Multi-Crop Intercrop trial (Pea-Oats-Canola-Wheat-Flax-Mustard)

Project duration: 2019-2021
Collaborators: Manitoba Pulse & Soybean Growers Association - Daryl Domitruk
Objectives: Evaluate agronomic performance of peas in a monocrop or when intercropped with oats, canola, spring wheat, flax or mustard

Background
Choice of an intercropping system depends on many factors including: weather, machinery available for seeding, harvesting and separation of seed, economics and compatibility of the crops involved. Many organic agriculture farmers have resorted to various intercropping systems with the aim of addressing weed and disease pressure, which often inhibits organic systems under monoculture situations (Pridham and Entz, 2007). Scientists have been advocating for ways to counteract effects of climate change. Intercropping systems can be one of the ways that can help address climate change in some ways such as biological control of insect pests, weeds and diseases. Biological control allows for less use of synthetic chemicals hence addressing the chemical resistance issues. Another benefit of intercropping is improving soil health at low cost considering residual nitrogen if a legume is included. In other studies, pea-wheat intercropping systems have been shown to be efficient in the use of nitrogen due to their spatial self-regulating dynamics, which allows pea to improve its interspecific competitive ability in fields with lower soil nitrogen and vice versa for wheat (Andersen et al., 2004 and Ghaley et al., 2005). This enables future options to reduce synthetic nitrogen inputs and negative environmental impacts of crop production. Compared to pea sole crop, pea-oats intercrop results in reduced pea lodging because of the support provided by oats to the pea crop, this also helps reduce harvesting difficulties and increase economic returns (Kontturi et al., 2010). This study evaluated various intercrop combinations that can be utilized by producers in different areas of production.

Materials and Methods
Experimental Design: Random Complete Block Design
Entries: 11
Varieties: Pea (Amarillo), Flax (Neela), Oat (Summit), Spring Wheat (Carberry), Canola (5545CL), Mustard (Andante)
Seeding: May 16
Harvest: Sept 25

Table 1: Intercrop Entries

Pea only	Spring Wheat only	Pea-Flax	Pea-Canola
Flax only	Canola only	Pea-Oat	Pea-Mustard
Oat only	Mustard only	Pea-Spring Wheat	

All treatments including peas were inoculated.

Data collected	**Date Collected**
Emergence Plant Count:	May 29
Flowering Plant Count:	Jul 16
Flowering Date:	Jul 2 – Jul 24
Weed/Crop Biomass Ratio:	Jul 15

Seed Separation:	Oct 2
Yield:	Oct 3-4
Moisture:	Oct 3-4
Splits per 500 seeds (pea):	Oct 24
Sampling for protein analysis	

Agronomic info

Previous year's crop:	Flax
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Tilled and harrowed

Table 2: Spring 2019 Soil Test

	Available
N	156 lb/ac
P	9 ppm
K	170 ppm

Results and Discussion

Results from Roblin (Table 3a) indicate that there were no significant differences in partial pea yield, land equivalency ratio (LER) or total land equivalency ratio (TLER) regardless of the intercrop option. At Reston, peas intercropped with canola yielded significantly (P=0.001) more grain resulting also in significantly higher partial pea LER (P=0.001) at 1.22 and higher TLER (P<0.0001) at 2.05 compared to other intercrop options. There were no significant yield differences in other pea intercrop options (Table 3b). At Elva, the highest partial pea yield (2405 kg/ha) obtained from a mustard intercrop was not significantly different from wheat or canola intercrops but was significantly higher (P=0.002) than pea yield obtained from oats and flax plots. Partial pea land equivalence ratio for pea followed the same pattern as yield with mustard intercrop having 0.76 pea LER which was significantly (P=0.001) higher than oats and flax. The TLER for the mustard intercrop was not significantly different from other treatments except flax which had the lowest at 0.94 compared to 1.27 (P=0.022) for the former (Table 3c).

