2015 Annual Report
For the
Agriculture Demonstration of Practices and Technologies
(ADOPT) Program

Project Title: Chickpea Flax Intercropping: Can flax stress chickpea to hasten seed set and maturity and/or act as a barrier to disease spread in chickpea?

Project Number: 20130460

Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location(s): The project is conducted at the AAFC Scott Research Farm. Legal land description: NE 17 39 20 W3

Project start and end dates (month & year): April 2014 to February 2016

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Objectives and Rationale

Project Objectives

The objective of this trial was to determine if intercropping chickpeas and flax improves yield performance and reduces disease incidence of the intercrop as compared to Desi and Kabuli chickpea and flax as monocrops.

Project Rationale

Chickpeas have been the highest profit grain crop on a per acre basis in Saskatchewan since their introduction. So far the lack of consistent terminal stress in the dark brown and black soil zones has limited the expansion of this crop into the southeast region and many other parts of Saskatchewan. The crop is also very susceptible to *Aschochyta* and requires repeated applications of fungicide. While breeding work has improved these characteristics, sustained expansion in acres has been very limited. Intercrops, while interesting in theory, have proven to be difficult to scale up on a commercial level due to many factors such as grain separation, timing of harvest and weed control among others. There needs to be a compelling agronomic reason to add the extra complication of an additional crop to get farmer and industrial adoption of this new practice. The chickpea flax combination may just be an intercrop that may work on a commercial scale in Saskatchewan because seeding, weed control, harvest timing, and grain separation are all manageable operations in that system. Given the agronomic problems with chickpeas in Saskatchewan, an intercrop may be a way to alter the area of adaptation for chickpea in the province. Chickpea and flax intercrops have been grown commercially in the Midale area with good success. If we can demonstrate that this success can be duplicated at other locations then the area in which chickpeas can be commercially grown could be expanded and the number of fungicide applications reduced. Chickpea requires moisture stress and scarce nitrogen to stop vegetative growth. In an intercrop with flax, chickpeas will compete with flax late in the season for moisture and nitrogen. Chickpea and flax are not competitive crops on their own, so neither one tends to dominate early in the season. Similar project was done in 2013 in Redvers with relatively good success, even though it was seeded late and there was excessive fall moisture. Due to the fact that this production practice may be highly influenced by both geographical location and local weather patterns, we have proposed doing this project for two years. More extensive regional testing is more likely to fully test the feasibility of this new technique. If the intercrop is proven successful at multiple locations for more than one year, the chances of it being adopted as a common practice is higher. It may also help generate interest in doing University level research projects.

Methodology and Results

Methodology

The trial was conducted at the AAFC Scott Research Farm in the 2014 and 2015 growing season. The experiment was set up as a randomized complete block design with four replicates and 10 treatments. The 2014 trial was unsuccessful due to the following reasons:

- Both chickpea cultivars were not inoculated. This might have led to the low emergence rates as adequate rhizobia strains may not have been present to nodulate them.
- There was cool spring in Scott in 2014 growing season and the crops were seeded relatively early.
- 'Authority', which is registered for both chickpeas and flax was applied as a pre-seed herbicide days before seeding, however, there was a second flush of volunteer canola that emerged with the crop and choked it out.

Therefore, modifications were made to the treatment list and agronomic practices for the 2014 and 2015 growing seasons (Table 1 and Appendix A1). The crop cultivars planted were Corinne & Alma and Bethune for chickpeas and flax, respectively. Both chickpea and flax were seeded directly into canola stubble with an R-tech seeder with 10 inch row spacing at rates as per the treatment.

In 2014, fertilizer in the form of P-K-S was applied in seed row with flax at rates 22.4 kg P_2O_5/ha as MAP, 11.2 kg K_2O/ha as KSO_4 and 3.8 kg S/ha as KSO_4, respectively and N was also applied according to the treatment prescription. All treatments received same blend of N in the form of Urea (11.2 kg N/ha) pre-planting through seed-openers except treatment 10 which received extra 44.8 kg N/ha and treatments 7 and 8 with no N. Pre-seed herbicide (Authority) was applied at a rate of 118 mL/ac on May 14, 2014 and Glyphosate + Bromoxynil at a rate of 1 L/ac on May 21, 2014.

In 2015, no fertilizer was applied except in treatment 10 which received 60 kg/ha N side-band. Both chickpea varieties were seeded with the openers in the monocrops whiles flax was seeded side-band in the intercrops. Nodulator XL inoculant was applied to the chickpeas in-furrow at a rate of 3.3lbs/ac. Pre-seed herbicide (Authority) was applied at a rate of 118 mL/ac on May 8, 2015 and Glyphosate at a rate of 1 L/ac on May 18, 2015 (See Appendix A1 for complete agronomic details).

