FINAL PROJECT REPORT
Canola Agronomic Research Program (CARP)

The Annual Final Report should fully describe the work completed for the year and note the personnel involved. It should also note any deviations from the original plan and next and/or corrective steps as may be required if deviations are noted. The report should also provide an update on the status of the Project including forecasted date of completion. A complete statement of expenses should be included. In the event major changes are anticipated within the budget supporting notes along with a proposed budget should also be included. The report should also capture a complete summary of activity for the year.

Project Title: **Seeding Between the Lines: evaluating the potential of inter-row seeding for canola in southern Alberta**

Research Team Information

Lead Researchers:		
Name	***Institution***	***Expertise Added***
Ken Coles	Farming Smarter	B.Sc, M.Sc
Research Team Members		
Name	***Institution***	***Expertise Added***
Mike Gretzinger	Farming Smarter	B.Sc

Project Start Date: May 1, 2011 **Project Completion Date:** March 31, 2015

Reporting Period: December 1, 2011 **to** March 31, 20 15

CARP Project Number: _____

Instructions: This Final Project Report shall be completed and submitted on or about March 31st of the fiscal year that the agreement is in effect (upon completion of the project). The Lead Researcher of the project in question shall complete and submit the report on behalf of his/her complete research team.

This Report is a means by which to provide a detailed account upon completion of the project.. Final project financial reporting should be provided at this time.

The following template is provided to assist you in completing this task. Please forward the completed document electronically to your appropriate CCC contact.

1. Date of Completion:

March 31, 2015

2. Status of Activity: (please check one)

_____ Ahead of Schedule __x__ On Schedule _____ Behind Schedule _____ Completed

Comment:

This is the final project report. Initially, the project was scheduled to end in 2014. However, the 2013 crop was lost due to hail and flooding and the project was extended by 1 season to complete the three site-year data.

3. Completed actions, deliverables and results; any major issues or variance between planned and actual activities.

Actions Completed

This is the final project report. All the actions competed under this study were guided by the main objective of the project as stated in the original project proposal: *"To evaluate inter-row seeding by measuring seedling establishment and yield in relation to stubble location, stubble heights and seeding rates."* All of the data gathering activities and statistical analysis have been completed.

The details and background information on the motivation for the study, potential benefit to the producers and industry and the methodology and research plan can be seen in the original project proposal attached as Appendix A. However, to make the study more useful, a few minor changes (variance) were made to the original research plan after the discussions with the producers and the agricultural Industry experts in the region.

Variance

- Based on consultations with the producers and agronomy professionals, it was decided that instead of using two canola seeding rates (standard and half of the standard) only the standard seeding rate would be used in the study. The half seeding rate was replaced by using two types of seed row openers (Pillar Lasers - disc hoe and Stealth Paired row hoe). This decision was made because the producers and industry seemed more interested in seeing the results of using the new strategies in combination of the standard practices. The modified experimental design consisted of the following:
    - Two factor factorial treatment arrangement within an RCBD with four replications
    - Factor 1: Type of seeding row opener with two types,
        - "Disc" (Pillar Lasers - disc hoe – Figure 1
        - "Hoe" (Stealth Paired row hoe) – Figure 2
    - Factor 2: Seeding orientation with three levels,
        - "InterRow" (between the stubble) – Figure 3
        - "OnRow" (directly on the stubble) – Figure 4
        - "Control" (no attempt to align with stubble)

- Initially, the project was scheduled from May 2011 to end of 2014. However, the 2013 crop was lost due to hail and flooding and the project was extended by 1 season to complete three site-years of data.

The field trial was set up on large-size plots (approximately 50m x 1.93 m) in the dark brown soils zone near Lethbridge, Alberta. Data was collected on the plant emergence and final plant stands, weed presence and

abundance, soil temperatures, canopy closure, stubble heights and yield. Further details of field operations and cultural practices are listed in Appendix B. As given in Table 1, a total of six two-way factorial treatment combinations within a RCBD were setup in the field with four replications and the data were collected. Descriptive statistics were estimated for all six treatments across all the crop parameters assessed. A two-way ANOVA was conducted and the mean separation was performed with Tukey's HSD test with a type I error rate (α) of 0.05.

Figure 1. A general view of the "Pillar Lasers - disc hoe" type seeding row openers mounted on the plot seeder.

Figure 2. A general view of the "Stealth Paired row hoe" type seeding row openers mounted on the plot seeder.

Figure 3. The "Stealth Paired row hoe" type seeding row opener mounted on the plot seeder shown between stubble rows, i.e., in the "Inter-Row" seeding orientation.

Figure 4. The "Stealth Paired row hoe" type seeding row opener mounted on the plot seeder shown on the stubble row, i.e., in the "On-Row" seeding orientation.

Table 1. Six treatment combinations with two-way factorial treatment arrangement used in the study.

Type of Seeding Row Opener (Factor 1)	**Seeding Orientation (Factor 2)**		
	Control (no attempt to align with stubble)	InterRow (between the stubble)	OnRow (directly on the stubble)
Disc (Pillar Lasers - disc hoe)	*Disc_Control*	*Disc InterRow*	*Disc_OnRow*
Hoe (Stealth Paired row hoe)	*Hoe_Control*	*Hoe_InterRow*	*Hoe_OnRow*

Results

Detailed data analysis and results are given in Appendix C. However, a brief overview of the analysis results is presented in the following.

Soil Temperature in InterRow and OnRow Seeding Orientations: Figure 5 shows soil temperature measured in InterRow and OnRow seeding orientations for three out of four study years. The crop was lost due to the flooding in 2013. As seen in Figure 5, soil temperature averaged close to 14 degrees Celsius during the season for all three study years in both seeding orientations. Because soil temperature averaged very close in both seeding orientations, it would not have apparently affected the three parameters assessed in the study, i.e., canola plant stand count, weed intensity and yield.

