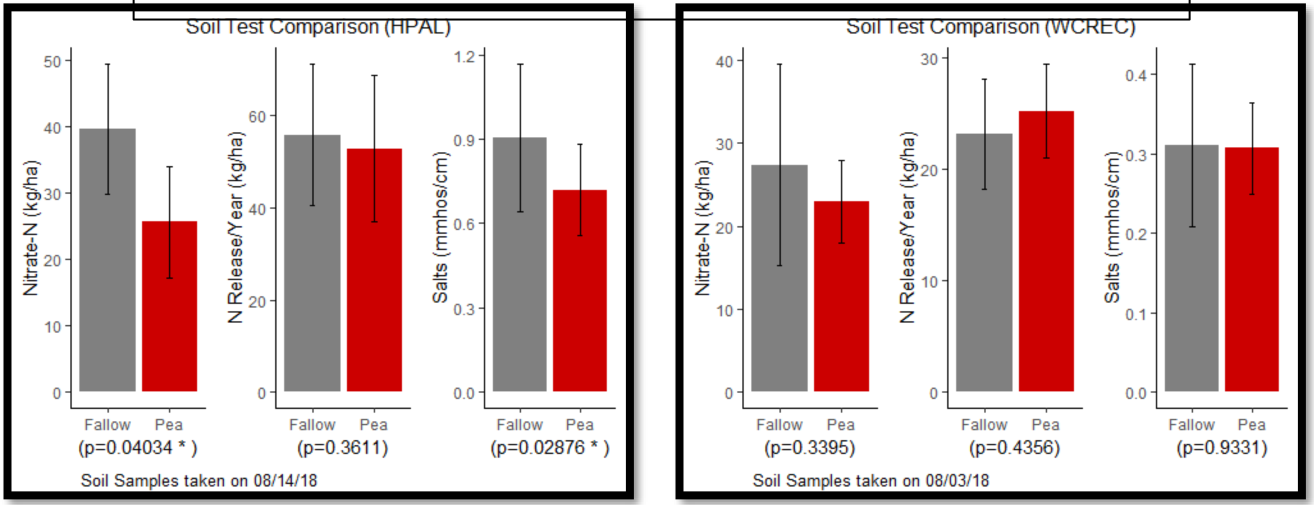


Figure 5 & 6. Nitrate, mineralization of nitrogen from organic carbon sources, and soluble salts in summer fallow and field pea treatments.

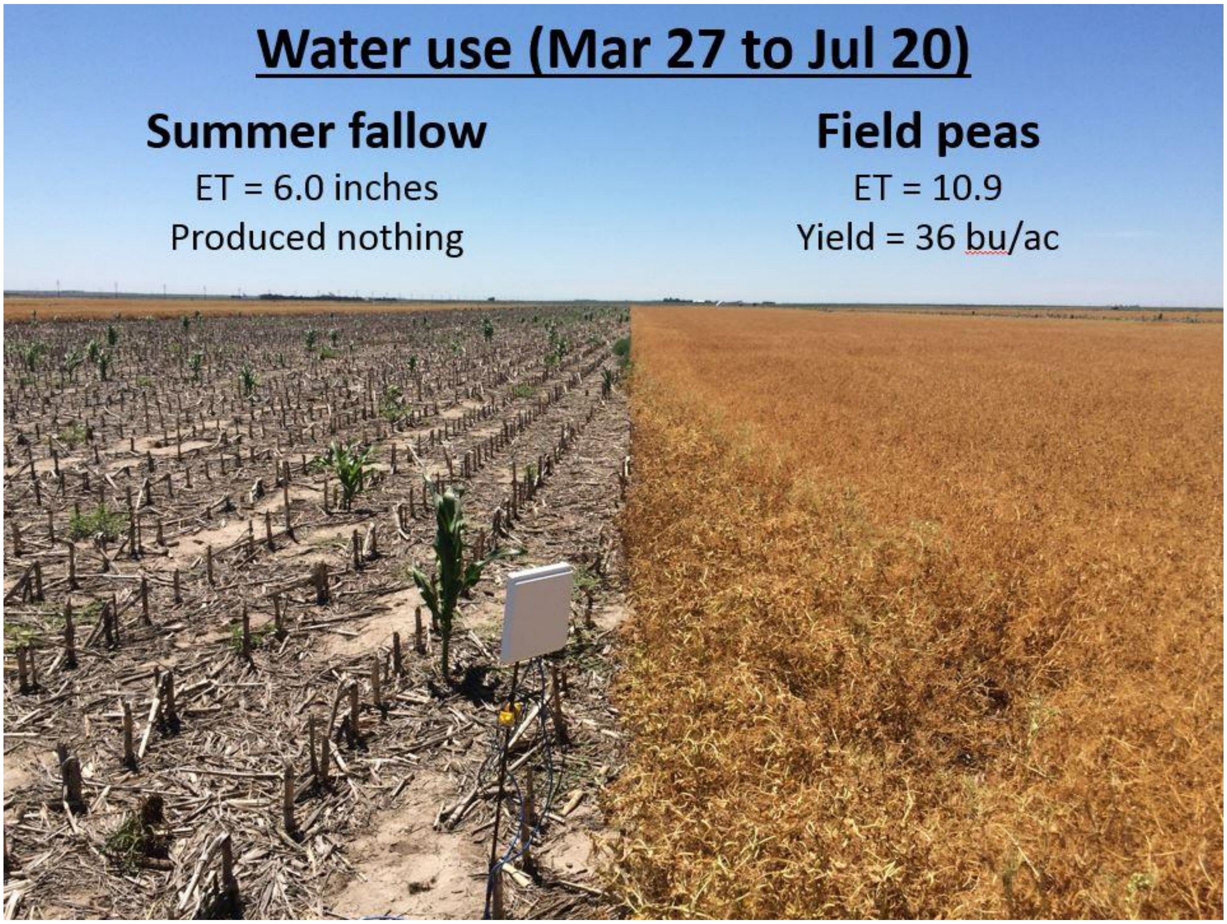
FIELD PEA PRODUCTION
Rotational Costs and Benefits

Strahinja Stepanovic, Rodrigo Werle, Cody Creech, Chuck Burr, Dipak Santra, Julie Peterson, Tony Adesemoye, Daran Rudnick

Overview

Grain-type field peas are a cool season grain crop (mid-March to late-July) typically grown as an alternative for no-till summer fallow in semiarid cereal-based cropping systems, such as wheat-corn-fallow or wheat-fallow. Two-year rotation study was set up on a cooperator's field located in Chase County near Enders, NE to compare the impact of field peas versus no-till summer fallow on the following parameters:

1. Soil: nutrient cycling, microbial activity, and water infiltration
2. Beneficial insects and microorganisms
3. Water use (i.e., evapotranspiration)
4. Yield of succeeding winter wheat crop
5. Profitability



Soil nutrient cycling, microbial activity, and water infiltration

3 key takeaways:

1. **No difference in soil nutrients -** Concentrations of soil nutrients (N, P, and K) did not differ between areas growing field peas and fallow at any time during the 2-year rotation study (Table 1). Rotational benefit from N being fixed from field peas may already be scavenged by wheat or is likely to be seen in next rotational crop (corn/sorghum), which we are currently investigating.
2. **Microbial activity higher with field peas -** Solvita (soil microbial activity expressed as CO_2-C release) test conducted after wheat planting in the fall and in the spring had higher soil-microbial activity and annual nitrogen (N) release in areas of the field where field peas were grown. After wheat harvest, Solvita results did not differ between field peas and fallow treatment (Table 1).
3. **Soil water infiltration higher with field peas -** The initial soil water infiltration was collected after wheat harvest by taking 4 subsamples in 6 replications. Time needed to infiltrate 0.4 inches (10 cm) of water until 50% of soil was exposed was 174 seconds for fallow treatment and 87 seconds for the field pea treatment, suggesting 50% faster soil infiltration rate with field peas in the rotation.

Table 1. Seasonal changes in soil nitrate (NO_3), phosphorous (P), potassium (K), and microbial activity (Solvita test) for the field peas and fallow treatments in 2015 in Chase County.

Date*	Treatment	Depth	NO3-N		P	K	Solvita	
		inches	ppm	lb/ac	ppm	ppm	CO_2-C ppm	lb of N/ac/year
Mar. 27, 2015	Baseline	0-8	8.5	20	23	389		
		0-8	8.1	19	26	365		
Sep. 14, 2015	Field pea	0-4	16.5	20	69	515		
		5-8	11.1	13	33	451		
	Fallow	0-4	19.3	23	61	598		
		5-8	8.8	11	21	488		
Oct. 16, 2015	Field pea	0-12	16.8	60	24	424	52.27	42
		12-24	11.2	40	14	361		
		24-36	12.0	43	13	442		
	Fallow	0-12	26.4	95	90	431	27.72	22
		12-24	9.7	35	9	340		
		24-36	13.0	47	9	519		
Mar. 16, 2016	Field pea	0-12	2.6	9	37	514	71.63	57
		12-24	1.5	5	9	344		
		24-36	2.9	10	2	452		
	Fallow	0-12	2.0	7	41	457	59.74	48
		12-24	2.2	8	4	338		
		24-36	1.8	6	4	506		
Aug. 30, 2016	Field pea	0-4	10.6	13	46	609	11.69	9
		0-12	4.0	14	22	552	8.50	7
		12-24	0.1	0	2	347		
		24-36	0.1	0	2	428		
	Fallow	0-4	7.4	9	70	623	14.00	11
		0-12	4.0	14	37	479	14.00	11
		12-24	1.3	5	11	323		
		24-36	1.1	4	2	449		

*Mar. 27, 2015 (prior to field pea planting), Sep. 14, 2015 (after field pea harvest, before wheat planting), Oct. 15, 2016 (fall after wheat plating), Mar. 16, 2016 (wheat in spring), Aug. 30, 2016 (after wheat harvest).

Beneficial microorganisms and insects

Beneficial microbial analysis showed that more diverse species were recovered in the wheat plants following field peas as compared to following fallow *(Table 2)*. Extraction of mycorrhiza spores showed an average count of 16.5 propagules in pea rhizosphere compared to average count of 8 propagules from the fallow plots. There was no significant difference in terms of foliar disease levels between wheat samples following peas compared to wheat samples following fallow, although non-pathogenic *Fusarium* species were recovered from the root of samples from both treatments.

Planting field peas positively affected the diversity of microorganisms that could be beneficial for the subsequent wheat crop. The beneficial bacteria recovered from the wheat has the potential to stop or reduce the impact of field pea disease/pathogens.

Table 2. Isolates recovered from wheat rhizosphere.

Wheat after fallow	Wheat after field pea
Bacillus megaterium (multiple strains)	Bacillus megaterium Bacillus pumilus Lysinibacillus fusiformis

In 2015, field peas supported greater numbers and diversity of insects than fallow *(Table 3)*. In particular, there were a greater number of beneficial predators (wolf spiders, rove beetles, hoverflies), parasitoid wasps, and decomposers (dung beetles and carrion beetles), but also a greater number of potential pests (click beetles and leafhoppers). In 2016, aphids were lower and some natural enemies (crab spiders and parasitoid wasps) were higher in wheat following field peas *(Table 3)*.

Table 3. Numbers of beneficial insects and potential pests in fallow and field pea treatments (letters signify significantly higher insect numbers at 0.05 significance level)

Insect group	Species	Fallow	Field pea
---------------Pitfall traps 2015 ---------------			
Predators	Wolf Spiders	2.1a	4.8b
	Flat Bark Beetles	1.7a	20.6b
	Rove Beetles	6.3a	17.0b
	Ants	1.1a	4.0b
Parasitoids	Chalcid Wasps	0.7a	1.5b
Decomposers	Dung Beetles	0.1a	2.6b
	Carrion Beetles	1.9a	20.6b
	Minute Brown Scavenger Beetles	53.2b	15.9a
Potential Pests	Click Beetles (adult wireworms)	2.3a	8.6b
	Sap Beetles	10.2a	110.2b
	Leafhoppers	0.4a	10.4b
	Bark Lice	31.7b	1.9a
--------------- Sweep nets 2015 ---------------			
Predators	Crab Spiders	0.0a	1.4b
	Long-jawed Orb Weaver Spiders	0.0a	0.8b
	Hover Flies	0.0a	0.9b
Insect group	**Species**	**Wheat after fallow**	**Wheat after field pea**
--------------- Pitfall traps 2016 ---------------			
Potential Pests	Aphids	31.8b	1.6a
--------------- Sweep nets 2016 ---------------			
Predators	Crab Spiders	2.0a	3.1b
	Parasitoid Wasps	1.3a	2.0b

Water use and crop yield

Water use data indicated that field peas used 10.9 inches of water in 2015 to produce 36 bu/ac yield, which resulted in crop water productivity of 3.3 bushel per acre-inch (Table 4). Fallow used 6.0 inches of water without producing any grain (Table 4). Available soil water at wheat planting (top 4 ft) was 3.2 inches less after field peas as compared to fallow treatment, which resulted in a 18 bu/ac yield peanalty in wheat at the end of the season (Table 4). Seasonal soil water dynamics are summarized in Figure 2. Note that the soil water level for wheat after field peas (green line) was below the 50% field capacity line for most of the growing season which likely led to the lower yield of 18 bu/ac as compared to the wheat after fallow treatment *(Figure 2b)*.

Table 4. Grain yield, seasonal evapotranspiration (ET), and soil water status at the beginning and ending of the growing season for the field pea (3 ft soil profile) and wheat (4 foot soil profile) treatments; yields with difference letters indicated significantly higher wheat yield.

