ADOPT Projects 2022

SERF ADOPT #20211058
ICDC ADOPT # 20211117
NARF ADOPT #20211116
WARC ADOPT #20211115
ECRF ADOPT # 20211114

Title: Demonstrating seeding methods to improve yield and maturity in camelina

Final ADOPT Combined Report

Report prepared by Lana Shaw with assistance from Ishita Patel and from ICDC, NARF, WARC and ECRF

Project Identification

1. **Project Title:**
2. **Project Number:** ADOPT 20211058, # 20211117, #20211116, #20211115, # 20211114
3. **Producer Group Sponsoring the Project:** N/A
4. **Project Location(s):**
    - South East Research Farm - SERF (Redvers)
    - Northeast Agricultural Research Foundation - NARF (Melfort)
    - Irrigation Crop Diversification Center - ICDC (Outlook)
    - Western Applied Research Corporation - WARC (Scott)
    - East Central Research Foundation ECRF (Yorkton)
5. **Project start and end dates (month & year):** April 2022 to January 2023
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

This project tests the seeding rates and depths for *Camelina sativa* under no-till seeding conditions in Saskatchewan. Camelina is a very small-seeded crop that is sensitive to excessive seeding depth.

8. **Project Rationale:**

Camelina is a new crop for Saskatchewan, but it has an ancient history in Europe as a cultivated oilseed. It is of interest as a Climate-Smart biofuel and food source. Seeding recommendations from camelina breeders have emphasized seeding very shallowly into cultivated, level soil but under dry spring conditions this resulted in delayed establishment in Redvers in 2021. Since no-till seeding is important to conserve moisture for spring emergence, this demonstration shows how camelina can be most effectively seeded under no-till conditions. The project will help to determine optimal target plant densities for maximizing yield, even establishment, and uniform maturation under no-till conditions.
Seeding rate and plant density effects on yield and maturity were investigated by Johnson et al in 2010 as part of an ADF-funded MSc Thesis for Chantal Bauche. In that multi-site trial, seeding rate of 500 seeds/m^2 was sufficient to optimize yield and improve evenness of maturity. That trial and the Urbaniak et al. trial did not investigate the effect of seeding depth on resultant establishment or seed mortality. This trial will build on their results to determine how to achieve an optimal plant density of >100 plants/m^2 with varying seeding depths.

Urbaniak, S.D., Caldwell, C.D., Zheljazkov, V.D., Lada, R. and Luan, L. 2008. The effect of seeding rate, seeding date and seeder type on the performance of Camelina sativa L. in the Maritime Provinces of Canada. Can. J. Plant Sci. 88: 501–508.

Methodology and Results

9. **Methodology:**

The project was carried out by seeding at five sites across the dark brown and black soil zones in spring 2022 (Table 1). Seed of Newgold SES1154HR was contributed by Smart Earth and the recommended rate of 6.7 kg/ha (6 lb/ac) was determined by this industry contractor. Newgold SES1154HR from Smart Earth contains thifensulfuron-methyl resistance, so some broadleaf weeds can be controlled by Pinnacle SG.

The field trials were set up with small field plots as strip-plot design with four replicates and 12 total treatments at Redvers, Scott, Melfort and Outlook. All sites use a narrow-type hoe opener on a small plot seeder with side-banding capabilities. The horizontal factor was seeding depth with three levels: Shallow, Medium, and Deep. The vertical factor was seeding rate with 0.25x, 0.5x, 1x, and 1.5x with 6 lb/ac being the X recommended rate. At ECRF, the same factors were arranged in a split plot design with four replicates due to their seeding equipment. In that case seed depth was the main plot and seed rate was the sub-plot.

Plant density was determined from four linear meter rows per plot after emergence. Uniformity of emergence was rated from 1 to 10 with 10 being the most uniform. Plant height was determined by measuring three plants per plot (font, middle and back) after completion of flowering. Maturity was based on color change in the middle of the main raceme on 75% of plants.