Table 1: Trial Treatment List for the 2014 and 2015 growing seasons

Trt#	2014	2015
1	Desi (30 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Desi (30 seeds m^{-2}) + Flax (40 kg/ha)
2	Desi (40 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Desi (40 seeds m^{-2}) + Flax (40 kg/ha)
3	Desi (50 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Desi (50 seeds m^{-2}) + Flax (40 kg/ha)
4	Kabuli (30 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Kabuli(30 seeds m^{-2}) + Flax (40 kg/ha)
5	Kabuli (40 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Kabuli (40 seeds m^{-2}) + Flax (40 kg/ha)
6	Kabuli (50 seeds m^{-2}) + Flax (40 lbs ac^{-1}) Low N	Kabuli (50 seeds m^{-2}) + Flax (40 kg/ha)
7	Kabuli (40 seeds m^{-2}) No N	Kabuli (40 seeds m^{-2})
8	Desi (40 seeds m^{-2}) No N	Desi (40 seeds m^{-2})
9	Flax (60 lbs ac^{-1}) Low N (11.2 kg N ha^{-1})	Flax (56 kg/ha)
10	Flax (60 lbs ac^{-1}) High N (56.0 kg N ha^{-1})	Flax (56 kg/ha) + 60 kg/ha N

Plant densities were assessed on June 09, 2015 when there were visible rows to determine plant emergence among treatments. These were assessed by counting one 1 m row in the front and back of the plot for a total of four rows per plot. The average of the two rows was converted to plants per m^{-2} based on 10 inch row spacing. Plant heights for both crops were assessed on August 5, 2015, 4 plants per plot were measured and an average height calculated to represent height per plot. Grain yields were determined after plots were mechanically harvested, cleaned and corrected to the respective seed moisture. Due to the absence of diseases in the field, no seed were sent for disease assessment as stated in the protocol. Again, at maturity, there was no lodging so no lodging assessment was done.

Statistical Analysis

An analysis of variance (ANOVA) was conducted on all response variables using the PROC MIXED in SAS 9.3. Treatment was considered as a fixed effect factor and replicates were considered a random effect factor. The assumptions of ANOVA (equal variance and normally distributed) were tested using Levene's test, and Shapiro-Wilks. The data fitted to the ANOVA assumptions. The data was normally distributed; therefore no data transformation was necessary. Treatment means were separated according to Tukey's Honestly Significant Difference (HSD) and considered significant at $P \leq 0.05$. Weather data was collected from the Scott Environment Canada weather station (Table 2).

Growing season weather conditions

In 2014, Scott saw slightly lower than average temperatures in May and June, but summer and fall were at or slightly above average temperatures (Table 2). Scott received 123 % of normal precipitation, most of which fell in July. The first fall frost at Scott occurred on September 12, 2014.

In 2015, the early growing season was very dry with only 4.1 mm and 19.4 mm accumulated precipitation during the month of May and June, respectively. July received 36 % less rainfall compared to the long term average. However, August received 39 % more moisture compared to the long-term average. The mean monthly temperatures were comparable to previous years (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree days accumulated from May to September in the 2014 and 2015 growing seasons at Scott, SK

Year	May	June	July	August	Sept.	Average /Total
--			*Temperature (°C)*			--
2014	9.3	13.9	17.4	16.8	11.2	13.7
2015	9.3	16.1	18.1	16.8	10.9	14.24
Long-term^z	10.8	15.3	17.1	16.5	10.4	14.0
--			*Precipitation (mm)*			--
2014	23.1	60.4	128.0	30.1	23.6	265.2
2015	4.1	19.4	46.4	74.5	49.6	194.0
Long-term^z	36.3	61.8	72.1	45.7	36.0	215.9
--			*Growing Degree Days*			--------------------------------------
2014	144.5	264.8	384.5	363.4	188.0	1345.2
2015	140.3	332	405.1	365.8	179.8	1423.0
Long-term^z	178.3	307.5	375.1	356.5	162.0	1379.4

^{z}Long-term average (1981-2010)

Results

Generally, all the measured parameters in chickpea were significantly affected by treatment, however, only yield in flax was significantly affected by treatment (P = 0.0057) (Table 3). The desi variety recorded higher values in all parameters in the intercrop relative to the kabuli, however, the kabuli recorded higher values in all the parameters in the monocrop and produced higher flax yield in the intercrop. This may be because different genotypes behave differently under different cropping systems and may also vary in their ability to compete with companion crops for growth resources (Thobatsi, 2009).

