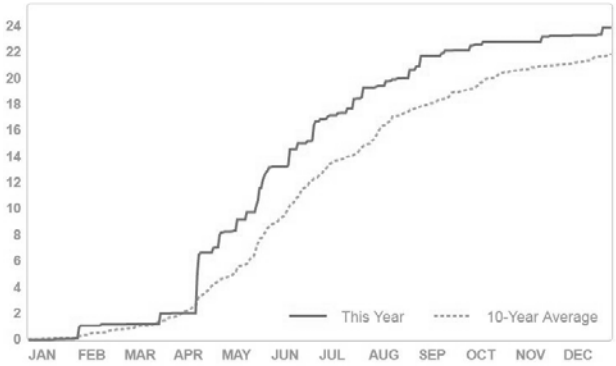
Sustainability of Replacing Summer Fallow with Grain-type Field Peas in Semiarid Cropping Systems

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) that are 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. Soil nutrient cycling, soil microbial activity, soil water infiltration
2. Beneficial insects and microorganisms
3. Water use (e.g., evapotranspiration)
4. Yield of succeeding wheat crop
5. Profitability

Research site and experiment: This two-year rotation study was conducted on a cooperator's 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 the field pea crop was harvested on July 20, 2015. Winter wheat was planted across the whole field on Sep 14, 2015 and was harvested in strips on July 15, 2016 to evaluate the rotational effects of the treatments on wheat yield and yield quality.

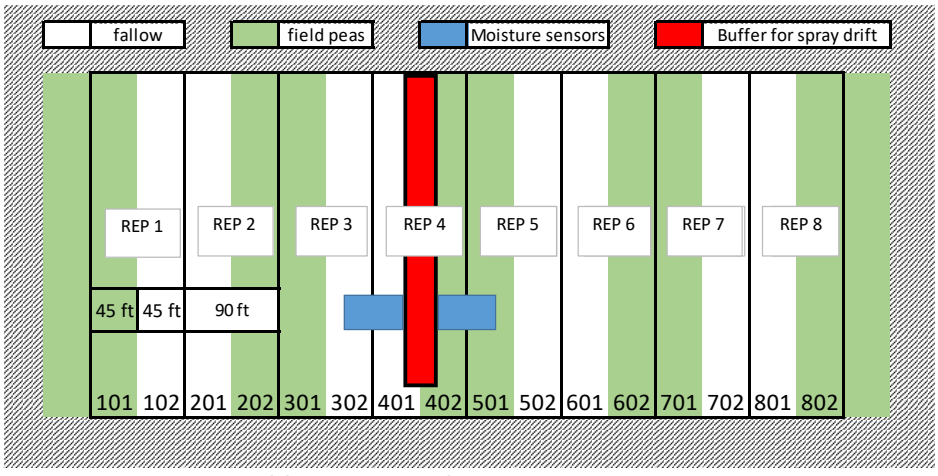


Figure 1. Plot layout of field pea and fallow strips.

Results:

Soil nutrient cycling, soil microbial activity, 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)*.

- Solvita test 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. Solvita test did not differ between field peas and fallow after wheat harvest in 2016 *(Table 1)*.
- Rotational benefit from N being fixed from field peas may already have been scavenged by wheat or is likely to be seen in the next cash 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 fallow treatment as compared to 87 seconds for the field peas treatment.

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	52.3	42
		12-24	11.2	40	14	361		
		24-36	12.0	43	13	442		
	Fallow	0-12	26.4	95	90	431	27.7	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	71.6	57
		12-24	1.5	5	9	344		
		24-36	2.9	10	2	452		
	Fallow	0-12	2.0	7	41	457	59.7	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	11.7	9
		0-12	4.0	14	22	552	8.5	7
		12-24	0.1	0	2	347		
		24-36	0.1	0	2	428		
	Fallow	0-4	7.4	9	70	623	14.0	11
		0-12	4.0	14	37	479	14.0	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 insects and microbes

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 in pea rhizosphere compared to average count of 8 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 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. 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 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)*.

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

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

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

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 penalty 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 compared to the wheat after fallow treatment *(Figure 3b)*.