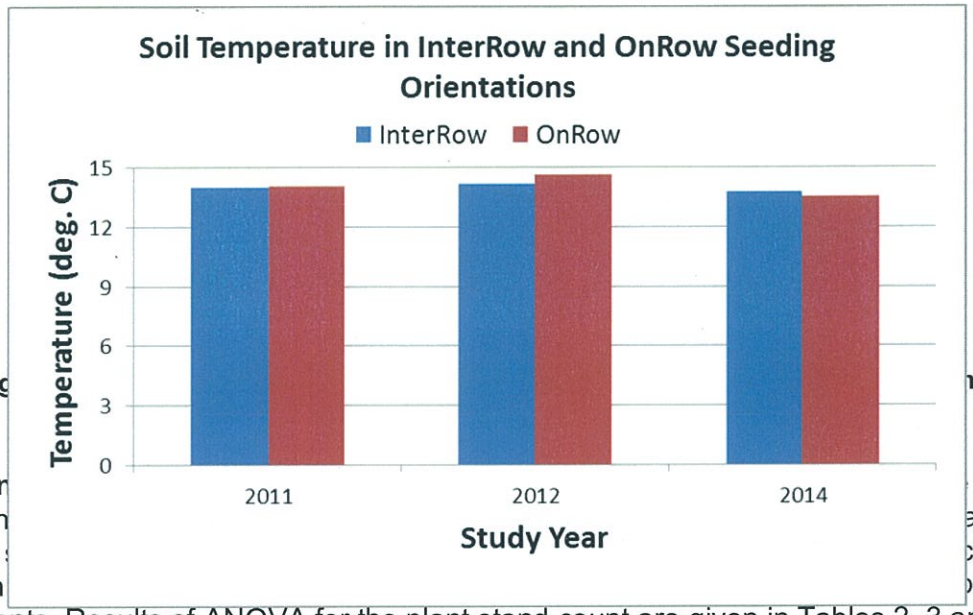

Fig ns.

Canola Plant Star four study years. Except for 2013, th ame years, plant stand consistently crop would have been possible with lant stand differed among the treatments. Results of ANOVA for the plant stand count are given in Tables 2, 3 and 4 for years 2011, 2012 and 2014, respectively. In 2011, the Inter-Row seeding orientation produced the highest plant stand count which was similar to the Control but significantly different from OnRow seeding with the lowest stand. The same trend was noted in 2012. However, in 2014 the Control treatment was significantly lower than the inter-row but not lower than the OnRow treatment.

When the plant stand data was examined for the two types or seeding row openers using ANOVA, there was no difference (P=0.05) between the treatments for three of the four years, 2011, 2013 and 2014. However, the overall trend shows that the performance of the "Pillar Lasers - disc hoe" type opener was significantly superior to the "Stealth Paired row hoe" type opener. Figure 7 shows treatment combination means for plant stand data (Figure 6) averaged over four project years and ranked in descending order. The treatments ranked in the order are: Disc_InterRow > Hoe_InterRow > Disc_Control > Hoe_Control > Disc_OnRow > Hoe_OnRow. The results of ANOVA for these treatment combination means are given in Table 6.

Conclusion: Based on the findings presented above, it can be concluded that on average, seeding canola crop between stubble rows from the previous crop with "Pillar Lasers - disc hoe" type seeding row openers produced the highest canola plant stand and is therefore is most likely to benefit producers in establishing a healthy and profitable canola crop. This practice can be even more beneficial in improving canola plant emergence and initial crop establishment under dryland condition because of its high potential of improving soil moisture conditions and reducing wind and water erosion.

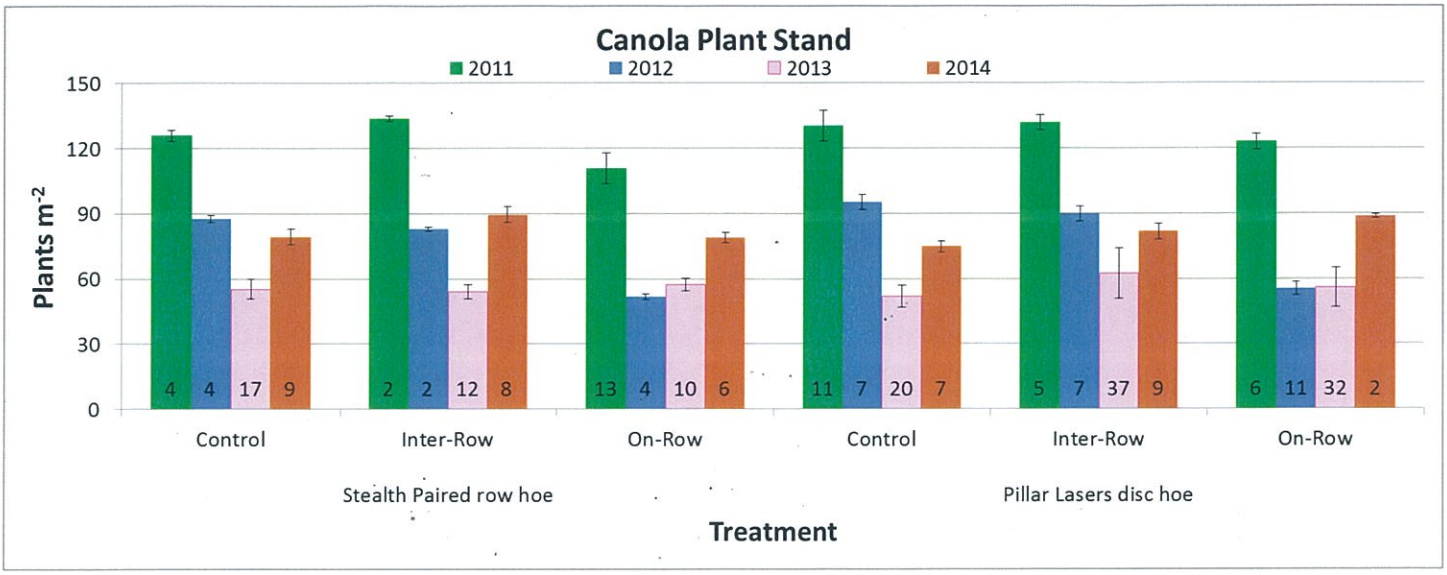

Figure 6. Treatment mean bar plots for canola plant stand (count) for the four crop years with standard error bars shown at the top and CV (%) values inside of each bar plot.

