The Potential for Pulse Crops to Lengthen Potato Rotations in Maine

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Background

Pectobacterium and *Dickeya* bacterial species are disease causing organisms of concern in potato production systems. These bacterium can be spread via infected seed, insects, irrigation and rain water, contaminated soil, and can be harbored on crop and weed residue. Research shows that these bacteria have a broad host range that include both monocot and dicot plant families (Ma, 2007).
Given that these pathogens infect a broad range of hosts, proper design of potato rotations is an important component in reducing both soil and crop residue inoculum levels.

Pectobacterium and *Dickeya* do not appear to thrive on legumes or small grains (Charkowski, 2016). A common two year crop rotation in Maine consists of following potatoes with a small spring grain undersown with clover or annual ryegrass. This rotation scheme may not be long enough to effectively reduce soil and residue inoculum levels as well as eliminate volunteer potatoes. Czajkowski (2011), suggests that survival of soft rot bacteria in the soil is restricted to 1 week to 6 months but can be longer in association with plant material, including volunteers, however the bacteria cannot survive in the soil in a crop rotation system of 3-8 years.

Designing long term rotations is challenging from an economic standpoint. Depressed market prices for small grains are putting pressure on the potato crop to generate a high percentage of total farm income therefore increasing the frequency of potato in the crop rotation. Determining higher value rotation crops, researching how to produce them successfully in Maine, and defining reliable markets are critical steps to designing successful 3 to 4 year crop rotations.

Pulse crops (field peas, lentils, and chickpeas), are annual legumes that grow very well in cool temperatures. Pulse crops are primarily produced in the arid climates of the North Central and Western US and Canada, however results from plot and field trials of yellow dry peas in Maine from 2013 through 2015 suggested that high yields are possible with minimal crop inputs. Average mid-western prices for these crops as of January 2016 were $8/bushel for yellow peas, $26/cwt for chickpeas, $30-$39/cwt for lentils, and $12/bushel for flax. Strong international demand coupled with potential regional markets for food processing and animal feed suggest that pulse production research is worthwhile.

If pulse crops can be successfully produced in Maine, they could play a beneficial role in extending and adding value to potato cropping systems.
***Note – flax is not a pulse crop and was added to this project out of interest to determine disease susceptibility and yield potential.**

Objective

The objective of this proposal is to investigate whether pulse crops can be successfully grown in Maine and integrated into current potato and grain rotations in order to decrease the frequency of potatoes to once every 3 years.

Materials and Methods
Chickpeas (var. Frontier), yellow field peas (var. Jetset), red lentils (var. CDC Maxim CL), brown flax (var. Neela and Prairie Thunder) were planted on May 19, 2016 at the University of Maine's Aroostook Farm in Presque Isle. The soil type was Caribou Loam and the previous crop was potatoes. The plot was prepared using a disk harrow and field cultivator just prior to planting. Soil test values are listed in Table 1. The experimental design was a strip trial with each crop representing a treatment. Treatments were replicated six times in plots that measured 6 feet wide by 25 feet long (150 square feet). Plots were planted using a cone seeder with 6.5 inch row spacing.

Table 1. Soil Test Values

pH	OM	CEC	P	K	Mg	Ca	S	Zn	B
	%	me/100g	lbs/a	lbs/a	lbs/a	lbs/a	ppm	ppm	ppm
5.8	3.4	6.38	21.18	476.3	262.8	1570	6.5	0.5	0.2

Seeding rates, seeding depths, seed treatments, and herbicide and fungicide selections (Table 2), were based on recommendations from production manuals published by North Dakota State University (field peas and flax), Saskatchewan Pulse Growers (Chickpeas and Lentils), and Flax Council of Canada (flax). Pulse seed was inoculated using N-Charge™, a high adhesion, peat based inoculant containing the appropriate strains of bacteria at 3 times the recommended rate. The high rate was used to ensure nodulation as there was no known prior history of these crops in the research plot. Seed treatments consisted of Maxim 4FS (fludioxonil) at a rate of .16 ounces per hundredweight of seed, Apron XL at a rate of 64 ounces per hundredweight, and Mertect 340-F (thiabendazole) at 2.4 ounces per hundredweight. Seed was sourced from Meridian Seeds (Cassleton, ND) and Steiglemeier Farms (Selby, SD) and was of registered or foundation pedigree.