Table 3a. Analysis of variance for yield, partial LER and TLER for Roblin Multi-Crop

Trt	Crop	Yield (kg ha^{-1})			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	939	*	*	1.00	*	1.00a
2,7	Flax	1386	347	869a	0.31	0.87a	1.18a
3,8	Oat	6794	4753	371a	0.71	0.43a	1.15a
4,9	Wheat	4505	2325	371a	0.52	0.44a	0.95a
5,10	Canola	4451	2071	1691a	0.44	1.98a	2.42a
6,11	Mustard	2142	1286	956a	0.61	1.07a	1.68a
	P value			**0.101**		**0.072**	**0.115**
	CV			**81**		**79**	**55**

LER=Land equivalence ratio, TLER=Total land equivalence ratio, IC=Intercrop

Table 3b. Analysis of variance for yield, partial LER and TLER for Reston Multi-Crop

Trt	Crop	Yield (kg ha^{-1})			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	531	*	*	1.00	*	1.00d
2,7	Flax	2463	1681	306b	0.64	0.58b	1.22cd
3,8	Oat	4328	4323	344b	1.01	0.66b	1.67ab
4,9	Wheat	3865	3177	322b	0.83	0.61b	1.44bcd
5,10	Canola	3735	3070	656a	0.82	1.22a	2.05a
6,11	Mustard	2034	1651	401b	0.80	0.76b	1.56bc
	P value			**0.001**		**0.001**	**<0.0001**
	CV			**23**		**23**	**13**

Table 3c. Analysis of variance for yield, partial LER and TLER for Elva Multi-Crop

Trt	Crop	Yield (kg ha^{-1})			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	3301	*	*	1.00	*	1.00ab
2,7	Flax	1865	909	1479bc	0.49	0.45bc	0.94b
3,8	Oat	4173	3390	1079c	0.83	0.35c	1.17ab
4,9	Wheat	2220	1302	1920abc	0.59	0.62ab	1.21ab
5,10	Canola	2602	1255	2258ab	0.51	0.71ab	1.22ab
6,11	Mustard	1318.4	666	2480a	0.51	0.76a	1.27a
	P value			**0.002**		**0.001**	**0.022**
	CV			**22**		**20**	**12**

In 2019, the percentage change in crop emergence and weed biomass was not significantly different at any of the three sites regardless of the intercrop combination. There was no evidence on whether one intercrop had an advantage over the other in suppressing weeds. These results suggest the need for additional site years of data to determine an appropriate intercrop option that producers can use as an alternative integrated weed control strategy in their areas of production (Tables 4a-4c).

Table 4a. Analysis of variance for crop emergence and weed biomass for Roblin Multi-Crop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	66	*	*	17	*	17a	93.8	*
2,7	Flax	153	65	49	41	42	14a	274	115a
3,8	Oat	102	84	29	47	15	39a	21.5	81a
4,9	Wheat	99	86	38	51	36	14a	25.75	32.8a
5,10	Canola	58	24	49	35	28	21a	91	35.25a
6,11	Mustard	31	24	48	22	26	0a	123.5	96a
	P value						**0.127**		**0.681**
	CV						**100**		**114**

Table 4b. Analysis of variance for crop emergence and weed biomass for Reston Multi-Crop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	77	*	*	13	*	13a	2193	*
2,7	Flax	469	190	41	4	19	13a	920	1274a
3,8	Oat	204	108	29	3	7	28a	1011	1636a
4,9	Wheat	247	106	38	7	3	15a	1302	1756a
5,10	Canola	71	36	33	3	0	29a	893	1026a
6,11	Mustard	33	22	37	0	3	17a	1991	1691a
	P value						**0.534**		**0.094**
	CV						**83**		**33**

Table 4c. Analysis of variance for crop emergence and weed biomass for Elva Multi-Crop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	85	*	*	9	*	9a	120	*
2,7	Flax	353	196	41	4	11	10a	53	66a
3,8	Oat	240	129	39	7	7	9a	79	25a
4,9	Wheat	270	133	45	0	5	13a	16	43a
5,10	Canola	77	47	41	16	13	5a	182	59a
6,11	Mustard	86	42	42	6	20	9a	90	40a
	P value						**0.942**		**0.083**
	CV						**113**		**73**

Although there were no significant differences in pea splits at Roblin, there was a significant (P=0.029) difference in protein content with mustard intercrop recording 26.5% compared to 22.3% for the wheat intercrop. Compared to other sites, Roblin recorded higher protein content with a range of 22.3 to 26.5% compared to 21.5 to 22.5% across all intercrop options in 2019 (Table 5). Whereas protein content (21.6 to 22.4%) was not significantly different among different intercropping systems, there were significant (P<0.0001) differences in pea splits at Reston. Pea splits were lowest in oats intercrop (3.5g per 500 seeds) compared to pea monocrop and flax intercrop that had 9.4 and 11.2g per 500 seeds,respectively. At Elva, pea splits were lowest (0.1g per 500 seeds) in oats compared to pea monocrop with 1.8g per 500 seeds (P=0.02). Pea splits in other intercrop options were not significantly different from pea splits in oats and pea monocrop. Pea protein content at the same site was significantly (P=0.014) lower in canola intercrop (21.5%) compared to oat and wheat intercrop (22.5%).