Table 2. Treatment means and Tukey groupings for canola plant stand count under three seeding orientations in 2011. Means with the same letter are not significantly different.

Seeding Orientation	Canola Plant Count per m^2	Tukey Grouping (P=0.05)
Control	128	A
OnRow	117	B
InterRow	133	A

Table 3. Treatment means and Tukey groupings for canola plant stand count under three seeding orientations in 2012. Means with the same letter are not significantly different.

Seeding Orientation	Canola Plant Count per m^2	Tukey Grouping (P=0.05)
Control	91	A
OnRow	53	B
InterRow	86	A

Table 4. Treatment means and Tukey groupings for canola plant stand count under three seeding orientations in 2014. Means with the same letter are not significantly different.

Seeding Orientation	Canola Plant Count per m^2	Tukey Grouping (P=0.05)
Control	77	B
OnRow	83	AB
InterRow	86	A

Table 5. Treatment means and Tukey groupings for canola plant stand count under two types of seeding row openers in 2012. Means with the same letter are not significantly different.

Type of Seeding	Canola Plant	Tukey Grouping

Row Opener	Count per m^2	(P=0.05)
disc (Pillar Lasers - disc hoe)	80	A
hoe (Stealth Paired row hoe)	74	B

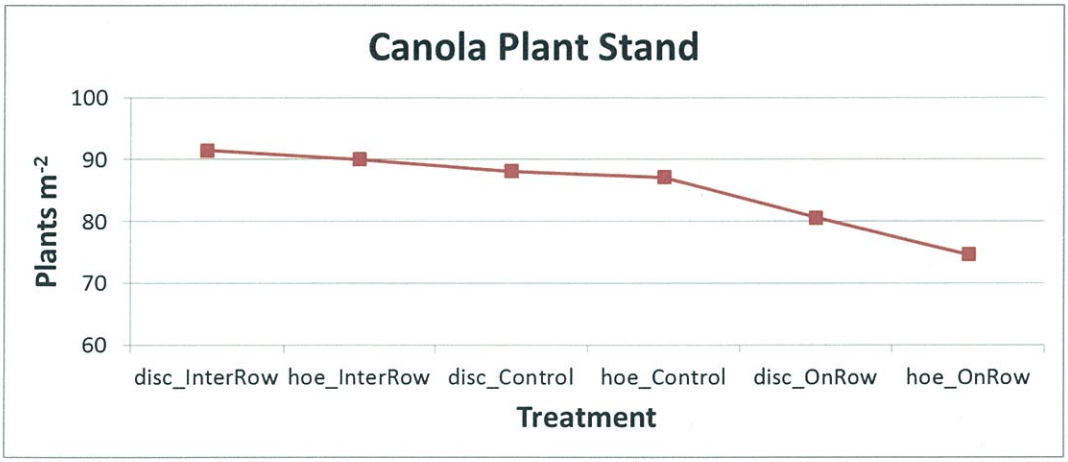

Figure 7. Treatment means for canola plant stand count over the six treatment combinations with three seeding orientations and two types of seeding row openers. The data was pooled over four project years and ranked in descending order.

Table 6. Treatment means and Tukey groupings for canola plant stand count under six treatment combinations with three seeding orientations and two types of seeding row opener. Means with the same letter are not significantly different.

Treatment Combination*	Canola Plant Count per m^2	Tukey Grouping (P=0.05)
Disc_InterRow	91	A
Hoe_InterRow	90	A
Disc_Control	88	AB
Hoe_Control	87	AB
Disc_OnRow	81	BC
Hoe_OnRow	75	C

* The prefixes "disk" and "hoe" in these treatment combinations refer to two different types of seed row openers, the "Pillar Lasers - disc hoe" and "Stealth Paired row hoe", respectively. The postfixes, "InterRow", "OnRow" and "Control" refer to the canola seeding orientations of "between the stubble", "directly on the stubble" and "no attempt to align with stubble", respectively.

Weed Count: Figure 8 shows treatment mean bar plots for weed count for the two crop years, 2011 and 2013, with standard error bars shown at the top and CV (%) values inside of each bar plot. Weed count data for years 2012 and 2014 were not collected. High CV values indicate the variation of weed counts within treatments was high in both years, with the year 2013 exceeding 2011. On average, weed counts were lowest in the treatment combination of Pillar Lasers - disc hoe type seeding openers and on-row seeding orientation. Figure 9 shows

the treatment means averaged over two project years and ranked in descending order, suggesting that weed count dropped in the order are: Hoe_Control > Hoe_InterRow > Disc_InterRow > Disc_Control > Hoe_OnRow > Disc_OnRow. However, an ANOVA of these data showed that because of the high within treatment variation in weed count, differences between treatment means were not statistically significant at 0.05 level.

Conclusion: On average, the weed count was lower when canola crop was seeded with "Pillar Lasers - disc hoe" type openers in On-Row and Control seeding orientations compared to the treatment combinations of Inter-Row and "Stealth Paired row hoe" type openers. However, because treatments were not found statistically different at 0.05 level, definite conclusions could not be drawn and further verification of those differences is needed.