After combine harvest, yield was calculated and samples were submitted for quality analysis to the Smart Earth laboratory. Table A1 in the Appendix provides temperature and precipitation data for the 2022 growing season, and Table A2 has the dates for operations at each site.

Data within each site were compared between treatments using Statistix 10.0 using either the strip-plot or split plot analysis. Treatment differences were considered significant at $P \leq 0.05$. There were minimal significant depth x rate interactions and this data is not shown because of the complicated nature of the LSDs for a strip-plot or split-plot comparison.

Table 1. Treatment list with approximated depth and seed rates evaluated.

Treatment #	Depth	Seeding Rate
1	1 (minimum)	0.25 x
2		0.5 x
3		1 x
4		1.5 x
5	2 (intermediate)	0.25 x
6		0.5 x
7		1 x
8		1.5 x
9	3 (3/4”)	0.25 x
10		0.5 x
11		1 x
12		1.5 x

Table 2. Soil type and texture at the four sites.

Site	SERF	ICDC	ECRF	WARC	NARF
Soil texture	Loam	Elstow loam	Clay Loam	Loam	Clay Loam
Soil Zone / Irrigation	Thin Black	Irrigated Brown 6.5 inches irrigation	Moist Black	Dark Brown	Moist Black

10. Results

All five sites were successful in producing a crop of camelina in 2022.

Table 3. Means of parameters and results after ANOVA analysis for each site. Different letters beside values, where present, indicate statistically significant differences in means for that column at 95% confidence level for that site based on Least Significant Difference. Absence of letters indicate no statistically significant difference between means for that site.

	Treatment Level	Plant Density (plants/m^2)		Uniformity Rating 1 to 10		Days to Maturity		Yield (kg/ha)	
SERF									
Depth	1. Shallow	163	A	8.7		91.5	B	2545	
	2. Medium	136	B	7.7		92.2	AB	2475	
	3. Deep	97	C	7.3		93.4	A	2396	
Seed Rate	1. Rate 0.25x	39	D	6.8	B	93.5	A	2227	B
	2. Rate 0.5x	80	C	7.9	A	92.6	AB	2497	A
	3. Rate 1x	171	B	8.4	A	91.8	BC	2613	A
	4. Rate 1.5x	238	A	8.5	A	91.6	C	2551	A
ICDC									
Depth	1. Shallow	122	A	n/a		87		2891	
	2. Medium	118	A	n/a		87		2912	
	3. Deep	82	B	n/a		87		2728	
Seed Rate	1. Rate 0.25x	17	D	n/a		87		2478	B
	2. Rate 0.5x	66	C	n/a		87		2977	A
	3. Rate 1x	155	B	n/a		87		2969	A
	4. Rate 1.5x	192	A	n/a		87		2951	A
WARC									
Depth	1. Shallow	59	A	4.3	A	96.4	B	1685	A
	2. Medium	60	A	4.4	A	95.9	B	1759	A
	3. Deep	24	B	2.4	B	100.1	A	1301	B
Seed Rate	1. Rate 0.25x	15	C	1.7	D	102.7	C	1174	B
	2. Rate 0.5x	41	B	3.4	C	97.2	B	1592	A
	3. Rate 1x	52	B	4.3	B	96.3	B	1720	A
	4. Rate 1.5x	84	A	5.5	A	93.8	A	1841	A
ECRF									
Depth	1. Shallow	176	A	5.5		103.8		2404	
	2. Medium	187	A	6.3		102.3		2384	
	3. Deep	191	A	6.1		104.6		2330	
Seed Rate	1. Rate 0.25x	59	D	3.4	D	105.3	A	2360	
	2. Rate 0.5x	130	C	5.1	C	104.7	A	2477	
	3. Rate 1x	215	B	6.9	B	102.4	B	2355	
	4. Rate 1.5x	336	A	8.3	A	101.8	B	2298	
NARF									
Depth	1. Shallow	57.1	A	5.3		N/A		1987	A
	2. Medium	44.0	B	4.6		N/A		1757	A
	3. Deep	31.7	B	4.1		N/A		1395	B
Seed Rate	1. Rate 0.25x	18.9	C	2.6	B	N/A		1429	B
	2. Rate 0.5x	23.4	C	3.6	B	N/A		1537	B
	3. Rate 1x	52.0	B	5.7	A	N/A		1865	A
	4. Rate 1.5x	82.6	A	6.7	A	N/A		2021	A