Period	Treatment	beginning soil water	ending soil water	ET	Yield (bu/ac)
3-27-15 to 7-20-15	Field peas	6.0	6.0	10.9	36
	Fallow	6.0	3.0	6.0	0
9-14-15 to 07-15-16	Wheat after field peas	5.8	3.5	TBD	74a
	Wheat after fallow	8.0	4.3	TBD	92b

3-27-2015 field peas planted, 7-20-2015 field peas harvested, 9-14-2015 wheat planted, 7-15-16 wheat harvested

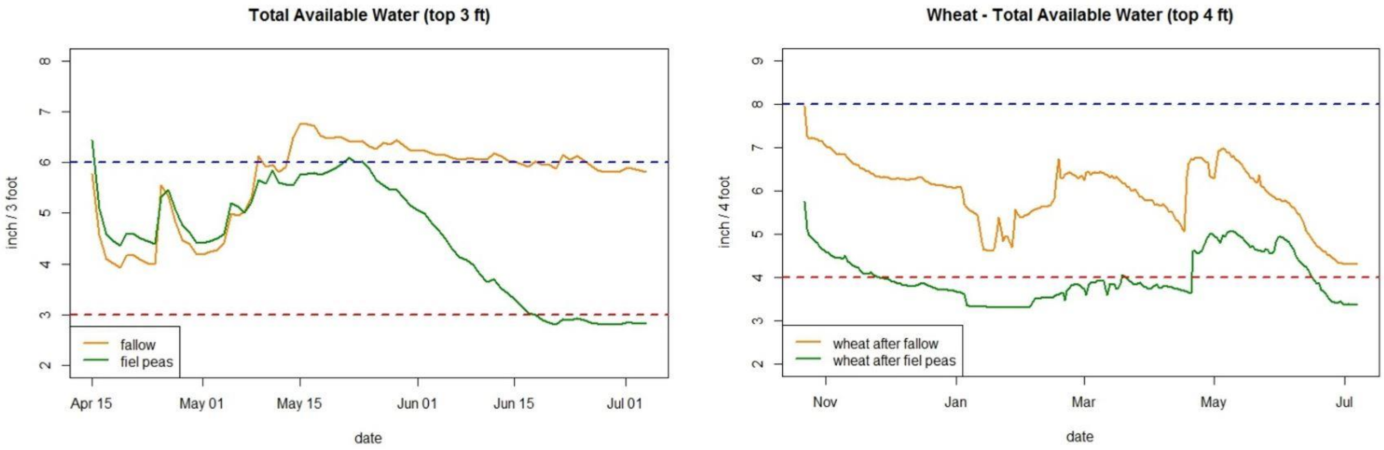


Figure 2a – left and 2b – right. Seasonal dynamics in soil water availability for field peas in the top 3 foot soil profile and wheat in the top 4 foot soil profile. An estimate of field capacity (FC; blue line) and 50% of FC (red line; level of soil water at which most crops exhibit drought stress) are shown for the Blackwood loam soil.

Profitability

Table 5 shows a simplified simulation of the input costs for the field pea-wheat and fallow-wheat rotations. In this example with wheat at $3/bu and field peas at $7/bu, field pea-wheat had a $98/acre profitability advantage over fallow-wheat rotation (Table 6). Assuming no changes in the costs estimated in Table 5 or the price of peas at $7/bu, wheat prices would have to be a little greater than $8/bu to provide a profitability advantage of fallow over field pea (Table 6).

Table 5. Input costs ($/ac) for field pea-wheat and fallow-wheat rotation

Input	Product	Rate	Field pea ($/ac)	Fallow ($/ac)
Insurance	crop insurance	$69.41/ac	7.22	
Planting	-	-	11.23	
Spraying	-	-	4.23	
Seed	Salmanca	3.3 bu/ac	45	
Inoculant	Cell-tech dry and liquid	labeled	12	
Herbicide	Sharpen	1.5 oz/ac	28.2	
	Pendimethalin	1.5 oz/ac		
	RT3 (Round-up)	22 oz/ac		
Harvest	-	-	24.1	
Spraying	-	-	4.23	
Herbicide	Honcho (Round-up)	labeled	14.92	
	Latigo (generic 2,4-D)	labeled		
Spraying	-	-		4.23
Herbicide	Honcho (Round-up)	labeled		14.92
	Latigo (generic 2,4-D)	labeled		
Spraying	-	-		4.23
Herbicide	Honcho (Round-up)	labeled		14.92
	Latigo (generic 2,4-D)	labeled		
Spraying	-	-		4.23
Herbicide	Honcho (Round-up)	labeled		14.92
	Latigo (generic 2,4-D)	labeled		
Insurance	after fallow	$138.31/ac		7.45
	after field pea	$89.71/ac	10.54	
Fertilizer	dry mix + application		30.5	30.5
Planting	-	-	11.23	11.23
Starter Fertilizer	fertilizer 10-34-0 + mix	3 gal/ac	23	23
Seed	Winterhawk cert/treat	65 bu/ac	15.2	15.2
Fertilizer	10-20-0-0.5	10 gal/ac	35.91	35.91
Herbicide	Affinity + Barrage	36.4 + 3.55 oz/ac	-	-
Harvest	-	-	24.1	24.1
Total costs			301.61	204.84

Table 6. Field pea-wheat profitability advantage over fallow-wheat rotation (shaded) for a given range of wheat and field pea market prices.

		Field pea ($/bu)						
		4	5	6	7	8	9	10
Wheat ($/bu)	3	-10	26	62	98	134	170	206
	4	-29	7	43	79	115	151	187
	5	-48	-12	24	60	96	132	168
	6	-67	-31	5	41	77	113	149
	7	-86	-50	-14	22	58	94	130
	8	-105	-69	-33	3	39	75	111
	9	-124	-88	-52	-16	20	56	92
	10	-143	-107	-71	-35	1	37	73

Conclusions

Field peas have potential to be used as an alternative to no-till summer fallow in wheat-fallow and wheat-corn-fallow rotations to increase sustainability of crop production systems in western Nebraska. Preliminary results of our rotation study show that replacing fallow with field peas can increase soil microbial activity and soil water infiltration, provide habitat for greater number of beneficial microorganisms and insects, more efficient cropping system water use, and be more profitable than no-till summer fallow.

Weather conditions throughout the first year of the experiment favored growth and production of field peas. Therefore, more research is needed to evaluate rotational effects of field peas during dry years.

Evaluating the effects of planting timing and seeding density on Yellow Field Pea (*Pisum sativum* L.) grain yield and physiological characteristics in western Nebraska dryland cropping systems

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Objective

Yellow field pea (*Pisum sativum* L.) is a cool-season legume crop that is a prominent member of the pulse crop market. Yellow field pea adoption and acreage has been growing throughout the semi-arid Central Great Plains due to the short growing season of pea, low input requirement, and a developing demand for alternative plant-based protein sources globally. While yellow field pea can be part of an ecologically based cropping system, current recommendations for establishing yellow field pea in the Central Great Plains are based on previous research from the Northern Great Plains and Pacific Northwest (Montana, North Dakota, Canada, and Washington). While these recommendations have worked in the past, pulse crop producers need precise planting recommendations that have been adapted to the dryer, warmer climate of the Central Great Plains. This study aims to quantify the effects that different planting timing and seeding rates have on yellow field pea yield and plant physiology in dryland cropping systems across western Nebraska.

Methods

Four sites across western Nebraska (Hemingford, Sidney, Grant, & North Platte) were established to evaluate planting timing and seeding rate of yellow field pea. The study was designed as a split-plot with the whole plot factor serving as the planting timing and the split plot factor serving as the seeding rate within each planting time. Three planting timing treatments (early, normal, late) and five seeding rate treatments (321,100 to 1,210,300 PLS/hectare) comprised the study with six replications at each site. At the time the first emerged plant in each plot was observed, emergence was recorded every three days until emergence reached a plateau within each plot. At harvest, five randomly selected plants were sampled in each plot for low pod height, high pod height, and plant height, and then stored for yield component analysis. Each plot was harvested for grain yield, test weight, and grain moisture. Yield components were calculated by counting pods on each plant and threshing samples to calculate seed weight per plant and seeds/pod in addition to other response variables such as whole plant biomass.

Results and Conclusions

Data analysis was conducted on results from Sidney and Hemingford locations due to weather and disease damage affecting the Grant and North Platte sites. Emergence was not affected by planting timing or seeding rate at Sidney, however “Late” planting timing increased retention of live plants at Hemingford, NE. Emergence was observed to be delayed over time in the “Early” planting timing across locations while emergence was noticeably more vigorous within “Late” planting timings. Grain yield was different between planting timings and seeding rates at Sidney and Hemingford sites. Higher planting populations tended to increase yield while delayed planting timing tended to increase yield. Yellow field pea physiological response to planting timing and seeding rate was quantified through yield component analysis of randomly sampled plants. When whole plant biomass or pods/plant were correlated with grain yield, “Late” planting timing displayed the strongest negative correlation while “Late” planting timing displayed the strongest positive correlation of whole plant biomass against pods/plant. In general, during 2018, higher seeding rates increased pea yield 58% across sites while later planting timing tended to increase pea yield 13% across sites.

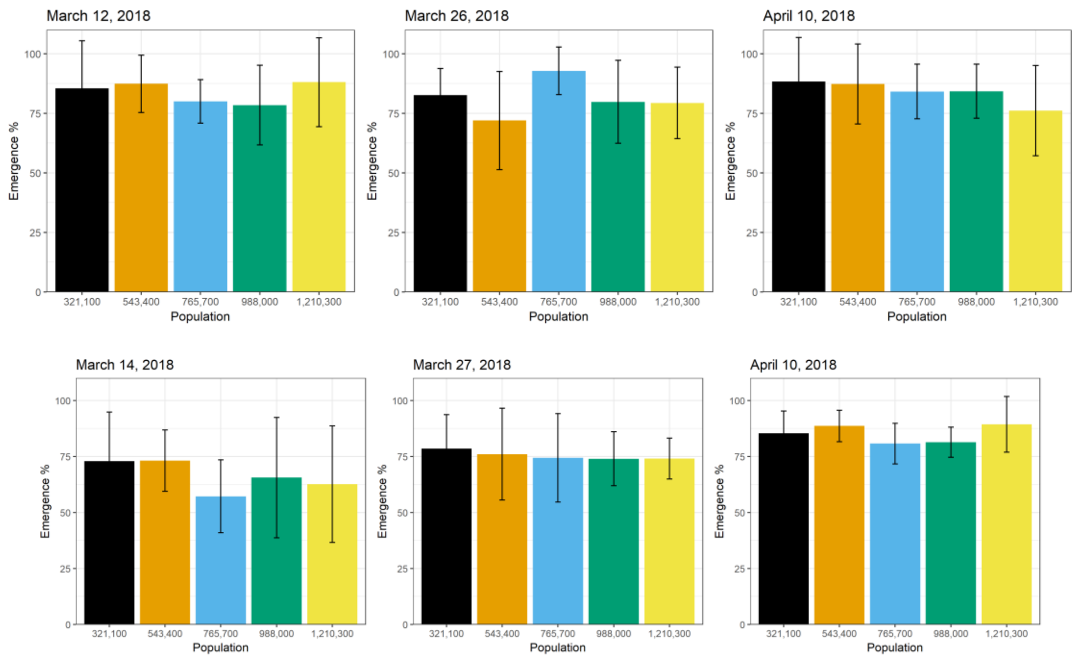

Figure 1 & 2. Emergence percentage at Sidney and Hemingford, NE separated by planting timing treatments and seeding rates in pure live seed (PLS) per hectare.

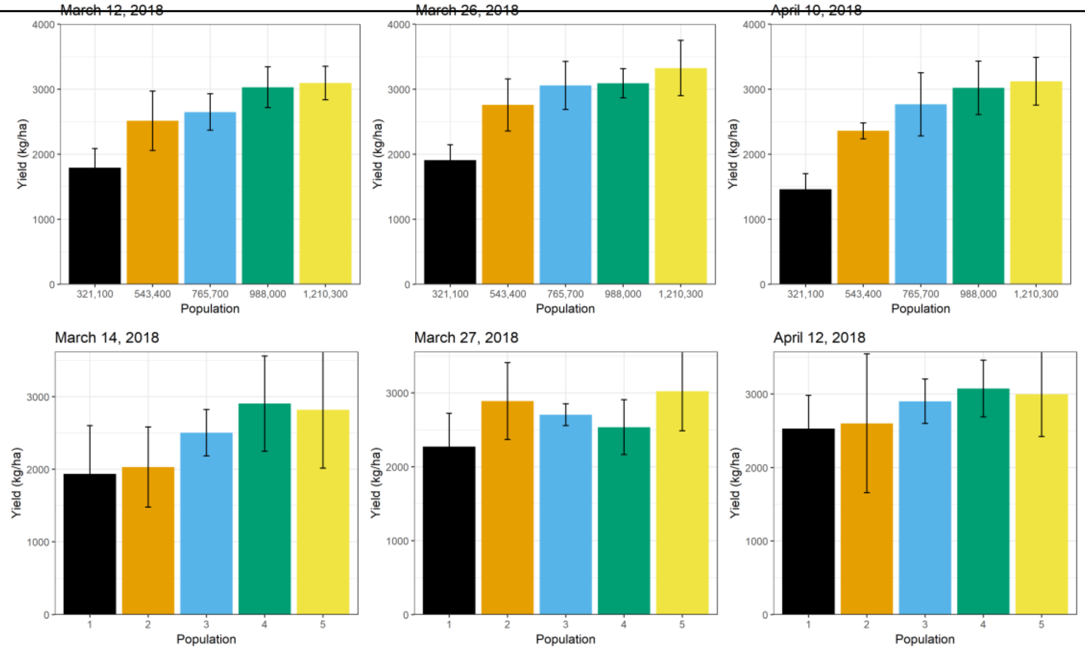

Figure 3 & 4. Grain yield at Sidney and Hemingford, NE in kilograms per hectare within each planting timing treatment.