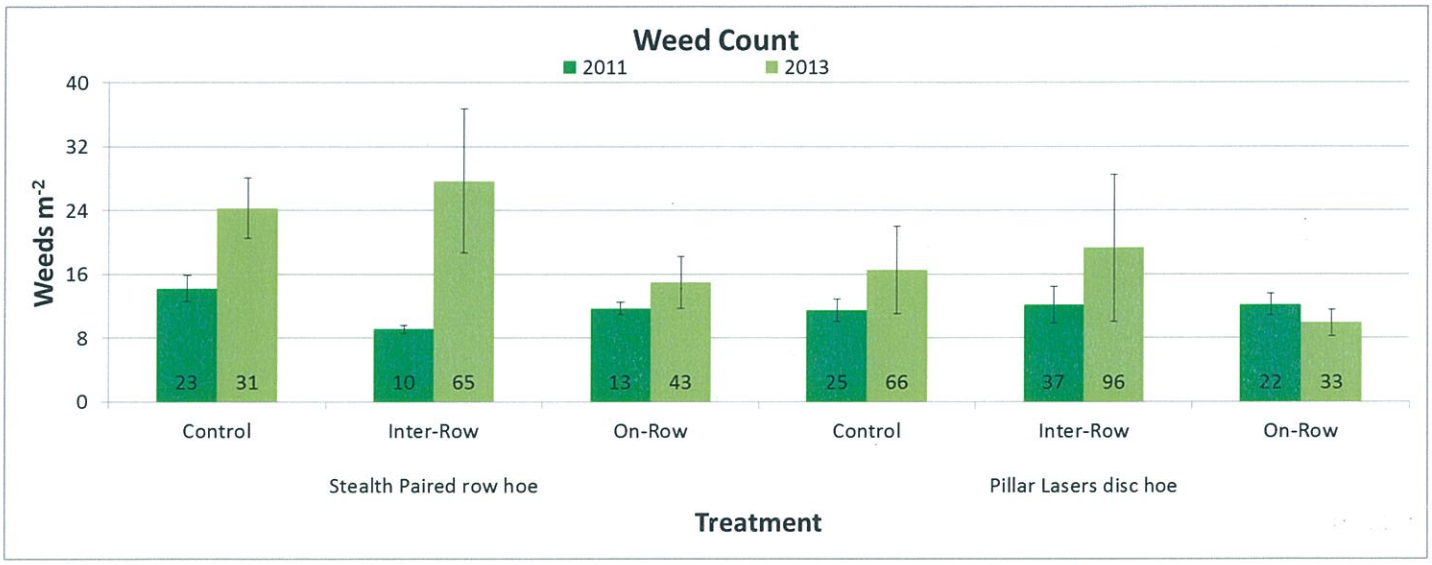

Figure 8. Treatment mean bar plots for weed count for the two crop years (2011, 2013) with standard error bars shown at the top and CV (%) values inside of each bar plot. Weed count data for years 2012 and 2014 was not collected.

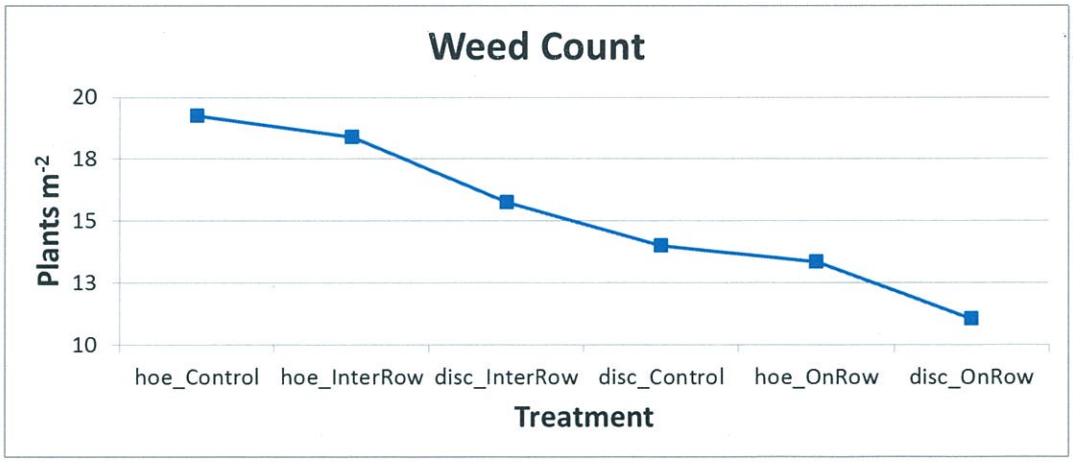

Figure 9. Treatment means for weed count for the six treatment combinations with three seeding orientations and two types of seeding row opener. The data was pooled over two project years (2011 and 2013) and ranked in descending order.

Canola Yield: Figure 10 shows treatment means for canola yield for three of the four study years. In 2013 the canola crop was lost due to hail and flooding and yield data could not be collected. Relatively large CV values for 2011 yield data show higher variation in treatment means compared to 2012 and 2014. In general, canola yield also showed an increasing trend for four of the six treatments from 2011 to 2014. However, an ANOVA

(data not shown) showed that seeding orientations alone did not have any effect on canola yield for all three years during the study. But, the two types of seeding row openers showed significant effect on canola yield in 2011 and 2012, as given in Tables 7 and 8. For both years, the "Pillar Lasers - disc hoe" type opener produced significantly better yields compared to the "Stealth Paired row hoe" type opener.

Figure 11 shows treatment combination means for the canola yield data (Figure 10) averaged over the three years and arranged in descending order. The ANOVA results for these treatment combinations are given in Table 6. The treatments ranked in the order are: Disc_InterRow > Disc_Control > Disc_OnRow > Hoe_Control > Hoe_InterRow > Hoe_OnRow. The highest yield was obtained by the treatment "Disc_InterRow" and the lowest was the "Hoe_OnRow". Canola yields from the three seeding orientations treatments with "disc" combinations were consistently higher than the ones with "hoe" combinations.

Conclusion: Based on the analysis discussed above, it can be concluded that the "Pillar Lasers - disc hoe" type seeding row openers performed significantly better than the "Stealth Paired row hoe" type openers and produced high yields especially when used to seed canola crop between the stubble of the previous crop.

