Sustainability of Replacing Summer Fallow with Grain-type Field Peas in Semiarid Cropping Systems

Study ID: 174029201602
County: Chase
Soil Type: Blackwood loam;
Reps: 8
Tillage: No-Till

Rainfall (in.):

Objective: 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 no-till cropping systems, such as wheat-corn-fallow or wheat-fallow. The objective of this study was to compare the impact of field peas versus no-till summer fallow on the following parameters:

1. Water use (soil moisture sensors)
2. Yield effect on succeeding winter wheat crop
3. Soil nutrient ccycling (several soil samples throughout the year)
4. Soil infiltration rates (NRCS soil infiltration test)
5. Beneficial soil microbial community (Solvita soil test and qualitative lab analysis)
6. Beneficial insects (pitfall traps and sweep nets)
7. Profitability (farmers reported crop production inputs)

Research site and experiment: This two-year rotation study was conducted on a cooperators' field located in Chase County near Enders, NE from March-2015 until July-2016. The field site has been historically operated under no-till in a wheat-corn-fallow rotation with Blackwood loam as the predominant soil type.
The strip trial was set as pairwise (side-by-side) comparison of field peas versus summer fallow with 8 replications (total of 16 strips evaluated, each being 60 ft × 2,650 ft long) *(Figure 1)*. Field peas cultivar Salamanca was inoculated (Cell Tech liquid inoculate) and drilled (10-inch drill) in strips at 180 lb/ac seeding rate on March 27, 2015. There was good establishment and nodulation, and field pea crop was harvested on July 20, 2015. Winter wheat was planted across the whole field on Sep 14, 2015 and it was harvested in strips on July 15, 2016 to evaluate the rotational effects of treatments on wheat yield and yield quality.

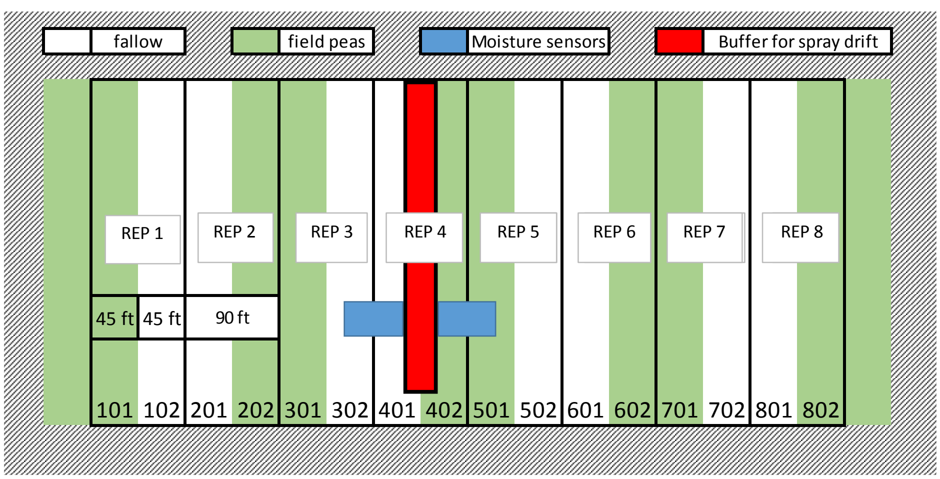

Figure 1. Plot layout of field pea and fallow strips.

Water use and crop yield

Water use data indicated that field peas used 10.9 inches of water to produce 36 bu/ac yield, which resulted in crop water productivity of 3.3 bushel per acre-inch, Table 4. Whereas, fallow used 6.0 inches of water without producing any grain. Available soil water at wheat planting (top 4 foot) 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. Seasonal soil water dynamics are summarized in Figure 3. Note that the soil water level for the wheat after field peas (green line) was below the 50% of field capacity line for most of the growing season which likely led to the lower yield of 18 bushels per acre compared to the wheat after fallow treatment *(Figure 3b)*.

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[1] to 7-20-15	Field peas	6.0	3.0	10.9	36
	Fallow	6.0	6.0	6	
9-14-15 to 07-15-16	Wheat after field peas	5.8	3.5	NA	74 a
	Wheat after fallow	8.0	4.3	NA	92 b

[1] 3-27-2015 field peas planted, 7-20-2015 field peas harvested, 9-14-2015 wheat planted, 7-15-16 wheat harvested
[2] Values with the same letter are not significantly different at a 95% confidence level.