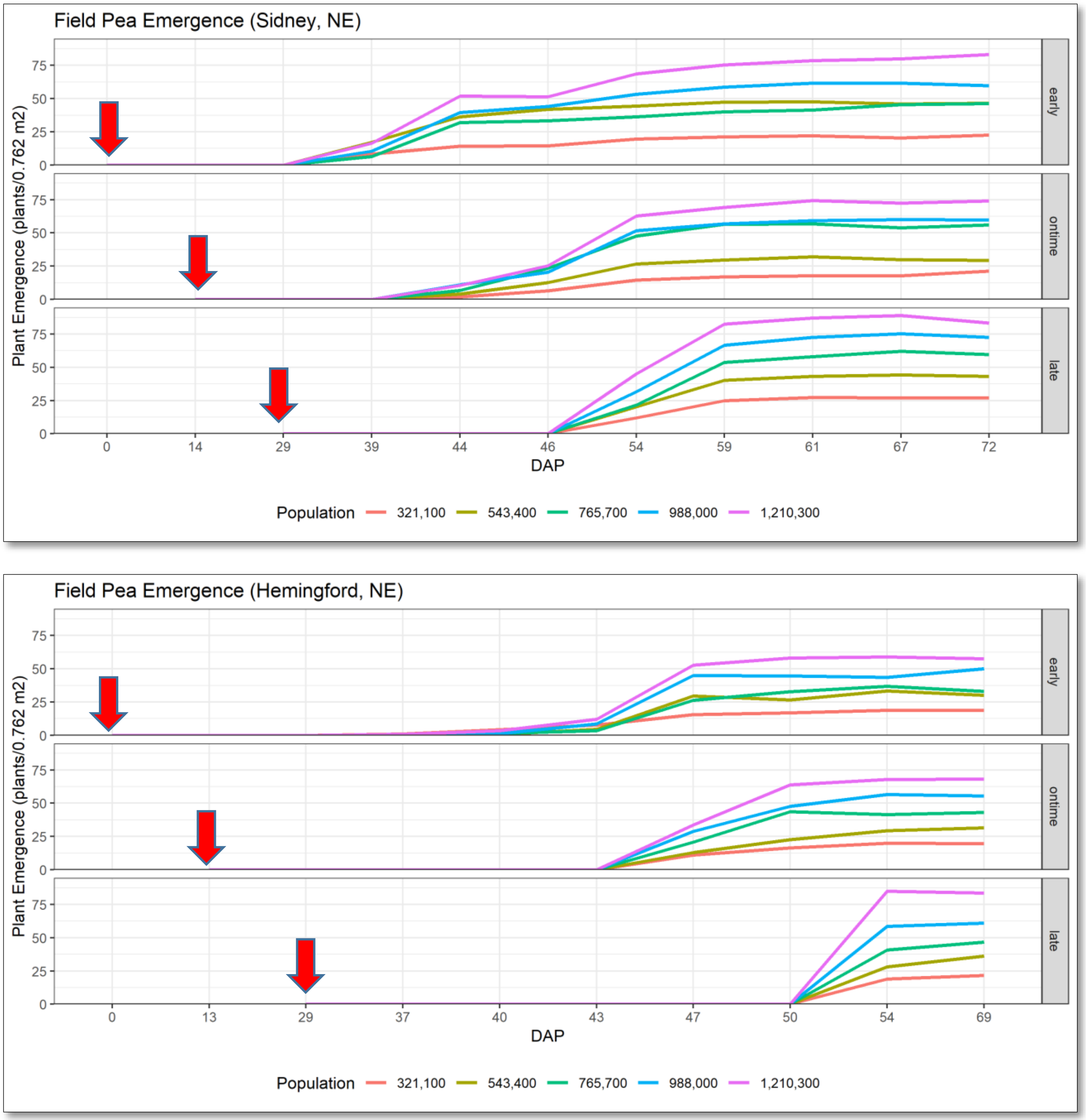

Figure 5 & 6. Emergence over time after day of planting within each planting timing treatment

FIELD PEA PRODUCTION
Seeding rates, seeding depth, and inoculant

Strahinja Stepanovic, Rodrigo Werle, Cody Creech, Chuck Burr, Julie Peterson, Daran Rudnick

Figure 2. Field peas in southwest Nebraska (Photos by Strahinja Stepanovic)

Overview

Grain-type field peas are a cool season grain crop (mid-March to late-July) typically grown as an alternative for no-till summer fallow in a semiarid cereal-based no-till cropping systems such as wheat-corn-fallow and/or wheat-fallow. Currently, no information is available on how field pea responds to seeding practices in semiarid Nebraska as compared to other major field pea growing regions (Table 1.). The objective of this study was to determine economically optimal seeding rate, seeding depth and inoculant to grow field peas in western Nebraska.

Table 1. Recommended field pea seeding practices for various regions (inoculant recommended for all regions)

Region	Seeding depth (inch)	Seeding date	Seeding rate (lbs/ac)*	Source
Manitoba, CA	1 - 2	Before May 21	150-171	Manitoba Agriculture (2016)
Alberta, CA	1 - 2	Before May 15	161-193	Alberta Pulse Growers (2016)
Saskatchewan, CA	1– 3	Mid-April to Mid-May	161-184	Saskatchewan Pulse Growers (2016)
North Dakota, USA	1 - 3	early-April to mid-May	161-184	Schatz and Enders (2009)
Montana, USA	1 - 3	late-March to early-May	184-229	McVay et al. (2016)
South Dakota, USA	1.5 - 3	mid-April	184	Beck et al. (2015)
Washington/Idaho, USA	1.5 - 3	March 25- May 10	191-231	Muehlbauer et al. (1997)
Wisconsin/Minnesota, USA	1 - 3	mid-March to mid-April	204	Oelke et al. (1991)

*Seeding rates target final plant population ranging from 300,000 to 500,000 plants/ac

Seeding rate study

According to the results of our three site-year study on seeding rates in Perkins County, NE field pea response to plant population was close to linear at lower densities (up to 200,000 plants/ac), then begins to plateau at about 200,000 plants/ac reaching its maximum at approximately 310,000 plants/ac (Figure 1.). Due to low germination rate (58%), yield response at higher populations was not obtained in 2015. Yield in 2015 was higher (max yield 33 bu/ac) than in 2016 (max yield 25-26 bu/ac) regardless of population density. Although yield response at populations higher than 310,000 plants/ac was seldom observed, there is an indication that for yield goals higher than 30 bu/ac increasing seeding rate may be justified.

The economically optimal plant population (EOPP) can be defined as population that maximizes profit made on investment, which in this case is seed. Our resutls suggest that maximum profit is obtained at 220,000 plants/acre, which coresponds to seeding rate of 116 lb of seed/acre (Figure 2). A penalty of about $0.19/acre per acre may occur for each additional pound of seed planted over this EOPP. Planting higher populations to maximize yield potential is not always the best economic strategy due to the asymptotic nature of yield response to planting density.

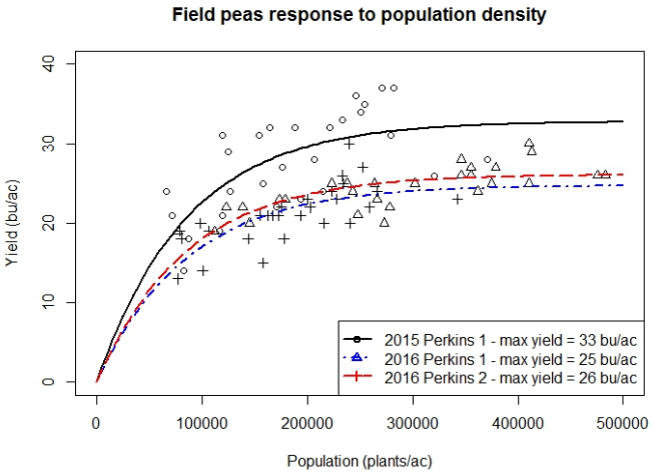

Figure 2. Field pea grain yield (bu/ac) response to population density

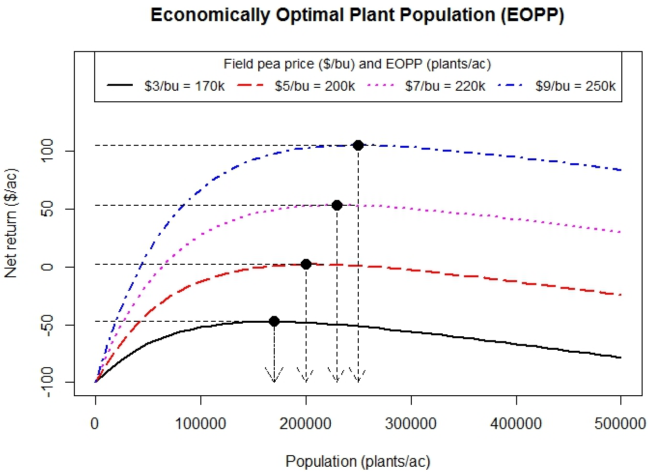

Figure 3. Changes in Economically Optimal Plant Population (EOPP) with increase in field pea price on the market.

<u>**Recommendation**</u>: Although this study shows the potential for reduction in field pea population without lowering profits, these results are yet to be confirmed in additional production years and/or locations and should be considered cautiously until further research is completed and results validated. Current recommendations for field peas seeding rates ranges from 180 to 200 lb/ac. UNL has been awarded a Research and Extension SARE grant for additional field pea research (2017-2020).

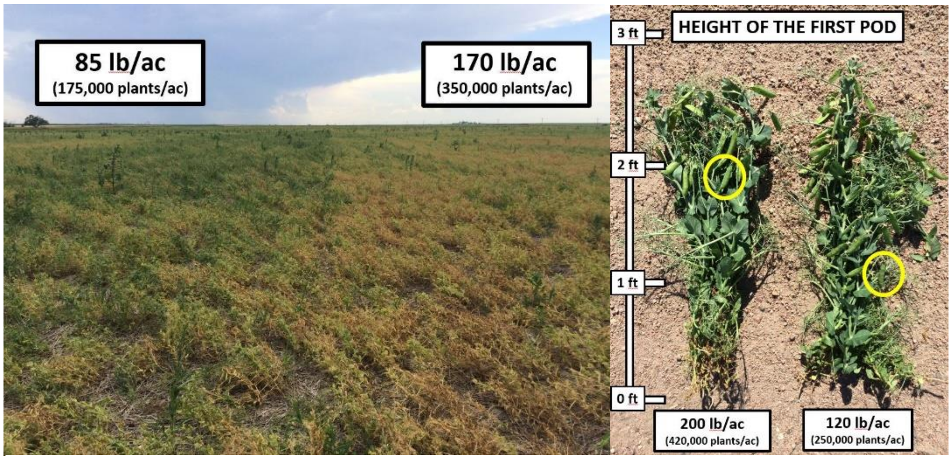

Figure 4. Field peas planted at lower population densities matured later and produced more pods per plant, and set first harvestable pot at lower plant heights then higher populations.

Seeding depth and rhizobia inoculant study

Figure 6. When planting field peas at greater depth, ensuring good seed-to-soil contact is a priority.

Seeding depth study. Feld pea is a large seeded crop that generally requires deeper seeding than smaller seeded cereals for proper soil-seed contact (Table 1). Large seeds can emerge from greater depths because they have larger amounts or stored energy. However, to ensure proper germination and emergence seeds should be placed in soil with adequate moisture. Dry top soil moisture at planting is the main reason why slightly deeper seeding is recommended for dryer and warmer climate of Pacific North West (1.5 inches) compared to Canada and Norther Great Plains (1 inch; Table 1). Although field pea can tolerate deeper seeding, research from Canada showed that seeding >2.5 inches deep can cause significant reduction in stand and up to 8.5% yield loss compared to shallower seeding (1-2.5 inches).

Rhizobia inoculant study. The need to re-introduce the Rhizobia with each field pea crop depends on the ability of the bacteria to survive in the soil over a given time period. Research conducted in Mediterranean soils showed that population size of field pea rhizobia is likely to be under the optimal nodulation thresholds (<100/g of soil) if soil pH <6.6, when summers are hot and dry, and a plant host has been absent for > 5 years. On the American continent, there are few documented studies that can provide economic justification for re-introduction of field pea rhizobia at each planting, especially at sites that have recent history of field pea production. Research needs to be done to verify these claims. Preliminary seeding depth and rhizobia inoculant studies were conducted in 2015 (at site 1). In 2016, we tested the potential for carryover of rhizobia inoculant in soil by selecting site 2 that had history of field pea crop grown two years ago (2014), and site 3 that had field pea crop grown 3 years ago (2013).

Table 2. Field pea grain yield from seeding depth and inoculant study

Study	Year	Location	Treatment	Yield (bu/ac)
Seeding depth (inches)	2015	central	1.5	29
			2.5	26
	2016	east	1	10
			2	13
			3	12
	2016	west	1	22
			2	23
			3	25
Rhizobia Inoculant	2015	central	none	25
			liquid	28
			granular	27
	2016	west	none	10
			liquid	13
	2016	east	none	20
			liquid	23

Recommendation: We observed no significant difference in yield between 3 seeding depths. We recommend planting in moisture zone, 1 to 3 inches deep, and ensuring good seed-to-soil contact. Although yield differences between inoculated and non-inoculated field pea were not observed, non-inoculated field peas did not produce nodules and will have to rely solely on residual soil nitrogen rather than biological fixation. Therefore, we recommend using inoculant at planting until more research is done to evaluate field pea nitrogen demand.

Figure 7. Proper inoculation is key to good nodulation and achieving higher field pea yields.

Field pea and chickpea germination and yield as affected by tillage

Strahinja Stepanovic, Nemanja Arsenijevic, Zaim Ugljic

Field peas and chickpeas are pulse crops often grown as a fallow replacement in western NE dryland cropping systems (wheat-fallow or wheat-corn-fallow). Although the most dominant cropping system is no-till, several farmers observed that tillage prior to planting produced better field pea yields. Possible reasons for increased yields using tillage is often attributed to earlier and more uniform emergence and canopy development, better weed suppression, extended flowering (reproductive) periods, and uniform maturity and dry-down at harvest.

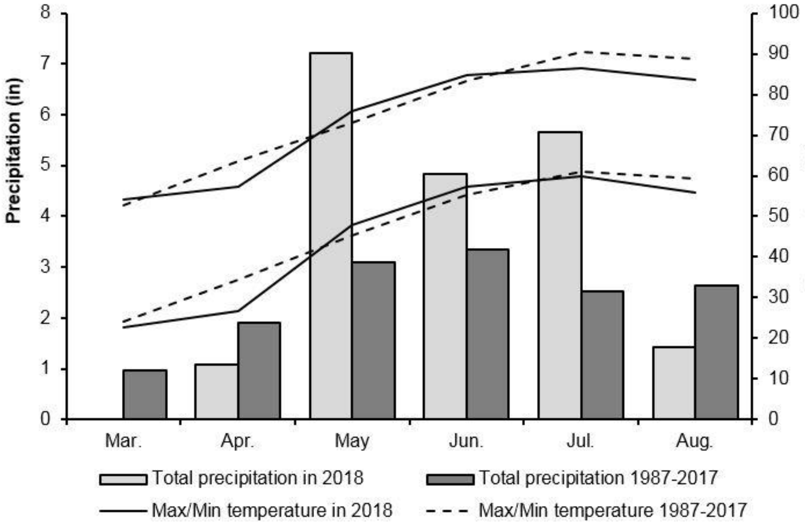

Figure 1. Total precipitation and temperature during the growing season of pulses at Grant, NE

The objective of this field study was to evaluate effects of tillage on germination patterns and grain yield of three pulse crop/varieties including Frontier (chickpea), Orion (chickpea) and Durwood (yellow field pea). The secondary objective was to develop a predictive emergence models based on the accumulation of heat units or growing degree days (GDD) above a minimum base threshold value, so that emergence can be predicted in other areas of NE where field peas and chickpeas are grown.