Table 2. Seeding Information

	Rate	Depth	Population	Seed Treatment	Inoculant Rate
	lbs/acre	inches	Plants/acre	product	oz/CWT of seed
PEA	250	1.5-2	392,040	Maxim + Apron	7.5
CHICKP	204	2	174,240	Maxim/Apron/Mertect	7.5
LENTIL	58.6	1.25	580,000	Maxim + Apron	7.5
N FLAX	56	1	3,049,200	Maxim 4FS	n/a
PT FLAX	54	1	3,049,201	Maxim 4FS	n/a

Field peas, lentils, and flax were harvested using a Wintersteiger™ Nursery Master combine. Samples were cleaned using an A.T. Ferrell Clipper™ Model 400 air screen office tester and cleaner. Moisture and test weight were measured using a DickeyJohn™ GAC 2100 AGRI grain analyzer. Due to their late maturity and the combine being in winter storage, chickpeas were harvested by hand. Whole plant samples were moved to a drying room for 1 week, processed using a stationary thresher, cleaned and analyzed using the aforementioned equipment.

Yields were determined by weighing samples collected over a known harvested area and converted into pounds per acre.

Chickpea and field pea plots received a pre emergence herbicide application Spartan Charge (sulfentrazone and carfentrazone) at 5 ounces per acre and Dual II Magnum (s-metolachlor) at 1.33 pints per acre and flax plots received a pre emergence application of Callisto (mesotrione) at a rate of 6 ounces per acre on May 20, 2016. Lentils received a post emergence application of Beyond (imazamox) at 6 ounces per acre tank mixed with a non-ionic surfactant and liquid nitrogen fertilizer on June 24. Lentil plants were approximately 6 inches tall and at 7^{th} node stage.

Adequate soil moisture and warm temperatures contributed to rapid germination and emergence in all treatments. Emergence of flax was noted on May 24, 5 days after planting (DAP). Chickpea, field pea, and lentils emerged on May 25, 6 DAP.

Plant stands were assessed once the crops had fully emerged on June 02 to determine if the target plant populations had been achieved. Plant stand counts were taken from 3 locations per replication and averaged. Table 3 shows the target versus actual stand counts. In all cases, actual plant stand densities were slightly higher than target populations.

Table 3. Target versus Actual Plant Populations

Crop	Target	Actual	Increase/Decrease	Difference from Target	
	pl/ft²	pl/ft²	pl/ft²	pl/Acre	%
PEA	9	9.15	0.15	6534	1.6
CHICKP	4	5.37	1.37	59,677	25.5
LENTIL	13.5	16.75	3.25	141,570	19.4
N FLAX	70	79	9	392,040	11.4
PT FLAX	70	70.7	0.7	30,492	1

Plots were monitored frequently throughout the season to document growth stages as well as scout for diseases. On July 5, field peas had approximately 15 leaves and were at R2 (open flower at 1 or more nodes) stage. No diseases were noted. Chickpeas were at V13 (13 node) stage and had not yet begun to flower. Flowers were first noted on chickpeas on July 11. No signs of disease were noted in the chickpeas. Lentil plants were at R1 (flower present on any node) with no disease noted. Flax varieties received 35 pounds per acre of nitrogen (urea) topdressed at stem extension on June 23. Neela flax was at growth stage 6 (buds visible) and 15.5 inches tall. Prairie Thunder flax was in early growth stage 7 (first flower visible) and measured 19.5 inches tall. No foliar diseases were present on the flax on July 5.