Table 3 summarizes the agronomic results of the five trials. The medium seeding depth had significantly lower plant density than the shallow, recommended depth at only SERF (83% of shallow depth). However, the deep seeding depth had a significantly lower plant density (59% of shallow depth) at four locations (SERF, WARC, ICDC and NARF). The varying seeding rate had significant effects on plant densities in line with expectations. The effect of seeding depth on uniformity of emergence rating was only statistically significant at WARC, but uniformity increased with seeding rates at all locations where it was assessed.

Seeding depth affected days to maturity (DTM) at two locations (SERF and WARC). In those situations, the deep seeding depth delayed maturity by 1.9 days at SERF and 3.7 days at WARC. Days to maturity decreased as seeding rate increased at three locations but at two locations there were no differences.

At WARC and NARF, the deep seeding translated into a yield reduction compared to the medium and shallow seeding. These were the locations with the lowest plant densities and also lower overall moisture. At the other locations where seeding depth reduced plant density, the camelina was better able to compensate and maintain yield levels. At three locations (SERF, ICDC, WARC), yield was significantly lower for the 0.25x seeding rate compared to all other rates. At two locations ECRF there were no significant effects on yield.

There were minor effects of treatments on plant heights or lodging with two sites showing significant increases in height related to increasing seeding rate (Table A3). At the irrigated ICDC site, lodging occurred early in the season, was severe for all treatments and it was difficult to harvest. This camelina variety may not be suited to irrigated production. At SERF, lodging was moderate and happened during heavy July rain events. There were considerable differences in overall site lodging between different locations.

Yield levels overall were strong considering it was a new crop for most locations and there were few herbicide weed control options. WARC particularly had low spring soil moisture and lower than average long term moisture throughout the season (Figure 1, Table A1).