Trial summary

The study was conducted at Henry J. Stumpf International Wheat Research Center at Grant, NE. The predominant soil type in the study area was Kuma silt loam and previous crop in rotation was corn. The tillage blocks were disked on Mar 14 using a heavy disk, while the whole study area was sprayed with Spartan Elite on Mar 11. Prior to planting, chickpea seed was treated with seed fungicide (Obvious®) and both field pea and chickpea seed was inoculated with full rates of liquid and peat inoculants (Cell-Ttech®). The field pea variety Durwood was planted on Mar 14 at 350,000 live seeds/ac using a 20 ft Crustbuster no-till box drill with 7.5 inch row spacing. The chickpea varieties Frontier and Orion were planted on Mar 23 at 220,000 live seeds/ac in 15 inch rows using making two passes with 8 row John Deere® planter. Durwood field pea was harvested on July 20, while Chickpeas were desiccated using generic paraquat product on Aug 10 and harvested on Aug 17.

Germination

Overall germination of both field peas and chickpeas was slow in 2018, which can be attributed to early planting (mid-late March) in combination with one of the coolest and wettest spring on record (Figure 1). The research area received precipitation from two snow storms in April and planted crops did not start germinating until late-April/early May (36-46 days after planting; Figure 2, Table 1).

‘Tillage had a positive impact on germination. The germination started, progressed and finished earlier in tillage treatments, regardless of the pulse crop variety (Table 1; Figure 2). For example, 10, 50 and 90% germination for Durwood yellow field pea happened 46, 49, and 54 days after planting, respectively; this was 4, 2 and 3 days earlier than 10, 50, and 90% germination in no-till bocks, respectively (Table 1). Two chickpea varieties showed similar trends in germination. Frontier and Orion chickpea finished germinating (90% germination) 6 and 3 days later in no-till treatments (Table 1). Frontier under no-till was the last one to germinate on May 10 (Table 1).

Earlier germination in tillage treatments can be attributed to warmer soil conditions as suggested by differences in GDD accumulation (Table 1). The GDD base temperatures varied between pulse crop varieties and were 41, 43, and 32 F for Orion (chickpea), Frontier (chickpea) and Durwood (yellow field pea), respectively. These predictive models suggest that field peas and chickpeas started to germinate at lower soil temperatures than previously thought (field peas at 40 F, chickpeas at 45 F).

Grain yield

Tillage increased the crop yield in pulse crop varieties during the 2018 growing season at Grant, NE. Although yields were not significantly different between tillage treatments, Frontier and Orion chickpea yielded 32 and 40 bu/ac in tillage vs 23 and 33 bu/ac in no-till treatment, respectively (Figure 3). Durwood yellow field peas yielded 40 bu/ac under tillage which was 12 bu/ac yield increase over no-till treatment that yielded 28 bu/ac (Figure 3).

Recommendations

Spring tillage prior to planting caused to faster germination and better yield of field peas and chickpeas as compared to no-till in field experiment conducted at Grant, NE during the above-average wet and cool 2018 growing conditions. We would caution farmers to carefully examine this practice on their fields, especially when pulse crops are grown on lighter soils and in dryer conditions.

We were able to gather some baseline information on GDD models to predict emergence of pulse crops in terms of base temperatures and GDD accumulation in different tillage treatments. These predictive models need to be validated in over years and locations.

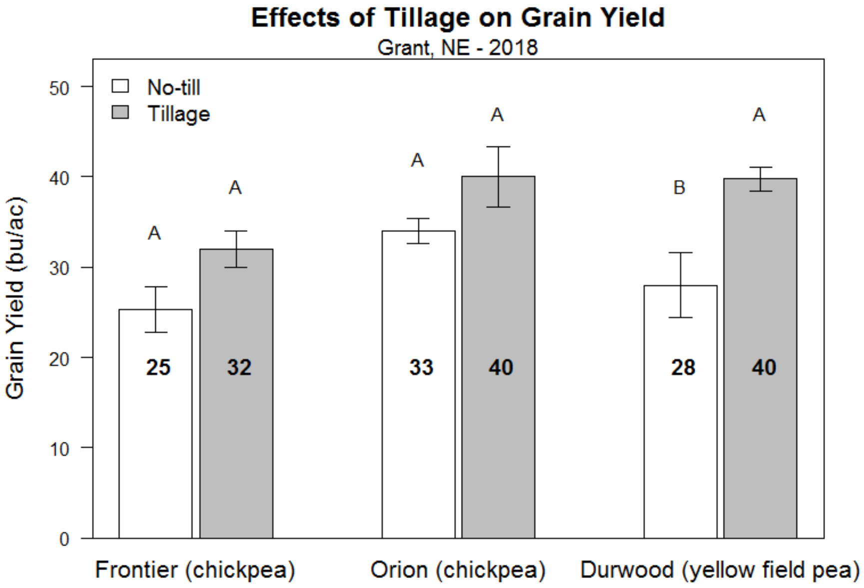

Figure 2. Effects of tillage treatment on grain yield of Frontier (chickpea), Orion (chickpea) and Durwood (yellow field pea) in field experiments conducted at Grant, NE during 2018 growing season. Different letters refer to statistically significant differences between the treatments.

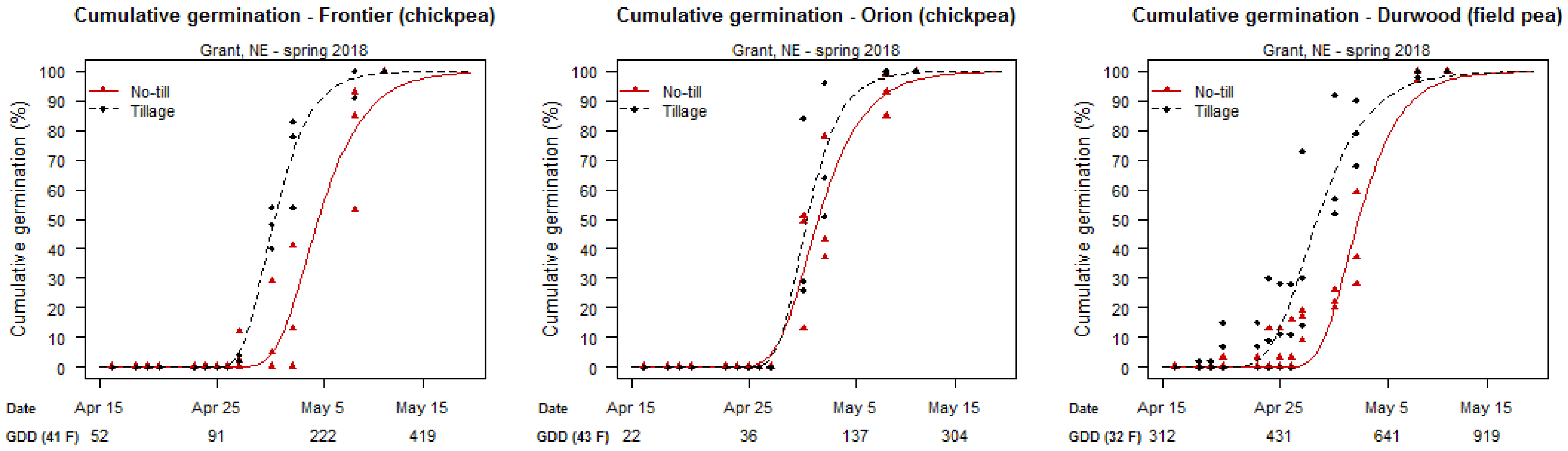

Figure 3. Cumulative germination (%) of Frontier (chickpea), Orion (chickpea) and Durwood (yellow field pea) as influenced by tillage treatment. The regression lines are plotted against day of year (i.e. Julian day). The GDD accumulation (base temperature F) is provided for designated dates on the second x-axis.

Table 1. Regression parameters (Equation 1) for the effects of tillage treatments on pulse crop germination and day of year (DOY), days after planting (DAP), date, and GDD accumulation at 10, 50 and 90% germination.

Pulse Crop/Variety	GDD base (F)*	Tillage	10 % germination			50 % germination			90 % germination		
			DOY (DAP)	Date	GDD	DOY (DAP)	Date	GDD	DOY (DAP)	Date	GDD
Frontier (chickpea)	41 F	tillage	121 (39)	1-May	267	124 (42)	4-May	315	130 (48)	10-May	456
		no-till	118 (36)	28-Apr	211	120 (38)	30-Apr	249	124 (42)	4-May	315
Orion (chickpea)	43 F	tillage	118 (36)	28-Apr	146	121 (39)	1-May	196	127 (45)	7-May	295
		no-till	118 (36)	28-Apr	146	120 (38)	30-Apr	180	124 (42)	4-May	238
Durwood (field pea)	32 F	tillage	119 (46)	29-Apr	506	122 (49)	2-May	576	127 (54)	7-May	695
		no-till	115 (42)	25-Apr	413	120 (47)	30-Apr	531	124 (51)	4-May	617

*Growing degree day (GDD) base temperatures for germination were estimated across tillage treatments for each pulse crop/variety.

Water Balance of Field peas, Chickpeas, Soybeans vs Fallow

Strahinja Stepanovic

Over the past 30 years, most of the dryland farmers have adopted no-till fallow and no residue removal as important water conservation practices under wheat-corn-fallow or wheat-fallow rotations. Sustainability of these practices, however, is becoming a major challenge as weeds evolving resistance to herbicides and forcing farmers to use summer tillage for weed control. Blanco-Canqui et al. (2010) reported that reduction in frequency of crops in semiarid environments (along with summer tillage) can lead to additional soil water losses, soil degradation, and reduction soil organic carbon (SOC).

Much attention has been given to cover crops and their potential to conserve soil moisture and improve soil health, but growing cover crops in semiarid environments will reduce amount of soil water available to subsequent cash crop and cause reduction in yield and profit (Nelson et al., 2015). Another option is to grow alternative crops such as pulses that can be harvested for grain and generate economic return.

Alternative crops can, if managed benefits of water conservation and soil health while assuring economic viability of the producer. This project properly, can diversify and intensify fallow based western NE cropping systems providing aims to compare fallow to field peas, chickpeas and soybeans in terms of water balance, impact on next year's wheat crop and profitability.

Trial summary

The demonstration plot was conducted at Henry J. Stumpf International Wheat Research Center at Grant, NE. The predominant soil type in the study area was Kuma silt loam and previous crop in rotation was corn. Demonstration plot will included side-by-side comparison of field peas, chickpeas, soybeans and fallow that were planted in 40 ft wide x 400 ft long strips. Seeding dates for field peas, chickpeas and soybeans were Mar 14, Mar 24 and May 17, respectively. Harvest was done on Jul 16, Aug 17, and Oct 23 for field peas, chickpeas and soybeans, respectively. Other cultural and agronomic practices were done following university-based recommendations. Winter wheat crop was planted on Oct 23 across all four strips following the soybean.

Results

Soil water balance (ΔSW). Water losses in fallow due to runoff (0.6 inches), deep percolation (11.5 inches), and evaporation (8.0 inches) were much greater than in any of the other fallow replacements, resulting in total of 20.1 inches of total water loss. However, fallow was also the only rotation that increased soil profile (5 ft) water storage by 1.9 inches over the course of the season.

Deep percolation (DP). Large deep percolation (DP) losses were observed across cropping systems due to heavy spring precipitation that was 6.5 inches higher then 30-year average (Table 1). Among cropping systems, largest (DP) was observed in fallow (11 inches) followed by chickpeas, soybeans and field peas which had 6.7, 6.0, and 5.0 inches of DP, respectively. Growing field peas lead to better utilization of spring precipitation and consequently reducing the water losses due to DP.

Soil evaporative losses (ET). Fallow periods were quite different between the cropping systems causing large differences in evaporative losses. While field peas were able to efficiently utilize early season precipitation, lack of plant cover during the hot and dry post-harvest period (Jul 16 to Oct 23; 7.1 inches) lead to 5.7 inches of evaporative losses. One month shorter post-harvest periods of chickpeas (Aug 17 to Oct 23) cut evaporative losses in chickpea-wheat cropping system to 1.4 inches. Finally, cooler pre-season fallow period of soybeans and no post-season fallow period at all resulted in no soil evaporative losses in soybeans.

Runoff (RO). All cropping systems had very little RO, due to good ground cover and relatively flat topography.

Crop Water Use Efficiency (CWUE). Among the fallow replacements, field peas was the most water use efficient crop with producing 30 bu/ac yield with 11.9 inches of water (2.5 bu/ac-inch) followed by chickpeas at CWUE of 1.9 bu/ac-inch. Soybeans was the least CWUE crop producing only 18 bu using 18.6 inches of water (CWUE of 1.0 bu/ac-inch).

Table 2. Yield (bu/ac), Crop Water Use Efficiency (CWUE), precipitation (P), runoff (RO), deep percolation (DP), evapotranspiration/soil evaporation (ET), and soil water change (ΔSW) from Mar 14 to Oct 23 for field peas, chickpeas, soybeans and fallow cropping systems from Mar 14 to Oct 23.

Cropping system	Periods of crop growth/fallow	Date	P (in)	RO (in)	DP (in)	ET (in)	ΔSW (in)	Yield (bu/ac)	CWUE (bu/ac-inch)
Field peas - Wheat	Crop growth	03/14 to 7/16	15.7	0.0	3.3	11.9	-1.4	30.0	2.5
	Fallow	7/16 to 10/23	7.1	0.2	1.7	5.7			
	Total	3/24 to 10/23	22.7	0.2	5.0	17.5			
Chickpeas - Wheat	Crop growth	03/24 to 8/17	19.8	0.0	4.9	15.5	-1.6	30.0	1.9
	Fallow	8/17 to 10/23	2.9	0.0	1.8	1.4			
	Total	3/24 to 10/23	22.7	0.0	6.7	16.9			
Soybeans - Wheat	Crop growth	5/18 to 10/23	18.3	0.0	4.7	18.6	-0.4	18.0	1.0
	Fallow	3/14 to 5/18	4.4	0.0	1.3	0.0			
	Total	3/24 to 10/23	22.7	0.0	6.0	18.6			
Fallow - Wheat	Total	3/24 to 10/23	22.7	0.6	11.5	8.0	+1.9		

Patterns in soil water extractions.