Foliar diseases of chickpeas and lentils, namely *Ascochyta*, *Anthracnose*, *Botrytis*, and *Sclerotinia*, are of major concern in production regions. It was unknown what the disease pressure in Maine would be so a fairly aggressive fungicide program was used preventatively. Field peas and flax did not receive fungicide applications at any point during the growing season. Lentils received 2 applications of Bravo (chlorothalonil) on July 6 and July 21 at a rate of 1.5 pints per acre. Chickpeas Received 3 applications of Bravo on June 24, July 6, and July 21 at a rate of 2.0 pints per acre. Chickpeas and lentils are both strongly indeterminate and were increasing both vegetation and flowers throughout this period. Multiple applications of Bravo were necessary to keep new leaves and stems covered. Chickpeas received 5.7 ounces per acre of Proline (prothioconazole) on September 2. Although *ascochyta* was not observed in either chickpeas or lentils, *sclerotinia* appeared in lentils on August 4 and became widespread prior to harvest. *Sclerotinia* appeared in chickpeas on September 20.

Results

In general, the 2016 growing season in Presque Isle, Maine was slightly warmer and wetter than the 30 year historical averages of NOAA data (1981-2010). Average daily temperature in May was 2.4°F higher than normal, June and July were .7°F and 1.2°F higher respectively, and August, September, and October were all 3°F higher than normal. Seasonal rainfall totaled 20.5 inches, an increase of 2.66 inches higher than normal (Table 4).

Table 5. 2016 weather data vs. 30 year averages (May 01-Oct 31)

Presque Isle, ME 04769	May	June	July	August	Sept	Oct
Average Temperature (°F)	53.9	61.4	66.8	66.6	58.6	46.5
Departure from Normal	2.4	0.7	1.2	3	3.6	3.2
Average Rainfall (In)	2.96	3.65	5.64	5.89	2.48	2.54
Departure from Normal	-0.37	1.17	1.56	2.13	-0.84	-0.99

*National Weather Service – Caribou, ME

Field peas were harvested on August 16. Field peas have a determinate growth habit with uniform dry down and earlier maturity (89 DAP). Lodging occurred throughout the field pea plots however the vines were not flat on the ground. Harvest losses of approximately 7% were attributed to shatter loss due to the pods beginning to open.

Flax was harvested on September 13 (117 DAP). Lodging was minimal and did not negatively affect the ability to direct combine the crop.

Lentils were harvested on September 29 (133 DAP). *Sclerotinia* stem rot caused a majority of the treatments to lodge. The lentils were direct combined and harvest losses were estimated at 15% due to lodging.

Chickpeas were harvested by hand on October 20 (154 DAP). The strong indeterminate growth habit and frost tolerance made machine harvest implausible. *Sclerotinia* stem rot was observed in all treatments but was not as widespread as with the lentils and did not cause the crop to lodge.

Yield information is included in Table 5. Yields were corrected to storage moisture levels. Statistical analysis was not performed on this data as there were no comparisons made between treatments. Values presented are averages from 6 replications of each treatment.

Table 5. Harvest and Yield Data

Crop	Harvest Area	Sample Weight	Moisture at Cleaning	Yield at Cleaning Moisture	Safe Storage Moisture	Yield at Storage Moisture	Yield at Storage Moisture
	FT^2	gr	%	Lbs/A	%	Lbs/A	Bu/A
PEAS	**135.4**	**4825.6**	**9.4**	**3422.6**	**16.0**	**3685.0**	**61.4**
CHICKP	**32.9**	**598.0**	**10.5**	**1842.6**	**14.0**	**1895.5**	**31.6**
LENTIL	**108.3**	**2062.3**	**13.1**	**1829.6**	**14.0**	**1843.8**	**30.7**
N FLAX	**101.6**	**1766.2**	**7.4**	**1684.9**	**8.0**	**1696.9**	**30.3**
PT FLAX	**101.6**	**2025.3**	**7.4**	**1909.1**	**8.0**	**1921.4**	**34.3**

Discussion

Results from this project show that field peas, chickpeas, lentils, and oilseed flax grown in Maine in 2016 produced yields comparable to the common production regions of the North Central and Mid-western United States and Canada. This project also brought to light challenges that can be expected in pulse crop production, particularly in Maine's humid climate and short growing season.