Table 3. Effects of treatments on measured response variables in chickpea and flax at Scott, SK in the 2015 growing season.

	Plant Density		**Height (cm)**		**Maturity Date**		**Yield (kg/ha)**	
	Flax	Chickpea	Flax	Chickpea	Flax	Chickpea	Flax	Chickpea
Effects	---------------------------------			*P-values*			---------------------------------	
Treatment	0.2276	***0.0002***	0.1418	***<.0001***	0.4586	***<.0001***	***0.0057***	***<.0001***

Plant density

There was a significant effect of treatment on chickpea plant population (P = 0.0002) but not on flax plant population (P = 0.2276) (Table 3). There was a general trend of increasing plant population with increased seeding rate in both chickpea and flax (Figure 1). The average range of plant population for the desi chickpea were 37-46 plants/m^2 and 21 plants/m^2, for the intercropped and mono-cropped, respectively. With the kabuli variety, the range of plant population were 14-29 plants/m^2 and 48 plants/m^2, for the intercropped and mono-cropped, respectively. Flax had average plant population of between 176-314 plants/m^2. Generally, the desi had higher plant density in the intercropped whiles the kabuli had highest plant density in the monocrop (Figure 1).

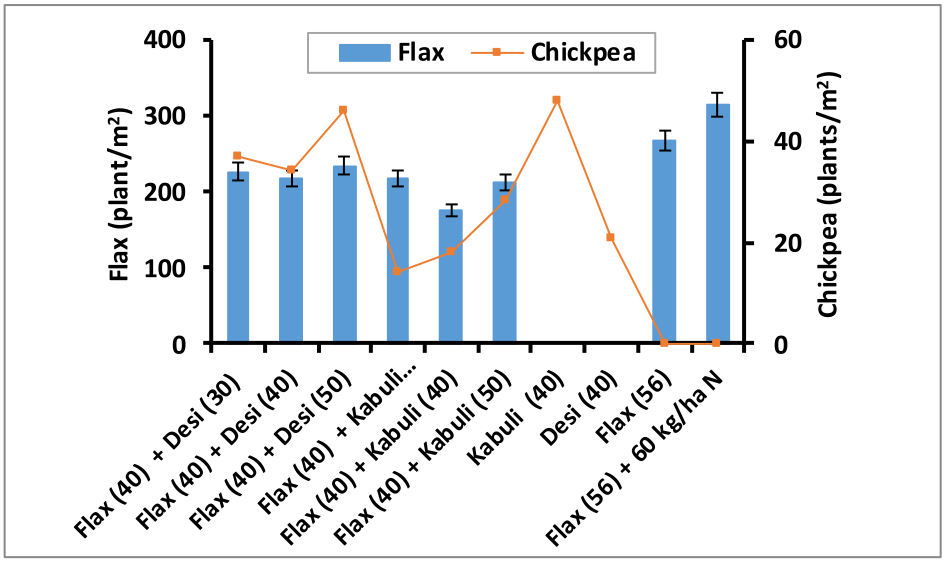

Figure 1: Treatment effects on flax (*columns*) and chickpea (*line*) plant population (plants/m^2) for the 2015 growing season at Scott. Treatment were considered significantly different according to Tukey's Honestly Significant Difference (HSD) ($P > 0.05$).