Table 4. Grain yield, seasonal evapotranspiration (ET), and soil water status at the beginning and end of the growing season for the field pea (3 feet soil profile) and wheat (4 feet soil profile) treatments; yields with different letters indicate significantly different 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	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 B
	Wheat after fallow	8.0	4.3	NA	92 A

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

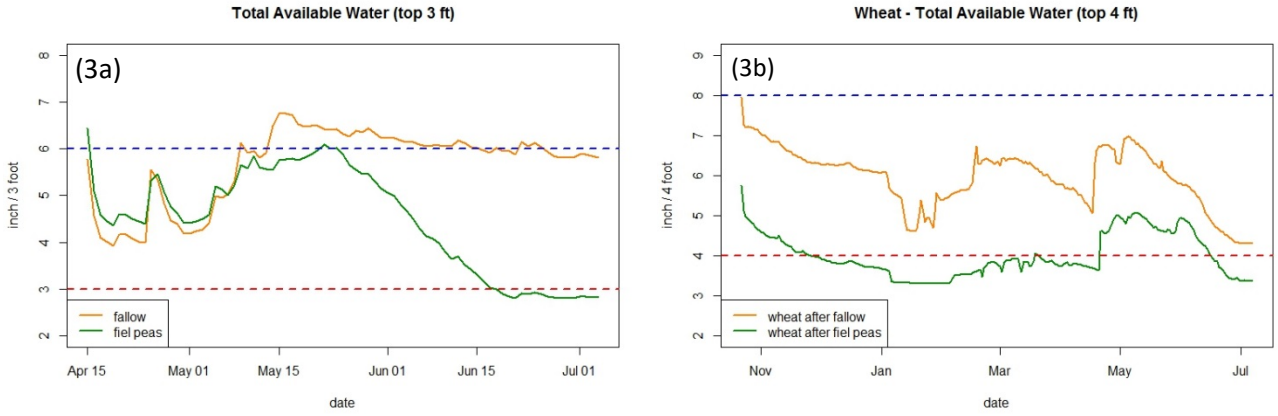


Figure 3a and 3b. Seasonal dynamics in soil water availability for field peas in the top 3 foot soil profile and wheat in the top 4 foot soil profile. An estimate of field capacity (FC; blue line) and 50% of FC (red line; level of soil water at which most crops exhibit drought stress) are shown for the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

Profitability

Table 5 shows 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 a profitability advantage of fallow over field pea.

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	NA
planting			11.23	NA
spraying			4.23	NA
seed	Salamanca	3.3 bu/ac	45.00	NA
inoculant	Cell-tech dry and liquid		12.00	NA
Herbicide mix			28.20	NA
herbicide	Sharpen	1.5 oz/ac		
herbicide	Pendimethalin	1.5 oz/ac		
herbicide	RT3 (Round-up)	22 oz/ac		
harvest			24.10	NA
spraying			4.23	NA
Herbicide mix			14.92	NA
herbicide	Honcho (Round-up)	labeled		
herbicide	Latigo (generic 2,4-D)	labeled		
spraying			NA	4.23
Herbicide mix			NA	14.92
herbicide	Honcho (Round-up)	labeled		
herbicide	Latigo (generic 2,4-D)	labeled		
spraying			NA	4.23
Herbicide mix			NA	14.92
herbicide	Honcho (Round-up)	labeled		
herbicide	Latigo (generic 2,4-D)	labeled		
spraying			NA	4.23
Herbicide mix			NA	14.92
herbicide	Honcho (Round-up)	labeled		
herbicide	Latigo (generic 2,4-D)	labeled		
insurance	after fallow	$138.31/ac	NA	7.45
insurance	after field pea	$89.71/ac	10.54	NA
fertilizer	dry mix + application		30.50	30.50
planting			11.23	11.23
starter	fertilizer 10-34-0 + mix	3 gal/ac	23.00	23.00
seed	Winterhawk cert/treat	65 bu/ac	15.20	15.20
Fertilizer/Herbicide			35.91	35.91
fertilizer	10-20-0-0.5	10 gal/ac		
herbicide	Affinity + Barrage	36.4 + 3.55 oz/ac		
harvest	NA	NA	24.10	24.10
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 ($/bu)						
		4.00	5.00	6.00	7.00	8.00	9.00	10.00
Wheat ($/bu)	3.00	-10	26	62	98	134	170	206
	4.00	-29	7	43	79	115	151	187
	5.00	-48	-12	24	60	96	132	168
	6.00	-67	-31	5	41	77	113	149
	7.00	-86	-50	-14	22	58	94	130
	8.00	-105	-69	-33	3	39	75	111
	9.00	-124	-88	-52	-16	20	56	92
	10.00	-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 the sustainability of crop production in western Nebraska. Preliminary results show that replacing fallow with field peas can increase soil microbial activity and soil water infiltration, provide habitat for greater number of beneficial insects and microorganisms, have more efficient cropping system water use, and be more profitable than no-till summer fallow.

Weather conditions throughout the experiment favored growth and production of field peas, thereby more research is needed to replicate this study in dry years to capture worst case scenarios. No-till summer fallow remains an important water conservation practice in western Nebraska.

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