Figure 1 also demonstrates the differences in soil water extraction patterns. Although field peas and chickpeas had same total soil water at wheat planting (13.1 inches), it is clear that field peas utilize water from soil depths > 3 ft, allowing precipitation storage in top 3 ft. Conversely, chickpeas and soybeans utilized most of the available water in top 3 ft of soil profile finishing off the crop during the summer months, thereby not reaching for water at depths greater then > 3ft.

Predicting next year's wheat crop

Research suggest that for 1 inch less in soil water profile yield penalties of between 4-6 bu/ac may occur in the following wheat crop (Nielsen et al., 2016; Stone and Schlegel, 2006). Compared to fallow, field peas, chickpeas and soybeans had 1.9, 1.9, and 2.3 inches less water in the soil profile at wheat planting, respectively (Figure 1). Therefore, if such water deficit is not narrowed or eliminated during the winter, yield penalties between 8-12 bu/ac can be expected in next year's wheat crop.

Conclusions

Final evaluations on water balance and profitability of the system will be done after winter wheat crop is harvested in July 2019.

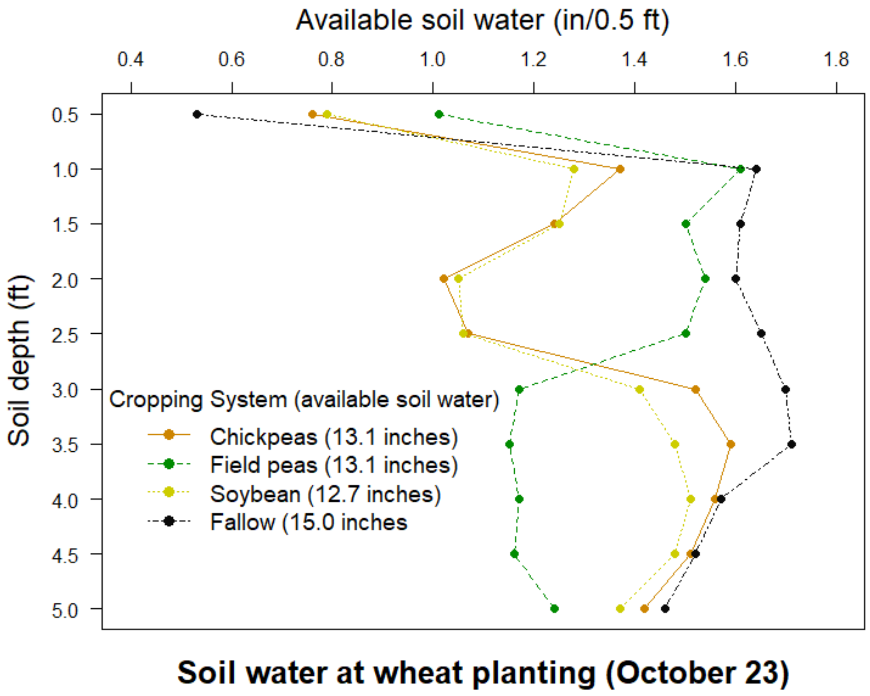

Figure 3. Plant Available Soil water (in/ 0.5 ft) and water extraction patterns for selected rotational crops.

Yield and Water Use of Field peas and Chickpeas Under Irrigation

Strahinja Stepanovic

Irrigation has been a crucial factor in maintaining high agricultural productivity in the semiarid climate of SW Nebraska (Payero et al., 2006). However, groundwater withdrawals have exceeded recharge since the 1950s, gradually depleting Nebraska's largest and most valuable water source, the Ogallala aquifer (McGuire et al. 2003). In addition to declining groundwater levels, drought, reduced stream flow, water allocations, light textured soils, and insufficient irrigation system design capacities often prevent SW Nebraska farmers from irrigating to meet full crop water requirements.

This is especially challenging when irrigating corn and soybean, as they have high evapotransipirational (ET) demand (0.35-0.40 inches per day) during the hot and dry summer months. Implementing alternative spring crops such as chickpeas and field peas in the irrigated crop rotations can provide benefits such as:

- Increase seasonal precipitation use efficiently by lowering water losses (evaporation, surface runoff and deep percolation) that typically occurs during the winter and spring. Consequently, preventing leaching of fertilizers into a stream flow and groundwater.
- Ability to produce more grain and profit per unit of water used – Increasing crop water use efficiency (CWUE).
- Increase the system's ability to meet the peak ET demands of both winter and summer crops, especially if grown under the same irrigation system.
- Increase the overall cropping system profitability.

STUDY OBJECTIVES

- Too investigate feasibility of irrigated field peas and chickpeas and better their potential for water conservation in both irrigated cropping systems.
- To quantify grain yield and crop water use efficiency (CWUE – grain yield produced per unit of water used) of field peas and chickpeas under irrigation.

RESULTS

Table 3. Yield (bu/ac), Crop Water Use Efficiency (CWUE), and sum of precipitation (P), irrigation (I), runoff (RO), deep percolation (DP), evapotranspiration/soil evaporation (ET), and soil water change (ΔSW) for field peas and chickpeas under dryland (DRY), deficit (DI) and full irrigation (FI).

Crop	Irrigation treatment	P (in)	I (in)	RO (in)	DP (in)	ET (in)	ΔSW (in)	Yield (bu/ac)	CWUE (bu/ac-in)
Chickpeas	DRY	19.6	0.0	0.0	4.2	16.7	1.4	53.5	3.2
	DI	19.6	2.2	0.0	3.0	19.0	0.1	37.0	2.0
	FI	19.6	4.4	0.0	4.6	19.9	1.5	25.0	1.3
Field peas	DRY	15.7	0.0	0.0	2.8	13.7	3.8	58.1	4.3
	DI	15.7	1.8	0.0	3.1	16.0	3.1	57.8	3.6
	FI	15.7	3.6	0.0	4.0	16.5	-0.8	62.1	3.8

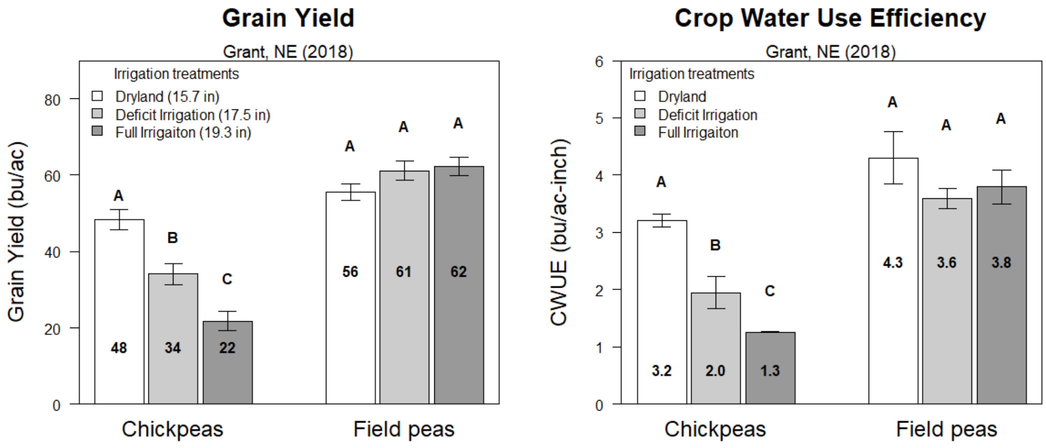

Figure 4. Yield (bu/ac) and Crop Water Use Efficiency (CWUE) for field peas and chickpeas under dryland, deficit and full irrigation during 2018 growing season in Grant, NE.

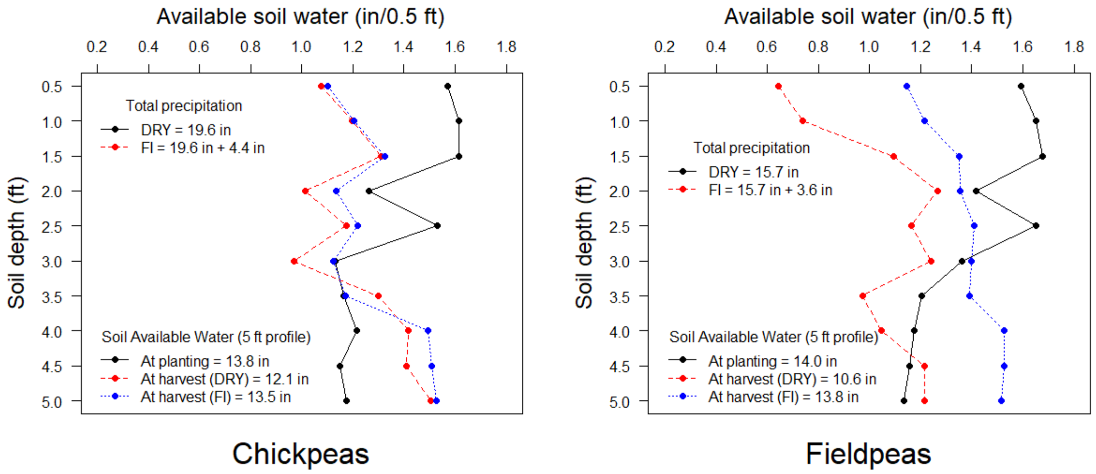

Figure 5. Soil Available Water for field peas and chickpeas at planting and at harvest for dryland and fully irrigated treatments.

Field Peas – A Guide to Herbicide Carryover and Herbicide Efficacy

Figure 1. Carryover injury of atrazine (2 lb ai/ac applied in the fall) and mesotrione (applied in the spring) on field peas.

Field pea is often described as an excellent rotational crop that can be effectively integrated into a variety of crop rotations. In semiarid western Nebraska, field peas are typically a fallow alternative in a wheat-corn-fallow or wheat-fallow rotation. In more humid (or irrigated) regions of the state, field peas are grown as an alternative to soybeans, providing opportunities to double crop or to integrate a cover crop grazing operation extending into the end of the growing season. Adding field peas can help reduce soil erosion, suppress troublesome weeds (e.g., Palmer amaranth), and minimize cost of crop production inputs.

When implementing field peas into a crop rotation, some of the most important things to consider are herbicide carryover and restrictions. This problem can be two-fold:

1) The herbicides you applied in last year's crop may damage this year's field peas.
2) The herbicides you apply in this year's field peas may affect grazing of this year's grazing annual forage, cover crop, fall-planted cash crop (e.g., wheat), or next year's crop.

This guide will help you avoid these carryover injury problems and design an effective herbicide program for your weed management. Use these tables when planning herbicide programs around field peas in crop rotations:

- Table 1. Corn herbicides that can cause serious carryover injury in field peas. These herbicides should not be used or should be used with caution when field peas fallow corn.
- Table 2. Corn burndown and PRE herbicides that will not cause carryover injury in field peas.
- Table 3. Corn POST herbicides that will not cause carryover injury in field peas.
- Table 4. Wheat herbicides that will not cause carryover injury in field peas.

- Table 5. Field peas – Weed Response to selected herbicides.
- Table 6. Field peas – Rate per acre, application time and remarks for selected herbicides.
- Table 7. Field peas – Rotation restrictions for selected field pea herbicides.
- (Set of Tables 1-7)

Carryover injury in field peas following applications of commonly used corn herbicides

Although herbicide labels provide guidelines on intervals between herbicide application and the planting of susceptible crops, the potential for herbicide carryover injury in field peas depends on a complex interaction between herbicide, soil, and the susceptible crop during that interval. Many farmers have observed that despite rotation restrictions, some herbicides in Table 1 appear to be safer than others.

The most concerning corn herbicides are certainly the ones containing mesotrione (Table 1,; e.g., Callisto). If you applied any mesotrione-based product (Table 1) in last year's corn, it is almost certain that this year's field pea crop will die after emergence (Figure 1). Solubility of mesotrione is very high (up to 3000 ppm), which means that this product moves with water. In rare cases, when field peas are planted on sandy ground that received high amounts of precipitation and/or irrigation during the season, mesotrione injury may be moderated and field peas may produce reduced grain yield. On the other hand, in a heavy clay soil with limited water, mesotrione would remain in its active form for a longer time.

A somewhat less concerning corn herbicide is isoxaflutole (Table 1; e.g., Balance Flexx®). We have received farmer reports that isoxaflutole-based products (Table 1), did not cause carryover injury in field peas. Depending on the product labels, rotation restrictions are based on either a 17-18 month rotational interval or a minimum of 15-30 inches of cumulative precipitation.

The least concerning corn herbicide is atrazine. Unlike mesotrione (e.g., Calisto) and isoxaflutole (e.g., Balance Flexx), atrazine is less water soluble (30-300 ppm) and it doesn't move much with water. Atrazine, however, is prone to enhanced microbial degradation, especially in soils where atrazine has been used in the past (Kurtz et al., 2010). Many farmers reported little to no atrazine injury on field peas, especially when applied in the spring at lower rates (less than 1 lb ai/ac). According to North Dakota State University recommendations, field peas may be planted the next cropping season if atrazine rates are less than 0.38 lb ai/ac. The University of Wisconsin recommends maintaining a nine-month rotation interval for field peas following the application of Harness Extra (acetochlor + atrazine premix). Severe atrazine injury was observed in field peas receiving the full rate of atrazine (2 lbs ai/ac) in the fall after grain sorghum harvest (Figure 1). In general, most atrazine-based products have field pea rotation restrictions of two cropping seasons.

If you plan to incorporate field peas in your rotation, we encourage you to select corn and wheat herbicides that provide efficacy equivalent to mesotrione-based, isoxaflutole-based, and atrazine-based products, but do not cause the carryover injury in field peas (Tables 2-4).

Carryover injury in forages and cover crops following applications of field pea herbicides

A good PRE herbicide program is a critical part of field pea production. Using PRE herbicides to control early season weed pressure can substantially increase the competitive ability of field peas to form the canopy and avoid any POST herbicides or harvest aid applications. This is commonly done by using herbicides that provide lasting and broad spectrum weed control (Table 5). In our studies, the most effective herbicides in achieving this goal were those that contained active ingredients for both broadleaf weeds and grasses control such as Spartan Elite®/BroadAxe XC® (Spartan® + Dual II Magnum® premix) or tank mixing Sharpen® + Prowl® (Table 5).