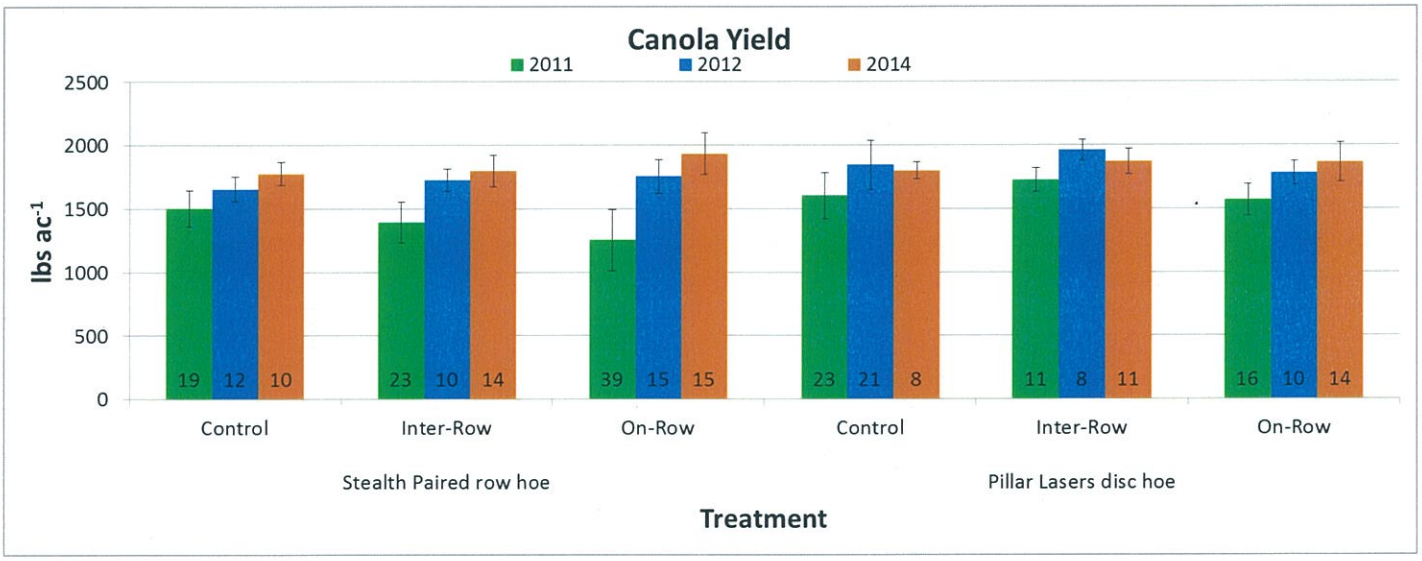

Figure 10. Treatment mean bar plots for canola yield for the four crop years with standard error bars shown at the top and CV (%) values inside of each bar plot.

Table 7. Treatment means and Tukey groupings for canola yield over two types of seeding row openers in 2011. Means with the same letter are not significantly different.

Type of Seeding Row Opener	Canola Yield (lbs ac^{-1})	Tukey Grouping (P=0.05)
Disc (Pillar Lasers - disc hoe)	1632	A
Hoe (Stealth Paired row hoe)	1383	B

Table 8. Treatment means and Tukey groupings for canola yield over two types of seeding row openers in 2012. Means with the same letter are not significantly different.

Type of Seeding Row Opener	Canola Yield (lbs ac^{-1})	Tukey Grouping (P=0.05)

Disc (Pillar Lasers - disc hoe)	1862	A
Hoe (Stealth Paired row hoe)	1712	B

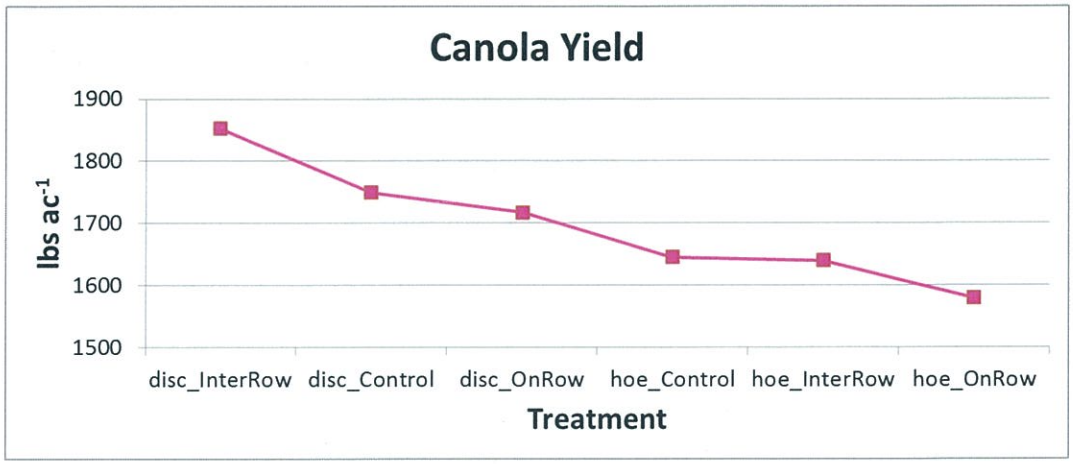

Figure 11. Treatment means for canola yield for the six treatment combinations with three seeding orientations and two types of seeding row opener. The data was pooled over two project years (2011 and 2013) and ranked in descending order.

Table 9. Treatment means and Tukey groupings for canola yield for the treatment combinations with three seeding orientations and two types of seeding row opener. Means with the same letter are not significantly different.

Treatment Combination*	Canola Yield (lbs ac^{-1})	Tukey Grouping (P=0.05)
Disc_InterRow	1853	A
Disc_Control	1749	AB
Disc_OnRow	1717	AB
Hoe_Control	1645	AB
Hoe_InterRow	1639	AB
Hoe_OnRow	1579	B

* The prefixes "disk" and "hoe" in these treatment combinations refer to two different types of seed row openers, the "Pillar Lasers - disc hoe" and "Stealth Paired row hoe", respectively. The postfixes, "InterRow", "OnRow" and "Control" refer to the canola seeding orientations of "between the stubble", "directly on the stubble" and "no attempt to align with stubble", respectively.