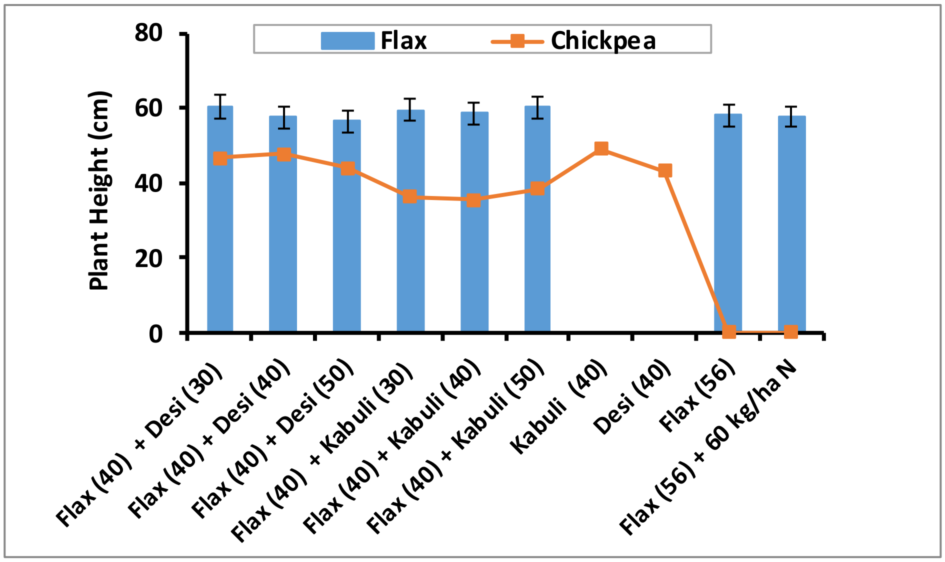

Figure 2: Treatment effects on flax (*columns*) and chickpea (*line*) plant height (cm) for the 2015 growing season at Scott. Treatment were considered significantly different according to Tukey's Honestly Significant Difference (HSD) ($P > 0.05$).

Plant height

There was a significant effect of treatment on chickpea plant height (P <.0001) but not on flax plant height (P = 0.1418) (Table 3). Generally, the desi variety was taller in the intercropped whiles the kabuli was taller in the monocrop (Figure 2). There was a general height increment with increased chickpea seeding rate in the kabuli variety (Figure 2).

Date of maturity

There was a significant effect of treatment on chickpea maturity date (P <.0001) but not on flax maturity date (P = 0.4586) (Table 3). There was generally no significant advantage of either seeding rate or intercrop vs monocrop in the maturity of the desi variety (Figure 3). However, in the kabuli variety, the monocrop had a slight delayed maturity with a slight seeding rate advantage of lower over higher seeding rate (Figure 3).

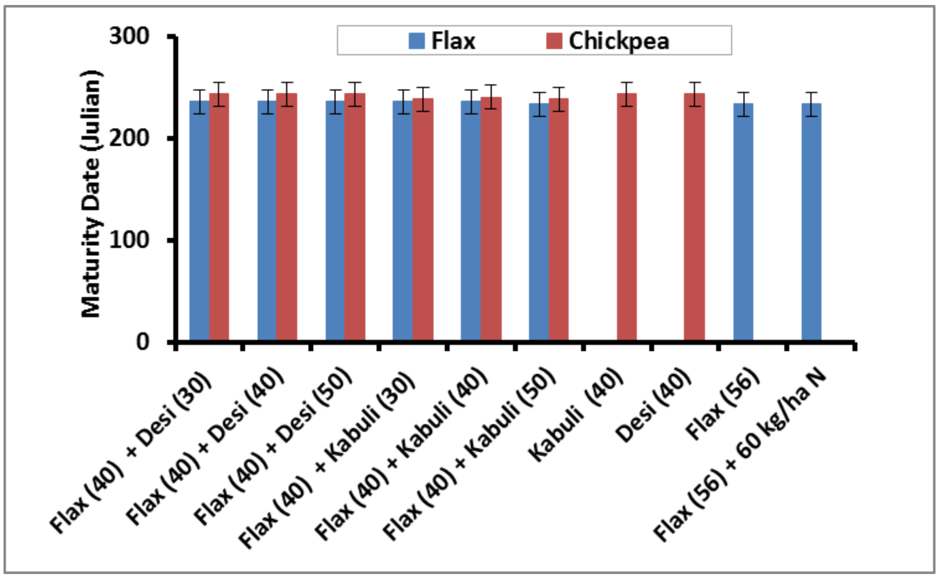

Figure 3: Treatment effects on flax and chickpea maturity date (Julian) for the 2015 growing season at Scott. Treatment were considered significantly different according to Tukey's Honestly Significant Difference (HSD) (P > 0.05).

Grain yield

There was a significant effect of treatment on both chickpea (P <.0001) and flax yield (P = 0.0057) (Table 3). There was a general trend of increasing yield of more than 100 % in the desi variety relative to the kabuli variety at all seeding rates in the intercropped (Figure 4). The superior yielding of desi in an intercrop may be because of better competition with companion crops. A study by Azar et al. (2013) found maximum grain yield (122.16 g/m^2) was obtained from the treatment of one row of barley and one row of desi chickpea, compared with other treatments, including one row of barley and one row of kabuli chickpea.