If your intention is to plant a multi-species cover crop after field pea harvest in mid-July, it is important to understand the components of PRE herbicides and their potential carryover injury on species in the cover crop mix (Table 7). In the aforementioned PRE herbicide mixes, Spartan® and Sharpen® typically provide broadleaf weed control while adding Dual II Magnum® and Prowl® helps control grasses; thus, the potential of carryover injury will follow the similar pattern. If you have a lot of grasses in your cover crop mix, Dual II Magnum® and Prowl® can be very damaging. Therefore, you should consider not using these two herbicide components (especially if grass pressure is low) or cutting back their rate so the carryover injury on grass species in the cover crop mix is reduced or negligent. Among the broadleaf herbicides, Spartan® has a higher potential for carryover injury in broadleaf species then Sharpen®. Table 7 provides specific rotation restrictions.

Bioassay

It is important to mention that chemical companies will often only evaluate major crops for carryover injury of a particular herbicide and will use a default interval (18 months or greater) for many minor crops. Herbicide degradation in the environment is a complex process and rotation restriction intervals may be different than labeled in your field. One of the most practical, inexpensive, and effective ways to evaluate whether herbicide carryover may affect your crop is a bioassay. In short, a bioassay includes collecting representative soil samples from the field suspected of having herbicide residue, planting and growing bioassay species, and visually evaluating herbicide injury. For more information, check this Nebraska Extension NebGuide A Quick Test for Herbicide Carry-over in the Soil (G1891).

Resources

For more information, check this Nebraska Extension NebGuide, A Quick Test for Herbicide Carry-over in the Soil (G1891).

Kurtz, J.L., D.L. Shaner, and R.M. Zablotowicz. 2010. Enhanced degradation and soil depth effects on the fate of atrazine and major metabolites in Colorado and Missisippi soils. J. Environ. Qual. 39:1369-1377. Available at https://pubag.nal.usda.gov/download/45083/PDF

North Dacota State University (NDSU) Herbicide carryover guide. Available at https://www.ag.ndsu.edu/weeds/weed-control-guides/nd-weed-control-guide-1/wcg-files/15-CO.pdf

University of Wisconsin (UW) Herbicide rotation restrictions in forage and cover cropping systems. Available at http://mccc.msu.edu/wp-content/uploads/2016/10/WI_2015_Herbicide-Rotation-Restrictions.pdf

Table 1. Corn herbicides that can cause serious carryover injury in field peas. These herbicides should not be used or should be used with caution when field peas fallow corn

Site of Action	Corn herbicide		Common name	Rotation Restiction (field peas)[1]
	Product name	Active ingredient[2]		
		PRE & Burndown		
5	Aatrex	atrazine	atrazine	2CS
14+15+5	Anthem ATZ	atrazine	pyroxasulfone + fluthiacet + atrazine	2CS
15+5	Bicep II Magnum	atrazine	S-metolachlor + atrazine + benoxacor	2CS
15+5	Breakfree ATZ	atrazine	acetochlor + atrazine	15
15+6	Cinch ATZ	atrazine	S-metolachlor + atrazine + benoxacor	2CS
15 + 5	Confidence	atrazine	acetochlor + atrazine	2CS
15+5	Degree XTRA	atrazine	acetochlor + atrazine + safener	2CS
15+5	Fulltime NXT	atrazine	encapsulated achetochlor + atrazine + safener	2CS
15+5	G-Max Lite	atrazine	dimethenamid + atrazine	2CS
15+5	Guardsman MAX	atrazine	dimethenamid-P + atrazine	2CS
15+5	Harnes Xtra	atrazine	acetochlor + MON 4660 safener + atrazine	2CS
5	Princep	atrazine	simazine	2CS
15+5	Volley ATZ	atrazine	acetochlor + dichlormid safener + atrazine	2CS
27	Balance Flexx	isoxaflutole	isoxaflutole + cyprosulfamide	18 [a]
2+27	Corvus	isoxaflutole	isoxaflutole + thiencarbazone + cyprosulfamide	17 b
2+27	Prequel	isoxaflutole	rimsulfuron + isoxaflutole	18 [b]
27	Callisto	mesotrione	mesotrione	18
27+27+15+5	Acuron	mesotrione	S-metolachlor + atrazine + mesotrione + bicylopyrone	18
27+2	Instigate	mesotrione	rimsulfuron + mesotrione + isoxadifen	18
27+15+5	Lexar EZ	mesotrione	S-metolachlor + atrazine + mesotrione	18
27+15+5	Lumax EZ	mesotrione	S-metolachlor + atrazine + mesotrione	18
15+27+4	Resicore	mesotrione	acetochlor + mesotrione + clopyralid	18
		POST		
5	Aatrex/atrazine	atrazine	atrazine	2CS
15+5+9	Expert	atrazine	S-metolachlor + benoxacor + atrazine + glyphosate	2CS
15+27+9	Halex GT	mesotrione	S-metolachlor + mesotrione + glyphosate	18
2+27	Realm Q	mesotrione	rimsulfuron + mesotrione + isoxadifen	18
14+27	Solstice	mesotrione	fluthiacet methyl + mesotrione	18
2+27	Capreno	tembotrion	thiencarbazone-methyl + tembotrione	18 [b]
27	Impact	topramezone	topramezone	9/18 [c]

[1] Months unless otherwise noted. D = Days; AT = Any Time; NCS = Next Cropping Season; 2CS = Second Cropping Season; 3CS Tird Cropping Season, NTE = No Tolerance Established, NI = No information, FBA = Field Bioassay, DNR = Do not rotate.

[2] Active ingredient causing herbicide rotation restriction for field peas

[a] 15 inches of cumulative precipitation from application to planting. (No more than 7 inches from overhead irrigation. Furrow or flood not to be included in total)

[b] When soil pH is 7.5 or above, 24 month rotation intervals. Additionally, 30 inch of cumulative precipitation must occur between application and planting of rotational crop

[c] Pea rotation interval 9 months for 0.5 and 0.75 oz rate, 18 months for 1.0 oz rate

Table 2. Corn burndown and PRE herbicides that will not cause carryover injury in field peas.

Herbicide table includes rotation restrictions for field peas and efficacy rating for NE most troublesome weeds

Site of Action	Corn herbicide	Common name	Rotation Restriction for Field Peas[1]	Weed Response to Selected Herbicides					
				Kochia	Lambsquarters	Marestail	Pigweeds	Russian Thistle	Foxtail species
		Burndown							
4	2,4-D ester 4L	2,4-D	NCS	7	9	7	-	9	1
14	Aim	carfentrazone-ethyl	AT	6	9	-	7-8	6	1
14+15	Anthem MAXX	pyroxasulfone + fluthiacet-methyl	6	7	9	8	-	9	1
4	Banvel/dicamba	Dimethylamine salt of dicamba	NCS [E]	9	9	8	-	5	1
2	Basis Blend	rimsulfuron + thifensulfuron	8/10 [ab]	3	7	5	9	4	7
4	Clarity	dicamba-glycolamine	180 D [m]	9	9	8	-	5	1
4+27	Diflex DUO	dicamba-glycolamine + tembotrione	10	9	9	8	-	5	2
19+4	Distinct	diflufenzopyr + dicamba	4	9	7	9	-	9	1
14+15	Fierce	flumioxazin + pyroxasulfone	6/11 [dq]		check 2018 weed guide for tank mixes				
9	Glyphosate	glyphosate	AT	8	8	8	-	9	9
22	Gramoxone SL	paraquat	AT	9	7	7	-	6	7
9+4	Land Master BW	glyphosate + 2,4-D amine	3	9	9	9	-	9	9
4	Python	flumetsulam	4		check 2018 weed guide for tank mixes				
14	Sharpen + glyphosate	saflufenacil	4-9 [cl]	9	9	10	-	10	10
14	Valor SX	flumioxazin + chlorimuron ethyl	4		check 2018 weed guide for tank mixes				
14+15	Verdict + glyphosate	saflufenacil + dimethenamid-P	NCS	9	8	9	-	10	10
		PRE							
14+15	Anthem MAXX	pyroxasulfone + fluthiacet-methyl	6	6	7	-	9	5	9
15	Breakfree NXT/Harness	acetochlor	NCS	2	7	-	7	3	9
15	Surpass NXT/Confidence	acetochlor	NCS	2	7	-	7	3	9
15	Dual/Chich/Parallel	S-metolachlor + benoxacor	AT	2	7	-	7	3	9
15	Degree/Topnotch	acetochlor + safener	NCS	2	8	-	8	5	9
4+2	Hornet WDG	flumetsulam + clopyralid	10.5/18 [p]	9	9	-	9	8	1
15	Outlook	dimethenamid-P	NCS	2	7		8	3	9
3	Prowl H2O	pentimethalin	NCS		check 2018 weed guide for tank mixes				
2	Resolve SG	rimsulfuron	10	8	7	-	9	3	8
14	Sharpen	saflufenacil	4-9 [cl]	7	8	-	9	8	2
15+4+2	SureStart II/Triple Flex	acetochlor + clopyralid + flumetsulam	NCS						
14+15	Verdict	saflufenacil + dimethenamid-P	NCS	7	9	-	10	9	9
15	Zidua	pyroxasulfone	6	7	7	-	8	6	8

[1] Months unless otherwise noted. D = Days; AT = Any Time; NCS = Next Cropping Season; 2CS = Second Cropping Season; 3CS Tird Cropping Season, NTE = No Tolerance Established NI = No information, FBA = Field Bioassay, DNR = Do not rotate.

[ab] 11 months for STS varieties, 36 months or earlier with a bioassay; 14 or 26 months if pH < 7.9 and rainfall limits are followed.

[cl] Rotation interval depends upon rate applied and soil texture. See the label for detailed instructions

[dq] 6 months for field peas, 11 month for edible peas

[E] Rotation interval is 45 days per pint of Banvel applied at 23 days per pint of Banvel SGF, excluding days when the ground is frozen

[m] Applications of 24 oz/A or less = 22 days for each 8 fluid oz; 24 oz/A or more = 45 day interval for each 16 fluid oz/A applied.

Table 3. Corn POST herbicides that will not cause carryover injury in field peas.

Herbicide table includes rotation restrictions for field peas and efficacy rating for NE most troublesome weeds

Site of Action	Corn herbicide	Common name	Rotation Restriction for Field Peas[1]	Weed Response to Selected Herbicides					
				Kochia	Lambsquarters	Marestail	Pigweeds	Russian Thistle	Foxtail species
			POST						
4	2,4-D ester 4L	2,4-D	NCS	5	8	6	7	4	1
2	Accent Q	nicosulfuron + isoxadifen	10	6	4	5	7	3	8
14	Aim	carfentrazone-ethyl	AT	6	9	7	8	6	1
27	Armezon	topramezone	9/18 [cb]	6	9	6	9	9	4
27+15+ 9	Armezon Pro	topronezone + dimethenamid-P	9/18 [cw]	check 2018 weed guide for tank mixes					
4	Banvel/dicamba	Dimethylamine salt of dicamba	NCS [E]	8	8	6	8	9	1
2	Basis Blend	rimsulfuron + thifensulfuron	8/10 [ab]	3	7	5	9	4	7
2	Beacon	primsulfuron	8	8	5	3	8	5	5
6	Buctril	bromoxynil	1	check 2018 weed guide for tank mixes					
14	Cadet	fluthiacet-methyl	NCS	6	8	5	6	6	1
2+27	Capreno	thiencarbazone-methyl + nicosulfuron	18 [co,cq]	8	9	6	9	9	8
4	Clarity	dicamba-glycolamine	180 D [m]	8	8	6	8	9	1
4	Diflex	dicamba-glycolamine	120 D/180 D [dw]	8	8	6	8	9	2
4+27	Diflex Duo	dicamba + tembotrione	10	8	9	8	9	9	6
9	Glyphosate	glyphosate	AT	8	8	8	9	7	10
4+2	Hornet WDG	flumetsulam + clopyralid	10.5/18 [P]	6	8	8	7	5	10
27	Impact	topramezone	9/18 [cb]	6	9	6	9	9	6
27	Laudis	tembotrione	10	7	9	6	9	9	6
10	Liberty	glufosinate-ammonium	180 D	7	7	5	9	7	8
2	Permit/Sandea	halosulfuron	9	6	5	5	9	4	1
2	Resolve Q	rimsulfuron + thifensulfuron + safener	10	8	6	8	8	3	8
2	Resolve SG/Solida	rimsulfuron	10	8	6	8	8	3	8
14	Resource	flumiclorac	1	3	7	3	5	3	1
2	Spirit	prosulfuron + primsulfuron	10	8	6	3	8	4	4
19+4	Status	diflufenzopyr + dicamba	120 D	8	8	8	8	9	6
2	Steadfast Q	nicosulfuron + rimsulfuron + isoxadifen	10	6	6	3	7	3	8
4	Starane Ultra	fluroxypyr	4	9	2	6	2	5	1
4+2	Yukon	halosulfuron-methyl + dicamba	9	7	8	6	9	7	1

[1] Months unless otherwise noted. D = Days; AT = Any Time; NCS = Next Cropping Season; 2CS = Second Cropping Season; 3CS Tird Cropping Season, NTE = No Tolerance Established NI = No information, FBA = Field Bioassay, DNR = Do not rotate.

[ab] 11 months for STS varieties, 36 months or earlier with a bioassay 14 or 26 months if pH < 7.9 and rainfall limits are followed.

[cb] Pea 9 months; snap bean 18 months

[cl] Rotation interval depends upon rate applied and soil texture. See the label for detailed instructions

[co] When soil pH is 7.5 or above, use longer rotation intervals. Consult the label; cq Additionally, 15 inch of cumulative precipitation must occur between application and planting of rotational crop

[cw] West of Hwy 83, 9 months up to 16 fl oz/A, 18 months over 16 fl oz/Al; on light textured soils such as sands and loamy sands extend time by 7 additional days, on high pH soils (>7.9), extend time to planting by 7 additional days.

[dw] 120 days and over 24 fl oz/A and over 30"rainfall annually. 180 days and over 24 fl oz/A and under 30"rainfall annually.

[E] Rotation interval is 45 days per pint of Banvel applied at 23 days per pint of Banvel SGF, excluding days when the ground is frozen

[m] Applications of 24 oz/A or less = 22 days for each 8 fluid oz; 24 oz/A or more = 45 day interval for each 16 fluid oz/A applied.

[P] Peas may be planted10.5 months following < 4 oz/A application rate; 18 monts when annual rainfall and/or irrigation is less then 15 inches on soils with less than 2% organic matter

Table 4. Wheat herbicides that will not cause carryover injury in field peas.