4. Significant Accomplishments

The results from this 3-year study validated the Farming Smarter's previous findings that seeding on-row significantly reduced plant stand establishment in canola compared to seeding between the row and check plots and that the canola yield was significantly higher with "Pillar Lasers - disc hoe" openers compared to the "Stealth Paired row hoe" type openers.

The results showed that, on the average, seeding canola crop between stubble rows with "Pillar Lasers - disc hoe" type seeding row openers produced the highest canola plant stand count and, therefore, would most likely benefit producers in establishing the healthiest and most profitable canola crop. The results also showed that the canola crop seeded with "Pillar Lasers - disc hoe" type seeding row openers produced significantly higher yields than the "Stealth Paired row hoe" type openers, especially when used for seeding between the stubble rows of the previous crop.

Based on our results, we anticipate that producers with the capability to inter-row seed would adopt the practice to enhance plant stands and protect against yield loss. It would also allow for better germination without increasing seed costs.

5. Research and Action Plans

No more research activities will be carried out under this project. The study has been completed and all the data gathered over the duration of the project have been completely analyzed and reported. This is the final report with concluding results of the study.

Our findings from the study will be shared throughout the winter months at various meetings such as the Farming Smarter Conference, the Farming Smarter AGM, the APCP regional meetings and other industry events. They may also be shared through the Farming Smarter website (www.farmingsmarter.com), the Farming Smarter Magazine and other news sources.

The expertise gained through funding this project will be applied to future research and demonstration opportunities regarding canola agronomics and precision agriculture. Knowledge about opener design, seeding rates, and residue management will help determine best practices for the industry moving forward.

Farming Smarter would like to continue studying canola agronomics through research projects aimed at evaluating long term canola rotational studies and addressing concerns such as the effect of a previous canola swath on a subsequent winter wheat crop.

6. Final Project Budget and Financial Reporting

N/A

Please forward an electronic copy of this completed document to:

Gail M. Hoskins
Crop Production Administrator and CARP Coordinator
Canola Council of Canada
400 – 167 Lombard Ave.
Winnipeg, MB R3B 0T6
Phone: (204) 982-2102
Fax: (204) 942-1841
E-Mail: hoskinsg@canolacouncil.org

Appendix A: Original project proposal and agreement

Research Agreement
Canola Agronomic Research Program (CARP)

"Seeding Between the Lines: evaluating the potential of inter-row seeding for canola in southern Alberta."

1. This is a Research Agreement between the Canola Council of Canada (CCC) and Farming Smarter (Institution) whereby the CCC pays to the Institution cash support of **CDN $35,000.00** (Contribution) for the Project detailed in Appendix "B" (Description of Research Project). CCC will advance funds to Farming Smarter according to Appendix "A" (Payment Schedule) and an initial payment is due upon the signing of this Research Agreement.

2. The Contribution will assist in conducting the Project, and the research will be of direct or indirect benefit to CCC.

3. The Project will be conducted from April 1, 2012 to March 31, 2014, inclusive.

4. (a) The Contribution will be used to fund the Project as outlined in Appendix "B";
   (b) Research Institution's obligation is to use the Contribution for the Project mentioned above;
   (c) If appropriate, research results will be published, subject to any patent or trade secret concerns; and
   (d) There are no other understandings or agreements regarding this contribution or Project except as stated in this Research Agreement.

If you find these terms and conditions acceptable, please have the appropriate authority in your organization date and sign both copies of this Research Agreement (in any colour of ink other than black), keep one original for your records, and return the other to us for our files (to the attention of Gail Hoskins, Canola Council of Canada, 400-167 Lombard Avenue, Winnipeg, MB R3B 0T6).

This Research Support Agreement has been executed, in duplicate, by duly authorized representatives of the parties and effective on the date of the last signature.

Yours truly,

_____

Name: Mr. Ken Coles
Title: General Manager, Agronomist
Institution: Farming Smarter
Date:

FOR Canola Council of Canada:

_____

Name: Cory McArthur
Title: Vice President, Market Development
Canola Council of Canada
Date:

APPENDIX "A"

CARP SCHEDULE/GUIDELINES

Payment #		Due Date	Amount
First Year Initial*	(40%)	Upon execution of agreement	$7,000.00
First Year Interim*	(40%)	December 1, 2012	$7,000.00
First Year Annual*	(20%)	March 31, 2013	$3,500.00
Second Year Initial*	(40%)	April 1, 2013	$7,000.00
Second Year Interim*	(40%)	December 1, 2013	$7,000.00
Second Year Final*	(20%)	March 31, 2014	$3,500.00
Total			**$35,000.00**

* Initial payment upon receipt of signed Research Agreement. Interim and Annual Payments will be based upon CCC's receipt and acceptance of Interim and Annual Project Reports, respectively.

Reports and Invoices:

Gail M. Hoskins
CARP Coordinator
Canola Council of Canada
400 – 167 Lombard Avenue
Winnipeg, MB R3B 0T6
Phone: (204) 982-2102
Fax: (204) 942-1841
Email: hoskinsg@canolacouncil.org

Project Payments:

Please Make Payments To:
Farming Smarter
Address: _____
_____
Postal Code: _____
Attention: _____

APPENDIX "B"

DESCRIPTION OF RESEARCH PROJECT

Abstract:

Highly accurate GPS guidance and automated steering has given producers the ability to seed between the stubble rows from previous crops. This practice may allow for improved canola emergence due to more accurate seed placement, improved seed to soil contact, improved micro-climate, higher soil temperatures, and seedling protection from more standing stubble.