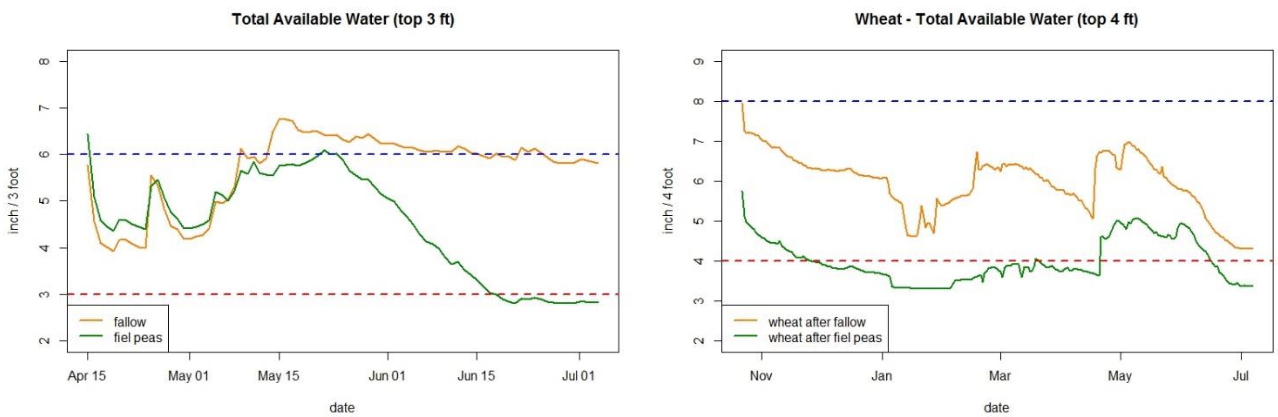

Figure 3a – left and 3b – right. Seasonal dynamics in soil water availability for field peas in the top 3 foot soil profile and wheat in the top 4 foot soil profile. An estimate of field capacity (FC; blue line) and 50% of FC (red line; level of soil water at which most crops exhibit drought stress)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

Soil nutrient cycling (N, P, K) and soil water infiltration

Concentrations of soil nutrients (N, P, and K) did not differ between field peas and fallow at any time during the 2-year rotation study (Table 1), suggesting that 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).

The initial soil water infiltration (1 inch; Figure 2) was collected after wheat harvest by taking 4 subsamples in 6 replications. To infiltrate 1 inch of water it took on average 174 seconds for wheat after fallow as compared to 87 seconds for wheat after field peas.

Figure 2. Soil water infiltration test conducted following wheat harvest.

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	42.00
		12-24	11.2	40	14	361		
		24-36	12.0	43	13	442		
	Fallow	0-12	26.4	95	90	431	27.72	22.00
		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	57.00
		12-24	1.5	5	9	344		
		24-36	2.9	10	2	452		
	Fallow	0-12	2.0	7	41	457	59.74	48.00
		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	9.00
		0-12	4.0	14	22	552	8.50	7.00
		12-24	0.1	0	2	347		
		24-36	0.1	0	2	428		
	Fallow	0-4	7.4	9	70	623	14.00	11.00
		0-12	4.0	14	37	479	14.00	11.00
		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 soil microbial community

Result of analysis of soil microbial activity through Solvita test showed that in the spring there was higher soil-microbial activity in pea fields that followed peas compared to wheat fields after fallow. Also, annual N release was higher for pea-wheat fields compared to fallow-wheat fields (Table 1). However, as revealed by the Solvita test, there was no difference in the carbon dioxide flush or burst between field pea and fallow after wheat harvest in 2016.

Beneficial microbial analysis showed that more diverse species were recovered in the wheat plants following field peas as compared to following fallow, while mycorrhizae population counts were similar in wheat following fallow (Table 2). 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 on the next year's wheat. The beneficial bacteria recovered from the wheat has the potential to stop or reduce the impact of field pea disease/pathogens.

Table 2. Bacterial strains and mycorrhizae populations recovered from wheat rhizosphere in 2016

Date	Wheat after field peas	Wheat after fallow
	Bacterial strains	
Apr. 6, 2016	Bacillus amyloliquefaciens Bacillus aryabhattai Bacillus meqaterium Bacillus subtilis Paenibacillus graminis Paenibacillus lautus Lysinibacillus fusiformis	Bacillus drentensis Bacillus meqaterium Bacillus pumilus Bacillus subtilis Cohnella sp. Paenibacillus tundra
May. 19, 2016	Bacillus amyloliquefaciens Bacillus megaterium Bacillus safensis Bacillus subtilis Lysinibacillus fusiformis	Bacillus megaterium Bacillus safensis Bacillus subtilis
	Mycorrhizae population (spores/ml)	
Apr. 6, 2016	11333	10667
May. 19, 2016	12083	14000

Beneficial insects

In 2015, field peas supported higher numbers of insects and more 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).