Table 5. Analysis of variance for pea splits and protein content at 3 Multi-Crop sites in 2019

		Reston		Elva		Roblin	
Trt	Crop	Pea splits g/500 seeds	Pea protein % DM basis	Pea splits g/500 seeds	Pea protein % DM basis	Pea splits g/500 seeds	Pea protein % DM basis
1	Pea	9.4ab	22.4a	1.8a	22.2ab	5.8a	24.5ab
2,7	Flax	11.2ab	22.1a	0.4ab	21.8ab	7.8a	24.8ab

3,8	Oat	3.5c	22.3a	0.1b	22.5a	5.1a	23.1ab
4,9	Wheat	5.1c	21.9a	1.7ab	22.5a	8.8a	22.3b
5,10	Canola	5.7bc	22.3a	1.4ab	21.5b	3.5a	23.7ab
6,11	Mustard	7.3abc	21.6a	1.1ab	21.7ab	6.8a	26.5a
	P value	**<0.0001**	**0.193**	**0.02**	**0.014**	**0.211**	**0.029**
	CV	**26**	**2**	**65**	**2**	**47**	**6**

Net revenue obtained from different cropping systems was significantly different (P=0.001 at Roblin and P<0.0001 at Reston and Elva). At Roblin, pea sole crop, pea-flax and pea-wheat resulted in negative net revenues, while pea-oats, pea-canola and pea-mustard recorded the highest net revenues (Table 6a). At Reston, pea sole crop had the lowest net revenue compared to the other cropping systems (Table 6b). There appeared to be significantly higher net revenues when pea was intercropped with oat, canola or mustard than pea sole crop. Net revenue obtained from intercropping pea with flax, oat or wheat was not significantly different (Table 6b). At Elva, net revenue obtained from pea sole crop and pea intercrop with flax, oats or wheat was significantly lower than that obtained from pea-canola or pea-mustard (Table 6c). These results provide some insight on viable options to reduce on-farm financial risk. Higher revenue from pea intercropping systems involving mustard or canola are a promising option. With additional site-years, this study will provide a better understanding of component crop dynamics.

Table 6a. Economic analysis for Roblin Multi-Crop in 2019

		Economics					
Trt	**Crop**	**Sole-CROP**	**IC – CROP**	**Gross Revenue**		**Net Revenue**	
				Sole	**IC**	**Sole**	**IC**
1	Pea	303	*	98	*	(206)	(206)b
2,7	Flax	289	325	281	161	(8)	(164)b
3,8	Oat	292	318	667	506	376	187a
4,9	Wheat	308	316	451	272	143	(44)ab
5,10	Canola	328	339	872	581	544	242a
6,11	Mustard	317	336	725	535	408	199a
	P value						**0.001**
	CV						**411**

Table 7b. Economic analysis for Reston Multi-Crop in 2019

		Economics					
Trt	**Crop**	**Sole-CROP**	**IC – CROP**	**Gross Revenue**		**Net Revenue**	
				Sole	**IC**	**Sole**	**IC**
1	Pea	303	*	55	*	(248)	(248)c
2,7	Flax	289	325	499	373	210	48b
3,8	Oat	292	318	425	461	134	142ab
4,9	Wheat	308	316	387	352	79	36b
5,10	Canola	328	339	732	669	404	329a
6,11	Mustard	317	336	689	601	372	265a
	P value						**<0.0001**
	CV						**28**

Table 7c. Economic analysis for Elva Multi-Crop in 2019

Trt	Crop	Economics					
		Sole-CROP	IC – CROP	Gross Revenue		Net Revenue	
				Sole	IC	Sole	IC
1	Pea	303	*	343	*	40	40bc
2,7	Flax	289	325	378	338	89	13c
3,8	Oat	292	318	410	445	118	127ab
4,9	Wheat	308	316	223	330	(86)	14bc
5,10	Canola	328	339	510	481	182	141a
6,11	Mustard	317	336	446	483	129	147a
	P value						**<0.0001**
	CV						**52**

References

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