Herbicide table includes rotation restrictions for field peas and efficacy rating for NE most troublesome weeds

Site of Action	Wheat herbicide	Common name	Rotation Restriction for Field Peas[1]	Weed Response to Selected Herbicides					
				Horseweed	Kochia	Lambsquater	Russian Thistle	Waterhemp	Downy Brome
			POST						
4	2,4-D	2,4-D	NCS	5	6	9	8	8	1
2	Affinity Broadspec	thifensulfuron + tribenuron	1.5		check 2018 weed guide for tank mixes				
2+4	Agility SG	dicamba + metsulfuron + tribenuron + thifensulfuron	10-22	6	10	10	9	9	NA
14	Aim	carfentrazone-ethyl	AT		check 2018 weed guide for tank mixes				
2	Ally Extra SG/Accurate Extra	thifensulfuron + tribenuron + metsulfuron	10/22 [ak,al]	7	6	7	6	7	NA
2	Ally XP/Accurate	metsulfuron	34 [x]	7	6	7	6	7	NA
2	Amber	tiasulfuron	4/FBA	7	7	6	6	7	3
2	Beyond (Clearfield only)	imazamox	18	1	1	1	1	1	8
4	Clarity	dicamba-glycolamine	180 D [m]	6	10	9	9	9	1
4	Curtail	clopiralid + 2,4-D	18	9	8	10	8	9	1
4	Curtail M	clopyralid + MCPA	18	9	8	8	7	7	1
4	Dicamba	Dimethylamine salt of dicamba	NCS [E]	6	10	9	9	9	1
14+15	Fierce	flumioxazin + pyroxasulfone	6/11 [dq]	7	5	8	5	7	NA
2	Fierce Cereal	flumioxazin + pyroxasulfone	-	6	9	10	8	9	NA
2+4	Harmony Extra SG	thifensulfuron + tribenuron	45 D		check 2018 weed guide for tank mixes				
27+6	Huskie	pryasulfotole + bromoxynil	9		check 2018 weed guide for tank mixes				
2	Maverick PRO (fall applied)	sulfosulfuron	12/FBA	6	3	3	3	3	8
4	MCPA	MCPA	0/3 [ae]	4	5	7	6	5	NA
2	Olympus (fall applied)	propoxycarbazone-sodium	FBA	-	-	-	-	-	8
2	Peak	prosulfuron	10 [bo]	7	5	6	6	7	NA
2	PowerFlex (fall applied)/GR1	pyroxsulam	9	-	-	-	-	-	7
2+4	Rave	triasulfuron + dicamba	4/FBA	6	10	10	9	9	NA
4	Starane NXT	flyroxypyr + bromoxynil	4	6	10	9	9	9	1
4	WideMatch	clopyralid + fluroxypyr	18	9	10	-	6	-	1

[1] Months unless otherwise noted. D = Days; AT = Any Time; NCS = Next Cropping Season; 2CS = Second Cropping Season; 3CS Tird Cropping Season, NTE = No Tolerance Established, NI = No information, FBA = Field Bioassay, DNR = Do not rotate.

[ae] Rotation interval varies with application rate

[ak] Application rate of one Soluble Pack per 10 acres on wheat, barley , or fallow on non-irrigated land

[al] Soil pH 6.8 or lower or those with a soil pH 6.9-7.9

[bo] Where soil pH is < 7.8; Maximum application rate 0.5 oz/A; Make application before July 10

[dq] 6 months for field peas, 11 months for edible peas

[E] Rotation interval is 45 days per pint of Banvel applied at 23 days per pint of Banvel SGF, excluding days when the ground is frozen

[m] Applications of 24 oz/A or less = 22 days for each 8 fluid oz; 24 oz/A or more = 45 day interval for each 16 fluid oz/A applied.

[x] At least 28 inches of cumulative precipitation during the period

Table 5. Field peas - Weed Response to selected herbicides

Site of Action	Field peas herbicide	Common name	Weed Response to Selected Herbicides													Crop Safety
			Broadleaf weeds								Grasses					
			Kochia	Lambsquarters	Lanceleaf Sage	Marestail	Redroot Pigweed	Prickly Lettuce	Russian-thistle	Wild Buckwheat	Barnyardgrass	Crabgrass	Downy Brome[1]	Fall Panicum	Millet	
	PRE															
14 + 15	BroadAxe XC / SpartanElite	sulfentrazone + S-metolachlor	9	9	4	6	9	6	9	6	9	8	9	9	8	2
15	Dual II Magnum	S-metolachlor + benoxacor	5	7	6	2	8	5	4	3	8	8	9	9	7	2
3	Prowl H2O	pendimethalin	7	7	6	6	7	7	8	5	8	7	8	8	8	2
3	Treflan (PPI)	trifluralin	7	6	3	5	6	5	7	4	8	8	8	8	8	1
14	Spartan Charge	sulfentrazone + carfentrazone	9	8	4	7	8	7	8	6	6	6	6	6	6	2
14 + 2	Optill	saflufenacil + imazethapyr	8	8	8	8	6	8	8	8	6	2	6	6	6	2
14	Sharpen	saflufenacil	8	8	7	8	5	7	8	7	2	4	3	2	2	2
14	Spartan	sulfentrazone	9	8	4	6	7	6	8	5	6	6	6	6	6	2
	POST															
1	Assure II	quizalofop-P	1	1	1	1	1	1	1	1	8	8	7	8	8	1
6	Basagran 5L	bentazon	7	7	5	4	5	7	4	6	1	1	1	1	1	2
1	Poast	sethoxydim	1	1	1	1	1	1	1	1	6	9	9	9	9	1
2	Pursuit	imazethapyr	7	4	4	5	8	7	7	7	5	6	7	1	8	3
2 + 6	Pursuit + Basagran 5L	imazethapyr + bentazon	8	7	6	6	8	8	7	6	5	5	7	5	6	2
2 + 6	Raptor + Basagran 5L	imazamox + bentazon	8	8	6	6	9	8	7	7	5	7	6	1	2	2
1	Select Max	clethodim	1	1	1	1	1	1	1	1	9	9	9	9	9	1
2 + 6	Varisto	imazamox + bentazon	8	8	6	6	9	8	7	7	5	7	6	1	2	2

[1] Field pea PRE herbicides used to control downy brome must be tank mixed with glyphosate or follow a glyphosate burndown application to obtain these levels of control.

Table 6. Field peas – Rate per acre, application time and remarks for selected herbicides

Herbicide	Rate Per Acre	Application Time	Remarks
Fall Applied			
BroadAxe XC / SpartanElite	19.0-32.0 oz	Fall	Cost: $20.75-$35.00.
Optill	1.5 oz	Fall	Can be tank mixed with other herbicides such as glyphosate for burndown. Cost: $12.00.
Spartan	3.5-8.0 oz	Fall	Application rate depends on soil type and organic matter. Cost: $16.50-$37.50.
Spartan Charge	4.0-10.0 oz	Fall	Use with other herbicides and COC for burndown purposes. Application rate depends on soil type and organic matter. Cost: $13.75-$34.50.
Valor SX	2.0-3.0 oz	Fall	Use only with appropriate tank mix partner such as 2,4-D, dicamba, or glyphosate. Cost: $15.50-$23.00.
Burndown and Preemergence			
BroadAxe XC / SpartanElite	19.0-32.0 oz	Preplant burndown, EPP, or PRE	Rate depends on soil texture, pH, and organic matter. DO NOT use on coarse textured soils with organic matter <1.5%. Cost: $20.75-$35.00.
Spartan Charge	3.0-8.0 oz	Preplant burndown, EPP, or PRE	Apply with COC, AMS, and glyphosate for burndown purposes. Application rate depends on soil type and organic matter. Cost: $10.25-$27.50.
Optill	1.5 oz	EPP, PPI, or PRE	Can be tank mixed with other herbicides such as glyphosate for burndown. Cost: $12.00.
Sharpen	1.0 oz	EPP	If needed, sequential applications can be made at least 30 days apart (no more than 4 ozs/A/plant season). Sharpen can be tank mixed with other Group 14 herbicides. Cost: $7.00.
Prowl H2O	1.5-3.2 pt	Preplant burndown	Rate based on soil texture and organic matter. Tank mix with or apply a postemergence herbicide following application. Irrigation or rainfall is required to infiltrate the herbicide into the upper soil surface. Cost: $9.75-$20.75.
Dual II Magnum	1.0-1.67 pt	PPI, or PRE	Rate based on soil texture and organic matter. Cost: $15.00-$25.00.
Pursuit	3.0 oz	Preplant, PPI, and PRE	Must be incorporated into the soil for best results. Postemergence application require use of an adjuvant and nitrogen fertilizer. Can be tank mixed with grass herbicides. Cost: $11.50.
Postemergence			
Assure II	5.0-10.0 oz	Grasses less than 4" tall	Apply with COC. Cost: $4.00-$8.25.
Basagran 5L	1.0-2.0 pt	After 3 pairs of leaves or 4 nodes are present on peas	Best performance when daily temperatures exceed 75 degrees. Apply with UAN or AMS. May tank mix with MCPA, Pursuit, or Raptor. 30 day PHI. Cost: $10.00-$20.00.
Poast	1.0-2.0 pt	Grasses less than 4" tall	Apply with 2.5 pounds AMS or 4 to 8 pints of UAN. Maximum seasonal application rate is 4 pints per acre. PHI is 30 days. Cost: $12.00-$28.00.
Pursuit	3 oz	Peas have at least one trifoliate leaf but before 5 nodes and flowering	Apply with NIS at 2 pints/acre. Cost: $11.50.
Pursuit + Basagran 5L	3 oz + 0.8 pt	After 3 trifoliate leaves are present until 5 nodes are on the peas	Apply with 1.25 at 2.5 gallons UAN or 12 to 15 pounds per 100 gallons AMS. 30 day PHI. Cost: $11.50.
Raptor + Basagran 5L	4.0 oz + 1.0 pt	After 3 pairs of leaves are present and prior to bloom	Apply with COC at 1-2% v/v. Cost: $29.00.
Select Max	9.0-16.0 oz	Before bloom	Apply with NIS at 0.25% v/v. PHI is 21 days. Cost: $7.75-$13-75.
Varisto	16.0-21.0 oz	After 3 pairs of leaves are present to bloom	Apply with COC at 1-2% v/v. PHII is 30 days. Cost: $20.75-$27.00.
Harvest Aid			
Gramoxone	1.2 - 2.0 pt	Apply when at least 80% of pods are yellowing	Apply using a minimum carrier of 20 GPA for ground or 5 GPA for air. Add NIS at 1qt/100 gal. Do not graze or harvest treated fields for 7 days after spraying.

Table 7. Field peas – Rotation restrictions for selected field pea herbicides

Site of Action	Field peas herbicide	Rotation Restrictions for selected crops																		
		Grass crops										Broadleaf crops								
		Field Corn	Seed Corn	Popcorn	Sweet Corn	Winter Wheat	Spring Wheat	Oat	Winter Barley	Spring Barley	Rye	Grain Sorghum	Proso Millet	Soybean	Canola	Buckwheat	Sunflower	Sugarbeet	Dry Bean	Potato	Alfalfa	Red Clover
	PRE																					
14+15	BroadAxe XC/SpartanElite	10	10	18	18	4.5	4.5	12	4.5	4.5	4.5	10	12	AT	NTE	12	AT	36	NTE	4	12	NTE
15	Dual II Magnum	AT	AT	AT	AT	4.5	4.5	4.5	4.5	NCS	3	7D/14D [cs]	NCS	15D/30D [cs]	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS
14+2	Optil	8.5 [ck]	8.5	18	18	4 [ck]	4 ck	18	9.5	9.5	4-18	18	40	0-1	9.5 [ck]	40	9.5-18 [ck]	40	4	26	4	4
3	Prowl H2O	NCS	NCS	NCS	NCS	4 **	NCS	NCS	4 **	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS
14	Sharpen	AT	AT	AT	0.5	0-3 [cl]	0-3 [cl]	0-3 [cl]	0-3 [cl]	0-3 [cl]	0-3 [cl]	0-1 [cl]	0-6 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]	4-9 [cl]
14	Spartan	10	12	12	18	18	4	4	12	4	4	10/18 [by]	12	AT	24	12/FBA	AT	36	12	12/FBA	12	12
14	Spartan Charge	4	12	12	12	4	4	12	4	3	3	10/18 [by]	12	AT	10/18 [v]	18	18	18	10/18 [v]	10/18 [v]	18	18
3	Treflan (PPI)	NCS	NCS	NCS	NCS	18	2CS	12/18 [ba]	2CS	2CS	2CS	12/18 [ba]	NCS	AT	NCS	NCS	AT	12/14 [as]	AT	AT	NCS	NCS
	POST																					
1	Assure II	4	4	4	4	4	4	4	4	4	4	4	4	AT	AT	4	4	AT	AT	4	4	4
6	Basagran 5L	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT
1	Poast	4 [bf]	4	4	4	4	4	4	4	4	4	4	4	AT	4	4	AT	AT	AT	AT	AT	AT
2	Pursuit	8.5 [h]	8.5	18	18	4	4	18	9.5	4	4	12	26/FBA	AT	26/FBA	26/FBA	18	26/FBA	4	12	4	26/FBA
6	Raptor	8.5	8.5	8.5	8.5	0/3 [bv]	0/3 [bv]	9	4 [ca]	4 [ca]	3	9	9	AT	18-26	18	9	18-26 [as,bv]	AT	18	3	18
1	Select Max	6 D	1	1	1	1	1	1	1	1	1	1	1	AT	1	1	1	AT	AT	1	AT	1
2+6	Varisto [a]	8.5	8.5	8.5	8.5	3	3	9	9	9	4	9	9	AT	26	18	9	26	AT	18	3	NTE

[1] Months unless otherwise noted. D = Days; AT = Any Time; NCS = Next Cropping Season; 2CS = Second Cropping Season; 3CS Tird Cropping Season, NTE = No Tolerance Established, NI = No information, FBA = Field Bioassay, DNR = Do not rotate.

[as] 18 months in eastern Nebraska if soil pH is 6.2 or grater and 26 months if the soil pH is less than 6.2; 26 months for western Nebraska

[ba] All areas receiving more than 20 inches of rainfall and irrigation - those areas receiving less than 20 inches of rainfall and irrigation to produce a crop.

[bf] Poast protected field corn hybrids may be planted anytime

[bv] Clearfield/normal non-Clearfield)

[by] 18-month rotation for rates above 0.25 lb ai/A sulfentrazone.

[ca] Applied prior to June 1 in previous year.

[ck] Check the label for specific rotations for Clearfield crops (corn, wheat, canola, and sunflower).