Aphids are sole vectors of barley yellow dwarf virus (BYDV), which is the most economically devastating virus disease in small grains worldwide. Outbreaks of BYDV occasionally reach epidemic proportions in some parts of Nebraska (as occurred in wheat in 2007 and 2011). Replacing fallow with field peas may be a good long-term strategy in reducing the negative impact of BYDV outbreaks in wheat.

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

Insect group	Species	Fallow	Field pea
	Pitfall traps 2015		
Predators	Wolf Spiders	2.1 a[1]	4.8 b
	Flat Bark Beetles	1.7 a	20.6 b
	Rove Beetles	6.3 a	17.0 b
	Ants	1.1 a	4.0 b
Parasitoids	Chalcid Wasps	0.7 a	1.5 b
Decomposers	Dung Beetles	0.1 a	2.6 b
	Carrion Beetles	1.9 a	20.6 b
	Minute Brown Scavenger Beetles	53.2 b	15.9 a
Potential Pests	Click Beetles (adult wireworms)	2.3 a	8.6 b
	Sap Beetles	10.2 a	110.2 b
	Leafhoppers	0.4 a	10.4 b
	Bark Lice	31.7 b	1.9 a
	Sweep nets 2015		
Predators	Crab Spiders	0.0 a	1.4 b
	Long-jawed Orb Weaver Spiders	0.0 a	0.8 b
	Hover Flies	0.0 a	0.9 b
Insect group	**Species**	**Wheat after fallow**	**Wheat after field pea**
	Pitfall traps 2016		
Potential Pests	Aphids	31.8 b	1.6 a
	Sweep nets 2016		
Predators	Crab Spiders	2.0 a	3.1 b
	Parasitoid Wasps	1.3 a	2.0 b

[1] Values with the same letter are not significantly different at a 95% confidence level.

Profitability

Table 5 shows the input costs for the field pea-wheat and fallow-wheat rotations. At current price of wheat at $3/bu and field peas at $6/bu, field pea-wheat has a $62/acre profitability advantage over fallow-wheat rotation (Table 6). Based off of the results of this study, wheat prices need to be higher to provide 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	NA	NA	11.23	
spraying	NA	NA	4.23	
seed	Salmanca	3.3 bu/ac	45	
inoculant	Cell-tech dry and liquid		12	
herbicide	Sharpen	1.5 oz/ac	28.2	
herbicide	Pendimethalin	1.5 oz/ac		
herbicide	RT3 (Round-up)	22 oz/ac		
harvest	NA	NA	24.1	
spraying	NA	NA	4.23	
herbicide	Honcho (Round-up)	labeled	14.92	
herbicide	Latigo (generic 2,4-D)	labeled		
spraying	NA	NA		4.23
herbicide	Honcho (Round-up)	labeled		14.92
herbicide	Latigo (generic 2,4-D)	labeled		
spraying	NA	NA		4.23
herbicide	Honcho (Round-up)	labeled		14.92
herbicide	Latigo (generic 2,4-D)	labeled		
spraying	NA	NA		4.23
herbicide	Honcho (Round-up)	labeled		14.92
herbicide	Latigo (generic 2,4-D)	labeled		
insurance	after fallow	$138.31/ac		7.45
insurance	after field pea	$89.71/ac	10.54	
fertilizer	dry mix + application		30.5	30.5
planting	NA	NA	11.23	11.23
starter	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	NA	NA	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. Our results showed that replacing fallow with field peas can: (1) provide more efficient cropping system water use (i.e. higer efficiency in coverting available soil water and seasonal precipitation into crop yield/biomass); (2) improve soil water infiltration; (3) increase soil microbial activity and provide habitat for a greater number of beneficial microorganisms and insects; and (4) be more profitable than no-till summer fallow.

The tradeoffs of replacing fallow with field peas in semiarid climates of western NE are associated with field pea water use and soil water depletion in top 3-4 foot, which may causes yield penalty in the succeeding winter wheat crop (18 bu/ac in this study). This yield penalty in succeding wheat crop will very from farm to farm depending on the soil type (e.g. soil water holding capacity), precipitation patterns in farmer's geography and crop management (e.g. tillage, residue removal, planting date, etc.). We recommend beginning field pea farmers to grow the crop on smaller acres and carefully examine what this "yield drag" is in their operation. This will allow them to gain experience of growing the crop, making adjustments in their management strategies, and ultimatelly make an informative decision on whether to fallow or plant field peas.

The data from the additional two site-years will be combined, analysed and submitted to a peer-review journal article for publishing.