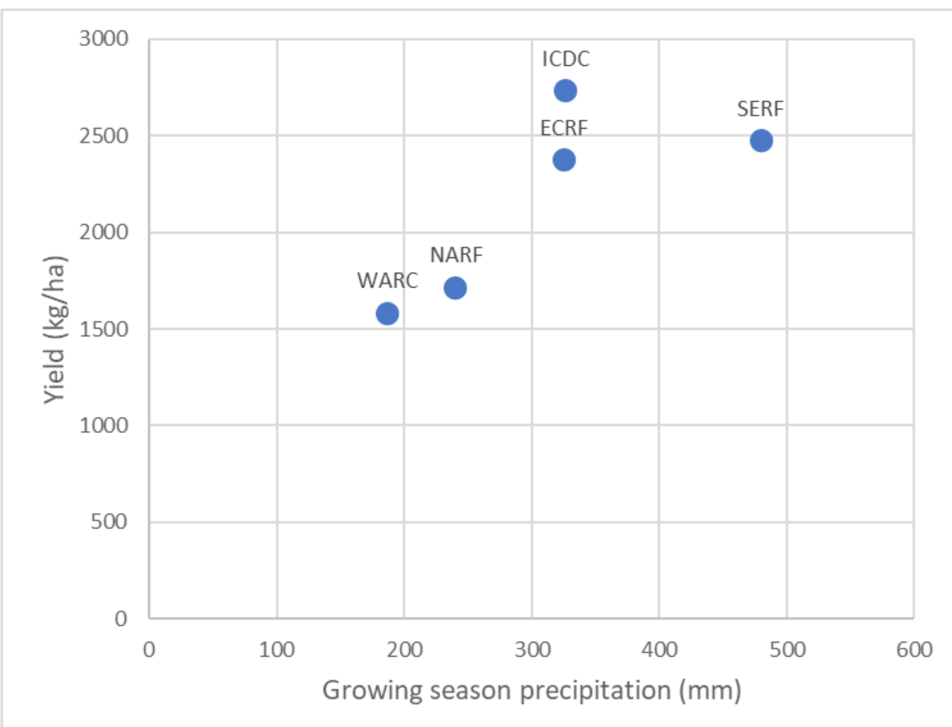

Figure 1. Average site yield and growing season precipitation (+irrigation) at each site.

Table 4. Oil quality analysis (Percent Omega 6, Omega 3, Ratio of 3 to 6), protein content (%) and oil content (%). Different letters beside values, where present, indicate statistically significant differences in means for that column at 95% confidence level for that site based on Least Significant Difference. Absence of letters indicate no statistically significant difference between means for that site.

	Treatment Level	Om 3 %	Om 6 %	3:6 Ratio	Protein %	Oil %
SERF						
Depth	1. Shallow	36.6 A	20.7 C	1.77 A	30.6	39.9
	2. Medium	35.6 B	21.2 B	1.68 B	30.0	40.1
	3. Deep	34.9 B	21.6 A	1.61 C	30.1	39.9
Seed Rate	1. Rate 0.25x	34.9 B	21.6 A	1.61 B	30.2	39.6
	2. Rate 0.5x	35.9 A	21.1 B	1.71 A	30.4	39.7
	3. Rate 1x	36.1 A	20.9 B	1.72 A	30.2	40.3
	4. Rate 1.5x	35.8 A	21.0 B	1.71 A	30.0	40.3
ICDC						
Depth	1. Shallow	36.4	20.3	1.80	31.9	38.6
	2. Medium	36.5	20.3	1.80	32.1	38.6
	3. Deep	36.4	20.2	1.80	32.1	38.5
Seed Rate	1. Rate 0.25x	35.8 B	20.8 A	1.72 B	32.8 A	38.0 B
	2. Rate 0.5x	36.6 A	20.3 B	1.81 A	32.1 B	38.7 A
	3. Rate 1x	36.7 A	20.0 B	1.84 A	31.8 BC	38.8 A
	4. Rate 1.5x	36.7 A	20.0 B	1.83 A	31.5 C	39.0 A
WARC						
Depth	1. Shallow	33.8	21.7	1.56	29.4	41.4
	2. Medium	34.2	21.7	1.58	29.4	41.4
	3. Deep	34.0	21.9	1.57	29.6	40.9
Seed Rate	1. Rate 0.25x	33.2 B	22.2 A	1.49 C	29.5	40.6 B
	2. Rate 0.5x	33.8 AB	21.9 A	1.54 BC	29.7	41.0 AB
	3. Rate 1x	34.5 A	21.4 B	1.63 A	29.3	41.6 A
	4. Rate 1.5x	34.5 B	21.4 B	1.60 AB	29.2	41.7 A
ECRF						
Depth	1. Shallow	36.6 A	20.73 C	1.77	28.8	41.2
	2. Medium	35.6 B	21.17 B	1.68	28.7	41.4
	3. Deep	34.9 B	21.6 A	1.61	28.6	41.3
Seed Rate	1. Rate 0.25x	34.9 B	21.59 A	1.60 B	29.1	40.7 B
	2. Rate 0.5x	35.9 A	21.13 B	1.71 A	28.8	41.2 AB
	3. Rate 1x	36.1 A	20.88 B	1.72 A	28.5	41.6 A
	4. Rate 1.5x	35.8 A	21.06 B	1.71 A	28.5	41.6 A
NARF						
Depth	1. Shallow	35.0 A	21.9 B	1.60 A	27.4	42.925
	2. Medium	34.8 AB	21.9 B	1.59 A	26.4	43.274
	3. Deep	34.1 B	22.5 A	1.52 B	26.7	43.067
Seed Rate	1. Rate 0.25x	34.4 B	22.3	1.55	27.1	42.479 B
	2. Rate 0.5x	34.4 B	22.3	1.55	26.9	42.852 B
	3. Rate 1x	34.6 B	21.9	1.58	26.8	43.097 B
	4. Rate 1.5x	35.2 A	21.9	1.60	26.5	43.927 A