[cl] Rotation interval depends upon rate applied and soil texture. See the label for detailed instructions

[cs] Rotation interval should be extended to 18 months if drought conditions prevail after application unless at least 15 inch of sprinkler irrigation has been applied

[h] Clearfield, IR, or IMR field corn hybrids may be planted "anytime".

[v] Rotation interval varies by location in Nebraska, soil pH, application rate, and cummulative precipitation

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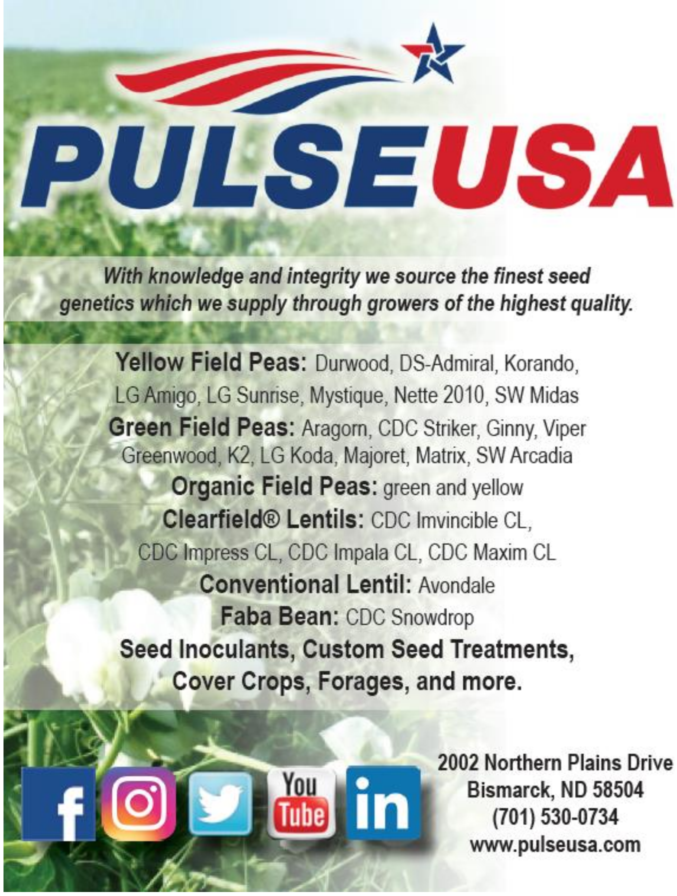

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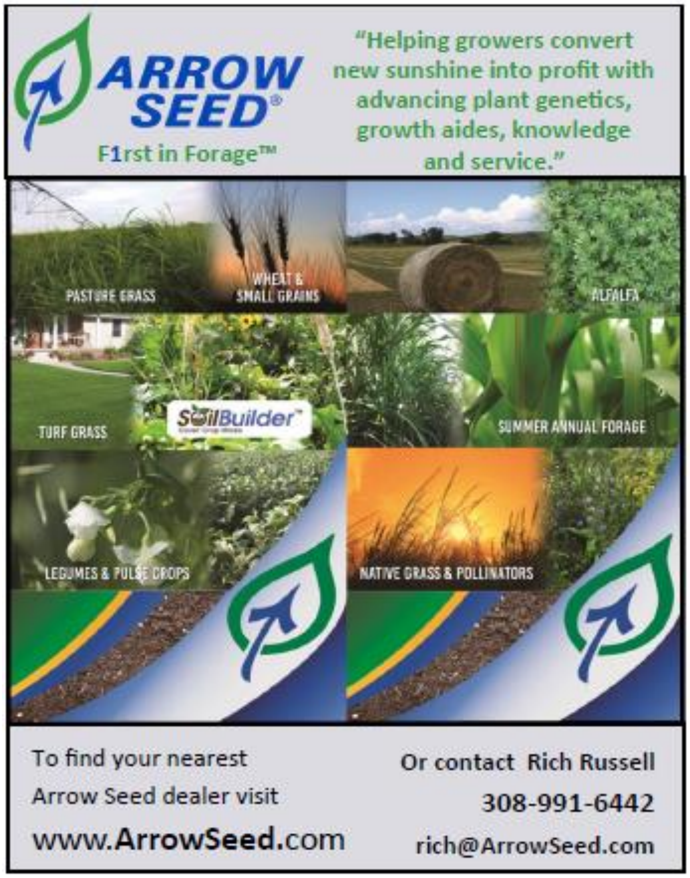

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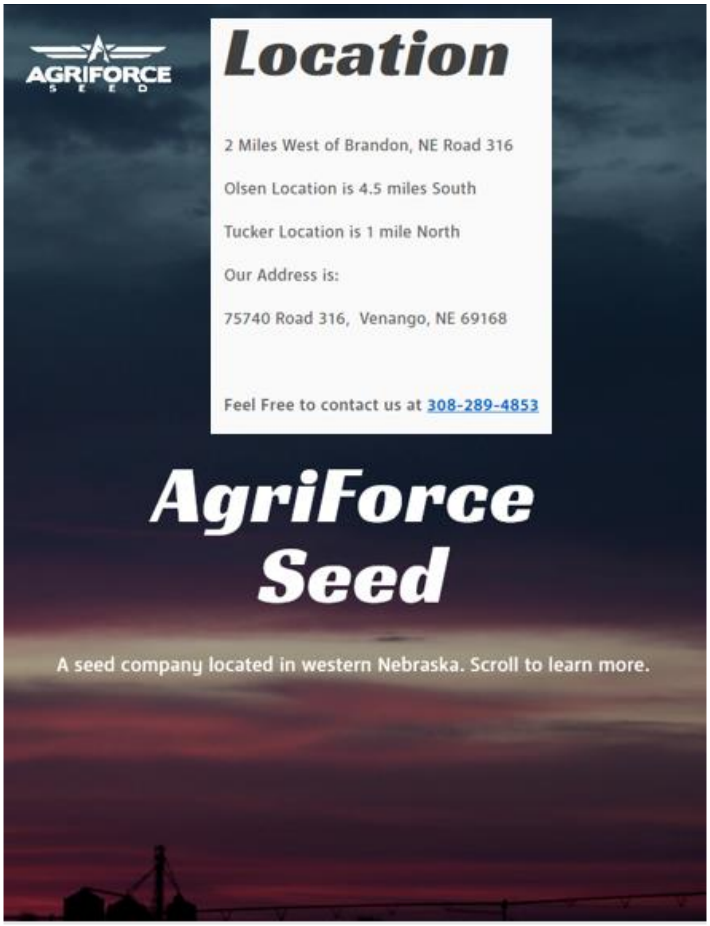

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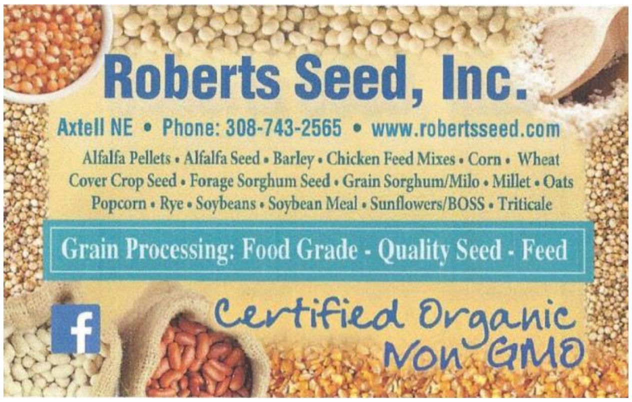

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NE Pulse Crops Checkoff Survey

Nebraska Extension

Dear NE Pulse Crops Grower,

Thank you for contributing to the amazing growth of pulse crops industry in NE. In 2017, combined field peas, lentils and chickpeas acreage in NE increased to approximately 80,000 acres and it is easier than ever to find the seed and market for pulses in NE. With support of UNL faculty and funding from NCR SARE and seed industry we have been able to carry out the research on field peas and learn more about their rotational benefits, agronomic traits and potential profit in different parts of the state. Lastly, NE pulse crop processors including New Alliance, Jelinek Custom Cleaning, Gavilon Grain, Redwood, and some out-of-state contractors like Farmers Business Network and Montana Integrity have also made their contribution to this synergistic effort to grow the NE pulse crops industry.

The establishment of a NE pulse crops checkoff would be very timely and much needed for the future of this industry in NE. We want you to consider this collective effort as an opportunity to send a clear signal to the processing industry that NE pulse crops are here to stay, to generate funds for needed research, and help us reap benefits from polices developed by the National Pulse Crops Coalition such as revenue insurance.

The National Pulse Crops Coalition is administrated by USA Dry Pea and Lentil Council / American Pulse Association, and has offered their assistance in this process. So far ID, WA, MT, ND, and SD are part of this coalition that provides equity for the industry, revenue based crop insurance for growers, and one seat on the national board. To become part of the coalition, NE would need to put a minimum assessment of 1% of net sales (like the rest of the states), monthly reporting, and $10,000 annual membership fee. The Pulse Crops Coalition does important work behind the scenes for the industry, therefore we are sending you the informative flyer on their activities.

Before you fill out the survey, we want you to be aware that Nebraska Extension in Perkins Co is willing to provide an unbiased platform for discussing the costs and benefits of Pulse Crops Checkoff. There are more ways than one to skin a cat and we want to make sure you are well informed and your opinion is heard before a draft legislation is formally introduced.

Once you fill out the survey, simply put it in the pre-addressed envelope provided and send your response to us for further processing.

Thank you for your consideration,

Strahinja Stepanovic
Nebraska Extension Educator – Cropping Systems
Henry J. Stumpf International Wheat Center, 76025 Road 329, Grant, NE 69140
office: 308-352-4340 | email: sstepanovic2@unl.edu | Twitter: @agwithstrahinja
N EXTENSION

The NE Pulse Crops Checkoff Survey

1. Are you growing pulses (dry peas, lentils or chickpeas) or plan on growing pulses in near future?
    a. YES, in the following Counties
    ____
    b. NO

2. How many years have you been farming pulse crops?
    a. 0-1
    b. 1-5
    c. 5-more

3. How many acres do you farm in a pulse crop?
    a. 0-200
    b. 200-500
    c. 500-1000
    d. 1000-more

4. Do you think that the activities of national Pulse Crops Coalition including marketing promotion, research in ag and health nutrition, and policy development (e.g. revenue insurance) are beneficial to NE pulse crop grower?
    a. YES
    b. NO

5. With the understanding of costs and benefits of joining national Pulse Crops Coalition, would you prefer NE Pulse Crops Checkoff to:
    a. Join the coalition
    b. Start independent checkoff

6. Which one of the following would best describes the size of the assessment that you would support.
    a. Percentage base system (% of net sales in the state) – required to join the national Pulse Crop Coalition; it must be 1 % to get revenue insurance for pulse crops.
    b. Cents/bushel checkoff - similar to corn or sorghum checkoff

7. Do you think Commissioners should be:
    a. Governor appointed
    b. Nominated by a grower process

8. How should Commissioners be selected:
    a. Districts divided into equal areas of acreage/production
    b. At large
    c. Combination of district and at large

9. How many years should commissioners serve on the board?
    a. 2
    b. 3
    c. 4
    d. 5

10. Considering that pulses are important for organic and transitioning-to-organic growers, would you support having at least one organic farmer on the board to ensure diverse representation?
    a. YES
    b. NO

11. Chickpeas (aka garbanzo beans) are currently assessed by dry bean commission at $.15/cwt. Would you support the transfer of chickpea assessment from NE Dry Bean Commission to newly formed NE pulse crops checkoff at 1 % of sales for the benefits of getting revenue insurance?
    a. YES
    b. NO

12. Would you be interested in receiving a copy and providing input on a rough draft of the legislation for NE Pulse Crops Checkoff?
    a. YES
    b. NO

13. Should Nebraska create a “Nebraska Pulse Crop Checkoff” to help guide the growth of the pulse industry?
    a. YES
    b. NO

2019 Pulse Crops Expo, Jan 7, 2019

General Information and demographics

1. Indicate County and State where you farm:

____

(County)

____

(State)

2. If you are a **farmer**: How many crop acres you directly manage/farm?
   - a. 0
   - b. 1-199
   - c. 200-999
   - d. 1,000-3,999
   - e. >4,000

3. If you are an **Advisor** and/or Employee: How many crop acres you influence?
   - a. 0
   - b. 1-9,999
   - c. 10,000-99,999
   - d. 100,000-999,999
   - e. >1,000,000

4. How did you **find out** about this meeting?
   - a. Crop Watch
   - b. E-mail from UNL
   - c. Radio
   - d. TV
   - e. Newsletter
   - f. Another person
   - g. Sponsoring

Have you increased your knowledge about:

5. Field pea growth and development (**keynote**)?
   - a. Yes
   - b. No
   - c. Not Applicable

6. High Performing Pulse crop **varieties**
   - a. Yes
   - b. No
   - c. Not Applicable

7. Pulse crops **water use** under dryland and irrigation?
   - a. Yes
   - b. No
   - c. Not Applicable

8. **Tillage** on pulse crops germination and yield
   - a. Yes
   - b. No
   - c. Not Applicable

9. Field pea **rotational benefits and seeding practices**?
   - a. Yes
   - b. No
   - c. Not Applicable

10. **Double cropping** pulses with short season crops and cover crops?
   - a. Yes
   - b. No
   - c. Not Applicable

11. **Chickpea** production?
   - d. Yes
   - e. No
   - f. Not Applicable

12. Pulse Crop **Marketing**?
   - a. Yes
   - b. No
   - c. Not Applicable

Do you think information and contacts you got at this meeting will:

13. Help you improve your current pulse crop **production and marketing**?
   - a. YES
   - b. NO

14. Help you **farm more profitably**?
   - a. YES
   - b. NO

15. **Adopt or expand** your current pulse crop acreage?
   - c. YES
   - d. NO

Rate the quality of our program

16. By adopting field pea (or other pulses) in your rotation were you able to (check all that apply):

☐ Reduce fertilizer and herbicide inputs
☐ Increase bio-diversity on the farm
☐ Better utilize available water
☐ Lower production risk
☐ Increase system profitability
☐ Improve soil
☐ Farm more sustainably
☐ All of the above

17. What is your estimated value of knowledge gained today ($/ac):
   - a. 0
   - b. 1-5
   - c. 6-10
   - d. 11-15
   - e. 50-100

18. How did today's program compare to other education opportunities available to you?
   - a. One of the Best
   - b. Above Average
   - c. Below Average
   - d. One of the Worst

Please leave any additional comments and suggestions on how to improve today's program