In previous studies, Farming Smarter has found that:

- seeding on-row significantly reduced plant stand establishment in canola compared to seeding between the row and check plots,
- canola yield was significantly higher with pillar laser disc/hoe openers compared to stealth paired row,
- canola yield was not affected by row placement.

This study will be a continuation of previous work and will include two trials at two locations for two years. Locations include one in the dark brown soils zone near Lethbridge, AB and one in the brown soils zone (tbd). The trials will be designed as a four replicate factorial using relatively large plots (50m x 1.37m). Treatments are as follows:

Row orientation
1. Inter-row (between the stubble)
2. On-row (directly on the stubble)
3. Check plots (no attempt to align with stubble)

Seeding rate
1. Standard seeding rate (5 kg/ha)
2. Half rate (2.5 kg/ha)

Data collection will include emergence and final plant stands, week presence and abundance, soil temperatures, canopy closure, stubble heights and yield.

Problem/Opportunity Identified by the Industry:

In previous studies, Farming Smarter has found that:

- seeding on-row significantly reduced plant stand establishment in canola compared to seeding between the row an check plots.
- canola yield was significantly higher with pillar laser disc/hoe openers compared to stealth paired row,
- canola yield was not affected by row placement.

Impact/Benefits:

Advanced GPS signals such RTK and Omnistar give producers the precision accuracy to seed within 2.5cm of their intended target. However, the cost to upgrade from a basic WAAS signal is cost prohibitive without a proven return on investment.

Enhanced signals may allow for practices such as inter-row seeding, which could increase profits by either increased yields or decreased costs. Inter-row seeding could allow for taller standing stubble which is proven to help increase yields in zero-tillage systems. It could also improve depth control and furrow closure improving seedling establishment. This would allow for justified reduction in seeding rates without compromising yield or increasing risk. Plan stand establishment, canopy closure and weed competition might also be improved by inter-row seeding.

Objectives:

To evaluate inter-row seeding by measuring seedling establishment and yield in relation to stubble location, stubble heights and seeding rates.

Research Plan:

Background work
- startup meeting: review project
- finding a suitable location with tall barley stubble on 9" row spacing
- create project files, protocols, randomization
- calibrate seeder
- PSBD

Data Collection
- seeding treatments
- plant counts
- weed counts
- stubble heights
- pictures
- harvest

Reporting period
- interim report
- data processing and analysis
- final report
- extension activities

Tech Transfer Plan:

This project will distribute information through:
- annual interim report (December 1, 2012 and December 1, 2013)
- annual final report (March 31, 2013)
- final report (March 31, 2014)
- crop walks (during the season TBA)
- Diagnostic Field School (July 10-12, 2012)
- Presentations made to grower groups and at conferences
- video library of events and presentations on this project on www.farmingsmarter.com
- updates from Farming Smarter Twitter feeds and Facebook page
- articles in the bi-annual Farming Smarter magazine.

Reports will be provided to CCC and data will be published in peer-reviewed journals where applicable. Such publications will acknowledge support of all following contributors, where appropriate: Alberta Canola Producers Commission, Manitoba Canola Growers Association, SaskCanola and the Alberta Crop Industry Development Fund.

Results may be used by CCC for extension purposes.

Appendix B

Table 1B. Seeding summary and cultural information for the canola inter-row seeding trials in Lethbridge and Medicine Hat, Alberta.

Field Operations				
Year:	**2011**	**2012**	**2013**	**2014**
Trial Name:	Inter-row	Inter-row	Inter-row	Inter-row
Location:	Wrentham, AB	Demo Farm	SW corner irrigation demo farm	SW quad
Previous Crop:	wheat	barley	barley	barley (sileage)
Seeding Information				
Seeding Date:	May 16, 2011	April 23, 2012	May 14, 2013	May 1, 2014
Crop (variety):	Canterra 1841 RR	Canterra 1970 RR	Canterra 1970 RR	Canterra 1990 RR
Rate:	5lbs/ac	5lbs/ac	6kg/ha	6kg/ha
Depth:	1/2"	1/2"	1/2"	1/2"
Soil moisture conditions:	excellent	excellent	excellent	excellent
GPS/Plot spacing (m):	2.5m	2.5m	2.5m	2.5m
Disk setting:	DEF	DEF	DEF	DEF
number of rows seeded:	8	8	8	8
number of rows harvested:	8	6	8	8
Seeding equipment:	65	plot seeder	plot seeder	plot seeder
Trimmed plot length:	65	75	75	100
Harvested plot area:	119	109	145	193
Seed treatment:	as given	Helix Xtra	as given	as given
Rate of seed treatment	as given	as given	as given	as given
Inoculant:	n/a	n/a	n/a	n/a
Rate of inoculant:	n/a	n/a	n/a	n/a
tractor operator:	KC	KC	KC	TM
observers:	TM, RN	BN, TM	MG, TM	MG
Box # 1:	canola	canola	canola	canola
ZM setting (rate):	1.4	1.3	1.5	1.28
Box # 2:				
ZM setting (rate):				
Box # 3:	11-52-0	11-52-0	11-52-0	11-52-0
ZM setting (rate):		1.02 (50 kg/ha product)	1.4 (70 kg/ha product)	1.66 (30 lbs/ac actual P)
Box # 4:	46-0-0	46-0-0	46-0-0	46-0-0
ZM setting (rate):	1.81 (100kg/ha product)	1.78 (100 kg/ha product)	2.4 (150 kg/ha product)	1.48 (75 kg/ha product)
Cone length:	n/a	n/a	n/a	n/a
ZM setting:	n/a	n/a	n/a	n/a
Spray Treatments				
Pre-seed Burn off:	glyphosate	glyphosate	glyphosate	glyphosate
Date:	May 16, 2011	April 23, 2012	May 14, 2013	May 1, 2014
Rate:	1L/ac eq	1L/ac eq	1L/ac eq	1L/ac eq
In-crop Treatment (s):	glyphosate	glyphosate		glyphosate
Date:	June 15, 2011	May 24, 2012		May 30, 2014
Stage:	4-6 leaf	4-6 leaf		4 leaf
Rate:	1L/ac eq	1L/ac eq		1L/ac eq
Harvest Data				
Harvest method:	Straight Cut	Straight Cut		Straight Cut
Harvest equipment:	1978 Hege Plot Combine	1978 Hege Plot Combine		2013 Wintersteiger Classic
Harvest date:	September 23, 2011	September 6, 2012		September 7, 2014

Appendix C

Table C1. Treatment means for the canola inter-row seeding project in Lethbridge, Alberta.