Seeding method had varied effects on oil quality characteristics, which could have an impact on its uses. Western diets are deficient in Omega 3 oils, and camelina oil is rich in this oil. Low seeding rate resulted in slightly lower ratio of Omega 3 to Omega 6 at four out of five locations. At two locations (ECRF and SERF), shallow seeding depth increased the Omega 3 content. Low seeding rate generally reduced oil content slightly at three locations.

Extension

The project was toured during the SERF field day on July 28 with 50 attendees. NARF has prepared a YouTube video for their location. The July 14 ECRF Field Day had close to 100 attendees. ECRF may produce a video based on the group report. ICDC and CSIDC held a joint virtual field day on Aug 31 and Sept 1. There was also an EMC tour on Aug 3 and an AAFC Director General tour on July 22. WARC Field Day was held on July 13 and had approximately 95 attendees. SERF will present results at a March webinar organized by SERF.

11. Conclusions and Recommendations

Where camelina was seeded at a usual depth for field crops (2 cm), there was a significant reduction in plant density compared with shallower seeding at three of five locations. At two locations there were no differences in plant density due to depth. Maturity was extended in two locations with deep seeding compared with shallow seeding and days to maturity decreased with increasing seeding rate at three sites. Yields were only affected by seeding depth at WARC with the deep seeding depth reducing yield. Seeding rate affected yield at three locations (SERF, WARC, and ICDC) with the 0.25x having a small reduction in yield. Camelina showed substantial capacity to compensate for low plant density, but this came at the cost of delayed maturity and more risk for shattering losses. There were small but significant reductions in oil quality associated with low seeding rate. While seeding at a normal canola depth reduced plant density, it had minimal impact on yield at all but one location. Seeding depth should be targeted to less than 2 cm for optimal densities, but camelina can compensate when conditions result in somewhat deeper seeding. Further breeding of camelina may result in increased seed size, which would allow for more resilience to seeding depth. The recommended seeding rate of 6 lb/ac was sufficient to achieve adequate plant densities.

Supporting Information

12. Acknowledgements

Smart Earth Camelina contributed seed to the project and conducted quality analysis for all sites. The ADOPT initiative provided financial support under the Canada-Saskatchewan Canadian Agricultural Partnership (CAP).

13. Appendices

Table A1. Mean long-term and 2022 temperature and precipitation over the growing season at the 4 sites.

Location	Year	May	June	July	August	Avg. / Total
			---------------------*Mean Temperature (°C)* -------------------			
Outlook	2022	11.8	16.3	19.7	20.5	17.1
	Long-term	***11.2***	***16.1***	***18.7***	***17.8***	***15.9***
Scott	2022	10.0	15.0	18.3	18.9	15.6
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Redvers	2022	10.2	16.3	19.2	18.9	16.2
	Long-term	***11.1***	***16.2***	***18.7***	***18.0***	***16.0***
Yorkton	2022	10.6	15.7	18.6	18.9	16
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
Melfort	2022	9.9	15.2	18.3	18.7	15.5
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
			--------------------------- *Precipitation (mm)* -------------------			
Outlook	2022	35.7	75.2	53.2	7	171.1
	Long-term	***42***	***63.9***	***56.1***	***45.3***	***214.3***
	Irrigation		35.6	55.9	63.5	155.0
Scott	2022	11	57.1	86.5	32.1	186.7
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***
Redvers	2022	121	75	259	25.2	480.2
	Long-term	***60.0***	***85.2***	***65.5***	***46.6***	***272***
Yorkton	2022	137.9	57.9	38.4	90.8	325
	Long-term	***51***	***80***	***78***	***62***	***272***
Melfort	2022	90.8	78.1	34.9	36.5	240.3
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***

Table A2. Dates of key operations at all sites.