However, when in a monocrop setting, kabuli yielded 33 % higher than the desi (Figure 4). Flax yield in the monocrop setting was higher (18 %) for treatment with additional N relative with the treatment with no N. However, when in an intercropping, flax yield was greatest when intercropped with kabuli compared to with desi (Figure 4). This may be because kabuli chickpea is an excellent nodulator and nitrogen fixer, however, desi chickpea is a good nitrogen fixer under ideal conditions, but may be a little sensitive to adverse environmental conditions (Saskatchewan Pulse Growers, 2016). For example, a study found that in general, both kabuli genotypes (CSG 9651 and BG 267) seemed to have a better potential for salt tolerance compared to the desi cultivars (CSG 8962 and DCP 92-3) (Garg and Singla, 2004).

Again, apparent yield reduction in kabuli relative to desi when intercropped with flax may be because of their relative resource sharing and superior competition capabilities. Because yield reduction under intercropping could be associated with the competition effect by component crops for nutrients, moister and space (Adeniyan et al., 2007). Carr et al. (1998) reported that intercropping reduced grain yield of lentil (*Lens culinaris* Medik.) by 87 to 95 %. Similar results were also found by Chemeda (1997) with maize-bean intercropping and Thawala and Ossom (2004) with maize-groundnut intercropping.

The higher flax yield when intercropped with kabuli relative to the desi varieties may be because of the greater contribution of fixed N from the kabuli to the flax. This may be because the kabuli variety being an excellent nodulator and nitrogen fixer (Saskatchewan Pulse Growers, 2016).

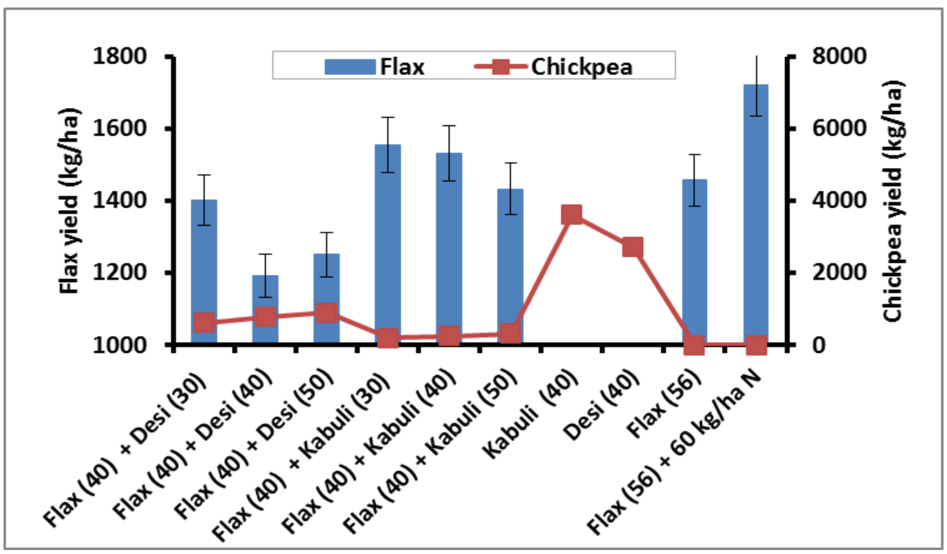

Figure 4: Treatment effects on flax (*columns*) and chickpea (*line*) yield (kg/ha) for the 2015 growing season at Scott. Treatment were considered significantly different according to Tukey's Honestly Significant Difference (HSD) ($P > 0.05$).

Conclusions and Recommendations

From the 2015 study, it can be concluded intercropping of flax with any of the chickpea varieties did not have any significant effects on plant density (P = 0.2276), height (P = 0.1418) and maturity date (P = 0.4586) in flax. However, there was a significant effect on flax yield (P = 0.0057) when intercropped with chickpea. Flax yield was significantly higher when it received higher N fertilizer and it only differs significantly (lower) when intercropped with higher rates of desi chickpea. Flax yield was greatest when intercropped with kabuli compared to with desi. However, it can be deduced that when chickpeas were intercropped with flax, it resulted in significant effects on plant density (P = 0.0002), height (P <.0001) and maturity date (P <.0001) and yield (P <.0001) of the chickpeas. The desi variety recorded higher values in all the measured parameters than the kabuli variety in an intercrop setting. However, the kabuli had higher values relative to the desi in a monocrop setting. This may be because the desi can utilize available resources in an intercropped setting as opposed to the kabuli that performs better under monocrop setting. Based on this demonstration and due to the fact this is the first successful year, further studies are needed to be able to make recommendations to producers around NW SK. Finally, since from previous studies, maximum grain yield (122.16 g/m^2) was obtained from one row of barley and one row of desi chickpea compared with other treatments, different chickpea/flax configurations (such as 2:1, 3:1 and 3:2) can be tested to determine which best combinations will give overall yield benefit in the intercrop relative to the monocrop.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support for this project. We would like to acknowledge Herb Schell and our summer staff for their technical assistance with project development and implementation. The final report will be distributed through WARC's website and included in WARC's annual report.