Study Year	Treatment ID	Treatment Combination*	Plant count per m^2	Weed Count per m^2	Canola Yield (lbs ac^{-1})
2011	1	hoe_InterRow	134	9	1394
	2	hoe_OnRow	111	12	1253
	3	hoe_Control	126	14	1503
	4	disc_InterRow	132	12	1724
	5	disc_OnRow	123	12	1570
	6	disc_Control	130	12	1603
2012	1	hoe_InterRow	83	N/A	1725
	2	hoe_OnRow	52	N/A	1756
	3	hoe_Control	88	N/A	1655
	4	disc_InterRow	90	N/A	1962
	5	disc_OnRow	55	N/A	1781
	6	disc_Control	95	N/A	1844
2013	1	hoe_InterRow	54	28	N/A
	2	hoe_OnRow	57	15	N/A
	3	hoe_Control	55	24	N/A
	4	disc_InterRow	62	19	N/A
	5	disc_OnRow	56	10	N/A
	6	disc_Control	52	17	N/A
2014	1	hoe_InterRow	90	N/A	1798
	2	hoe_OnRow	79	N/A	1932
	3	hoe_Control	79	N/A	1776
	4	disc_InterRow	82	N/A	1872
	5	disc_OnRow	89	N/A	1864
	6	disc_Control	75	N/A	1800

* The prefixes "disk" and "hoe" in these treatment combinations refer to two different types of seed row openers, the "Pillar Lasers - disc hoe" and "Stealth Paired row hoe", respectively. The postfixes, "InterRow", "OnRow" and "Control" refer to the canola seeding orientations of "between the stubble", "directly on the stubble" and "no attempt to align with stubble", respectively.

Table C2. Standard Error of the mean values for the treatment means given in Table C1, above.

Study Year	Treatment ID	Treatment Combination*	Plant count per m^2	Weed Count per m^2	Canola Yield (lbs ac^{-1})
2011	1	hoe_InterRow	1.1	0.5	157.9
	2	hoe_OnRow	7.1	0.8	241.6
	3	hoe_Control	2.5	1.6	139.9
	4	disc_InterRow	3.4	2.3	93.0
	5	disc_OnRow	3.7	1.3	121.7
	6	disc_Control	7.1	1.4	180.7
2012	1	hoe_InterRow	1.0	N/A	87.6
	2	hoe_OnRow	1.1	N/A	133.1
	3	hoe_Control	1.6	N/A	96.4
	4	disc_InterRow	3.3	N/A	82.8
	5	disc_OnRow	3.1	N/A	93.4
	6	disc_Control	3.5	N/A	195.6
2013	1	hoe_InterRow	3.2	9.0	N/A
	2	hoe_OnRow	3.0	3.3	N/A
	3	hoe_Control	4.7	3.8	N/A
	4	disc_InterRow	11.5	9.2	N/A
	5	disc_OnRow	9.0	1.6	N/A
	6	disc_Control	5.2	5.5	N/A
2014	1	hoe_InterRow	3.6	N/A	122.0
	2	hoe_OnRow	2.3	N/A	163.9
	3	hoe_Control	3.6	N/A	90.2
	4	disc_InterRow	3.7	N/A	99.2
	5	disc_OnRow	0.9	N/A	152.1
	6	disc_Control	2.6	N/A	67.7

* The prefixes "disk" and "hoe" in these treatment combinations refer to two different types of seed row openers, the "Pillar Lasers - disc hoe" and "Stealth Paired row hoe", respectively. The postfixes, "InterRow", "OnRow" and "Control" refer to the canola seeding orientations of "between the stubble", "directly on the stubble" and "no attempt to align with stubble", respectively.

Table C3. Coefficient of variation (CV: %) values for the treatment means given in Table C1, above.

Study Year	Treatment ID	Treatment Combination*	CV (%)		
			Plant count	Weed Count	Canola Yield
2011	1	hoe_InterRow	2	10	23
	2	hoe_OnRow	13	13	39
	3	hoe_Control	4	23	19
	4	disc_InterRow	5	37	11
	5	disc_OnRow	6	22	16
	6	disc_Control	11	25	23
2012	1	hoe_InterRow	2	N/A	10
	2	hoe_OnRow	4	N/A	15
	3	hoe_Control	4	N/A	12
	4	disc_InterRow	7	N/A	8
	5	disc_OnRow	11	N/A	10
	6	disc_Control	7	N/A	21
2013	1	hoe_InterRow	12	65	N/A
	2	hoe_OnRow	10	43	N/A
	3	hoe_Control	17	31	N/A
	4	disc_InterRow	37	96	N/A
	5	disc_OnRow	32	33	N/A
	6	disc_Control	20	66	N/A
2014	1	hoe_InterRow	8	N/A	14
	2	hoe_OnRow	6	N/A	15
	3	hoe_Control	9	N/A	10
	4	disc_InterRow	9	N/A	11
	5	disc_OnRow	2	N/A	14
	6	disc_Control	7	N/A	8

* The prefixes "disk" and "hoe" in these treatment combinations refer to two different types of seed row openers, the "Pillar Lasers - disc hoe" and "Stealth Paired row hoe", respectively. The postfixes, "InterRow", "OnRow" and "Control" refer to the canola seeding orientations of "between the stubble", "directly on the stubble" and "no attempt to align with stubble", respectively.