	SERF	WARC	ICDC	NARF	ECRF
Stubble	Soybean	Wheat	Wheat	Wheat	Wheat
Row Spacing (cm)	25	25	25	30	30
Harvested plot size (m2)	7.4	12.2	12	11	11
Pre-seed/pre-emergent Herbicide Application	None	Glyphosate 540 1L/ac & AIM 35 mL/ac on May 16	n/a	RoundUp 0.67 L/ac May 21	Pardner, May 28
Post-Emergent Pesticide	n/a	Assure II on June 13	Matador 33 ml/ac on July 12	Arrow All In 150 mL/ac June 23	n/a
Fertilizer before or at seeding (kg/ha)	83 N, 19 P, 5.5 S	74 N, 26 P, 12 S	110 N, 60 P	68 N, 61 P, 15 S	83 N, 28 P
Seeding Date	May 22	May 23	May 21	May 27	May 25
Plant Density	June 9	June 20	June 13	June 22	June 8
Uniformity Rating	June 17	June 20	June 13	June 23	June
Plant Height (3 plants)	Aug 4	Aug 3	n/a	Aug 5	Aug 4
Lodging	Sept 2	n/a	n/a	Sept 8	Aug 22
Desiccation	0.5L Bolster on Sept 2	Reglone Ion 0.83 L/ac on Sept 10	Reglone Aug 19	Aug 31	None
Harvest	Sept 9	Sept 16	Aug 24	Sept 8	Sept 13

Table A3.

Treatment Level		SERF	ICDC	WARC	ECRF	NARF
		------------------------------Height (cm)------------------------				
Depth	1. Shallow	81.4	96.5	66.4	72.4	78.4
	2. Medium	81.1	95.4	68.2	72.4	78.1
	3. Deep	81.0	93.7	67.6	70.4	77.3
Seed Rate	1. Rate 0.25x	78.7	89 b	66.9	71.1	74.8 c
	2. Rate 0.5x	80.8	95.0 a	69.6	72.7	76.4 bc
	3. Rate 1x	81.9	98.7 a	66.5	72	78.4 bc
	4. Rate 1.5x	83.3	98.1 a	66.7	71.1	82.2 a
Lodging		------------------------------ Lodging (1-5)------------------------------				
		1-5				
Depth	1. Shallow	3.0	5	2	2.2	1
	2. Medium	3.3	5	2	2.2	1
	3. Deep	3.4	5	2	1.9	1
Seed Rate	1. Rate 0.25x	3.4	5	2	2.1	1
	2. Rate 0.5x	3.2	5	2	2.1	1
	3. Rate 1x	3.1	5	2	2.0	1
	4. Rate 1.5x	3.3	5	2	2.1	1

Abstract

14. Abstract/Summary

Camelina is a new oilseed crop in Saskatchewan and there are challenges with achieving adequate establishment because of the small seed size. Camelina sativa seeding rates and depths were evaluated at five locations in Saskatchewan across the dark brown and black soil zones. Five seeding rates (0.25x, 0.5x, 1x, 1.5x) were evaluated for each of three seeding depths. The deepest seeding depth was targeted to 2 cm. The shallow seeding depth was about 0.5 cm and the medium depth was intermediate between deep and shallow. The deepest seeding resulted in a reduction in plant density at three locations and a yield reduction at only one location compared to shallow seeding. Deep seeding and the lowest seeding rate resulted in delays in maturity and reductions in oil quality. The moderate seeding depth had minimal negative effects on plant density, maturity, or yield. No-till seeding was effective in establishing adequate densities of camelina and seeding depths of about 1 cm or shallower were optimal but seeding at 2 cm was relatively effective.