Appendices

Appendix A – Agronomic information specific to 2014 and 2015 demonstrations

Abstract

Abstract/Summary

Chickpeas have been the highest profit grain crop on a per acre basis in Saskatchewan since their introduction. So far the lack of consistent terminal stress in the dark brown and black soil zones have limited the expansion of this crop into the southeast region and many other parts of Saskatchewan. The crop is very susceptible to *Aschochyta* and requires repeated applications of fungicide. Intercropping is considered for increasing and stability of yield per average unit and despite being an interesting theory, it

has gained little attention on a larger scale due to factors such as grain separation, timing of harvest and weed control among others. There needs to be a compelling agronomic reason to add the extra complication of an additional crop to get farmers and industrial adoption of this new practice. The chickpea flax intercropping may be an economically feasible venture on a commercial scale in Saskatchewan. This is because seeding, weed control, harvest timing, and grain separation are all manageable operations. Therefore, in order to evaluate the effect of chickpea/flax intercrop, a study was carried out at the Scott Research Farm in the 2014 and 2015 growing season as a randomized complete block design, with four replicates. There was generally a significant difference among treatments in chickpeas on all measured response variables, with desi recording significantly higher values relative to the kabuli in an intercropping setting and kabuli recording highest under mono-cropping setting. Yield results indicated that the highest yield was obtained from both desi and kabuli chickpeas as sole crops relative to their intercrops, with kabuli yielding the highest under monocrop. In terms of flax yield, it tended to be high when intercropped with the kabuli compared to the desi variety. Finally, since maximum grain yield was obtained from the treatment of one row of barley and one row of desi chickpea, compared with other treatments from previous studies, different chickpea/flax configurations (such as 2:1, 3:1 and 3:2) can be tested to determine which best combinations will give overall yield benefit in the intercrop relative to the monocrop.

Appendix A
Agronomic information specific to 2014 and 2015 demonstrations

Table A.1. Selected agronomic information for Chickpea Flax Intercropping trial at Scott, Saskatchewan.

Seeding	**2014 Details**	**2015 Details**
Seeder	R-Tech Drill, 10 inch row spacing, knife openers	R-Tech Drill, 10 inch row spacing, knife openers
Seeding Date	May 21, 2014 for both crops	May 19, 2015 for both crops
Cultivars	Corinne – Desi Chickpea Alma – Kabuli Chickpea Bethune –Flax	Corinne – Desi Chickpea Alma – Kabuli Chickpea Bethune –Flax
Seeding Rate (based on treatment)	Chickpea (Desi) – 30, 40 and 50 seeds m^{-2} Chickpea (Kabuli) – 30, 40 and 50 seeds m^{-2} Flax – 40 and 60 Ibs/ac	Chickpea (Desi) – 30, 40 and 50 seeds m^{-2} Chickpea (Kabuli) – 30, 40 and 50 seeds m^{-2} Flax – 56 kg/ha
Stubble Type	Canola	Canola
Fertilizer applied to Chickpea and Flax	P-K-S was applied in seed row with flax at rates 22.4 kg P_2O_5/ha as MAP, 11.2 kg K_2O/ha as KSO_4 and 3.8 kg S/ha as KSO_4, respectively All N treatments received same blend of N in the form of Urea (11.2 kg N/ha), except treatment 10 which received extra 44.8 kg N/ha	No fertilizer was applied except treatment 10 which received 60 kg/ha N
Plot Maintenance		
Pre-plant herbicide	Authority @ 118mL/ac on May 14, 2014 and Glyphosate + Bromoxynil @ 1 L/ac on May 21, 2014.	Authority @ 118mL/ac on May 8, 2015 and Glyphosate 1 L/ac on May 18, 2015.
In-crop herbicide	None	None
Data Collection		
Emergence Counts	June 02, 2014 for Chickpea May 31, 2014 for Flax	June 09, 2015 for both crops
Plant Height	N/A	August 05, 2015
Desiccation	N/A	September 24, 2015
Harvest Date	N/A trial failed	October 01, 2015

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