Production recommendations from the North Central and Mid-western regions are a useful tool in obtaining background information with regards to nutrient requirements, pest pressures and concerns, and harvest and storage practices. Due to the climatic differences, some of these recommendations will need to be adjusted for successful production in Maine.

High humidity and extended periods of leaf wetness presented challenges with management of late season foliar diseases in chickpeas and lentils. Excessive vegetative canopies due to high plant populations and narrow row spacing created ideal environments for fungal pathogens. The dense canopies restricted airflow and foliage remained wet for several days after heavy dew or rain events. Late season fungicide applications could not penetrate the canopies and adequate coverage of plant tissue could not be attained. The indeterminate growth habit of both chickpea and lentil also produced challenges related to disease and harvest. The continual flowering provided a food source for *sclerotinia* to become widespread when coupled with the dense foliage and high relative humidity. The decision of when to harvest was also challenging as the crop has mature seed pods, immature pods, and flowers simultaneously. Chickpea and lentil are both frost tolerant. *Sclerotinia* in the lentil plots desiccated the foliage and allowed for mechanical harvest. Chickpea was able to withstand frosts into late October.

From an agronomic standpoint, pulse crops can perform well in Maine. Field peas produced high yields for the fourth consecutive year. Flax produced satisfactory yields with little disease or harvest issues. However, it is evident from the results of this project, that additional research is warranted before pulses (especially chickpea and lentil) become a cornerstone of potato crop rotations. Future research plans would include investigating the following:

- Spatial design (between row, in-row, and plant populations) to allow increased airflow and fungicide coverage
- Using nitrogen fertilizer in place of inoculant as a tool for maturity management
- Sourcing determinate and earlier maturing cultivars

- Developing a desiccation plan – materials and proper timing – as an harvest aid
- Inclusion of additional pulse crops able to tolerate higher moisture environments such as IP soybean, fava bean, and dry bean
- Fall and/or pre plant incorporated herbicide programs

Table 6 show a breakdown of input costs, yield, and revenue potential. It should be noted that variable costs associated with planting, sprayer applications, harvesting, trucking, and storage are not included and are assumed to be the same for small grains.

Table 6. Return over Input Costs vs. Oats

	PEA	CHICKP	LENTIL	FLAX	OAT[3]
	PER ACRE				
Seed	$70.00	$112.00	$15.00	$17.00	$25.40
Inoculant	$18.00	$14.00	$4.00	$0.00	$0.00
Herbicide	$35.00	$35.00	$29.00	$34.00	$2.78
Fungicide	$0.00	$67.00	$20.00	$0.00	$0.00
Fertilizer	$0.00	$0.00	$0.00	$13.00	$13.00
TOTAL	$123.00	$228.00	$68.00	$64.00	$41.18
YIELD[1]	36.9	19.0	18.4	17.0	38.0
$/CWT[2]	$13.33	$26.00	$30.00	$21.42	$3.94
Gr. REV	$491.21	$492.96	$553.20	$363.50	$149.72
ROInput	**$368.21**	**$264.96**	**$485.20**	**$299.50**	**$108.54**

*[1] measured in CWT/A, *[2]USDA/AMS Jan 16, *[3]$7/bu seed cost, 38 lb bushel, 100 bu/acre

In comparison to oats, the crops evaluated in this project; field peas, chickpeas, lentils, and flax all have the potential to generate greater revenue per acre. Although input costs for pulse crops are generally greater than for the oats, the value on a per unit basis is substantially higher resulting in greater revenue over input cost per acre. If markets can be developed in Maine or other regional locations, pulse and alternative oilseed crops could be an attractive agronomic and economic addition to potato crop rotations.