

Growing Oilseed Flax for Fibre

Byron Irvine AAFC Brandon, Jody McConnell SAF Agri-ARM Coordinator,
Gordon Hultgreen, Pami Humbolt, Alvin Ulrich Biolin, Saskatoon, Bill May, Guy Lafond,
AAFC Indian Head, Kim Stonehouse ECRF Canora, Scott Chalmers SERF Redvers

Summary

When flax was planted at recommended seeding rates for oilseed flax production seed; neither seed or fiber yields were affected by the seeding tool used. This differs significantly from long line fiber production in Europe where narrow row spacing is practiced. This is positive for producers since they can use their existing seeding system without sacrificing seed or fiber yield.

Increasing seeding rate from 40 to 120 kg ha⁻¹ did not increase seed yield at any location or seeding date. While fiber content was not affected by seeding rate, higher seeding rates increased stem numbers, decreased stem size and reduced the variability in stem size. Finer stems, with lower variation in stem size, are likely to result in more uniform retting and improved fiber quality. Fiber yield was increased by increasing seeding rate in the cool wet season of 2004 but had little impact in 2003, a dry season. These findings are similar to European research and would indicate that increasing seeding rates of oilseed flax cultivars will likely be necessary to optimize fiber yield and quality. Higher seeding rates tend to increase lodging potential and thus lodging prone cultivars should not be used; particularly in fields which are prone to lodging. The impact of seeding date was erratic presumably due to the widely differing soil moisture levels between site years. We expected later seeded flax to have lower seed yields and higher fiber yields but this did not occur. The fiber cultivar Evelyn had nearly double the fiber yield of Flanders and Taurus but seed yields of Evelyn were approximately half the yield of the oilseed cultivars.

Fiber content and fiber yields increased at sites where moisture content was higher and total straw yields were greater. This may be due to the greater fiber content of lower part of the stems and the greater height when crops are produced under better moisture conditions.

Delaying seeding until the end of May increased fiber yields in this set of trials by an average of 35% without a corresponding drop in seed yield. This is in contrast to other work when delayed planting often reduced seed yield. Thus delayed planting may improve fiber yield by increasing total biomass but reduced seed yields may occur.

The development of a fibre industry based on production of oilseed flax with fiber as a by product will likely occur when superior genetics are identified and improved retting systems are developed so that the cost of fiber production is reduced. As markets develop, the value of the fibre may improve such that specialized management will be profitable. A higher fiber content cultivar, which has good lodging tolerance, planted at least 80 kg ha⁻¹ (70-75 lb/ac) would likely be an effective method of improving fiber yield and quality of oilseed flax.

Objectives: To investigate the potential of existing seeding equipment for fiber production.

1. To identify a production system that will result in fiber suitable for mid to upper end uses at the least possible cost.
2. To determine if varieties differ in relative fiber yields based on seeding system (full coverage of soil vs rows).

Materials and Methods

Effect of seeding system and seeding rate on yield of flax fiber

This trial was planted at Redvers, Canora and Indian Head in a 3 replicate split plot design with seeding dates being the main plots and seeding rate*cultivars as a complete factorial. Plots were 3.048 x 9.144 m with a spacing of 0.305 m between the plots A control treatment was planted at 40 kg ha⁻¹ with a hoe opener.

Seeding equipment was modified to produce a broad band of seed below the surface using existing plot drills modified to use sweeps and overall packing to enhance germination. This consisted of the use of a “Frock boot” and the appropriate level of air to provide a “solid” seeding as is possible with an air seeder. All planting was done by PAMI using the same equipment at each site. After planting sweep plots were with harrowed with coil packer or rolled with a pea roller to create rapid uniform emergence. Nitrogen and phosphorus were applied at seeding as a side band with hoe openers and with the sweep with 85%+ seed bed utilization with the sweeps.

The oilseed cultivars with high fiber content were Flanders and Taurus while Evelyn was the fiber variety. All of these cultivars were planted at 40, 80 and 120 kg ha⁻¹ with the sweeps and at 40 kg ha⁻¹ with the hoe openers.

Results and Discussion

Impact of seeding rate on yield of flax fiber

Increasing seeding rate from 40 to 120 kg ha⁻¹ did not increase seed yield at any location (Tables 1-5). Evelyn, the fiber variety, had lower seed yields at all sites. In 2003 all sites had seeding date by cultivar interactions while this did not occur in 2004

Seeding rate increased the number of stems at all sites and as number of stems increased, stem diameter decreased (Tables 1-5). There was a significant cultivar impact on stem numbers in both seasons but in 2003 Flanders had the highest plant numbers but the lowest at all sites in 2004. This did not appear to be related to cultivar per se but likely due to seed source. There was a significant interaction between seeding date and seeding rate in the number of stems at all locations. This interaction is likely due to moisture and temperature differences between the seeding dates.

As seeding rate, and hence stem numbers, increased the size of the stems decreased by 20-35% (Tables 1-5). Smaller stems are generally considered to be easier to ret and have superior fiber quality but depending on the end use. However the increased cost of these high seeding rates

may not be warranted unless the processor is willing to provide a bonus. There was a small but significant reduction in stem size variation as seeding rates increased at half of the sites but once again value of this will have to be determined under commercial extraction systems. Smaller stems may be more susceptible to lodging but no significant levels of lodging occurred in these trials.

Fiber content was not affected by seeding rate at any of the six sites (Tables 1-5). Thus differences in fiber yield were due to the amount of straw which was available for salvage. In 2003 there were no significant differences in the amount of salvaged straw resulting from seeding rate. However, in 2004 the amount of salvageable straw and hence fiber yield increased 20% ,at Canora, and 34% at Redvers. Thus in seasons with adequate moisture, such as 2004, there is value to higher seeding rates to increase fiber yield. This advantage occurred equally for all cultivars but the fiber yield of Evelyn was 80-120% greater than Flanders and Taurus.

At the sites where there were differences due to seeding date, late seeding increased seed and fiber yield in 2003 but this did not occur in 2004 (Tables 1-5). However, differences due to seeding date were less than that due to location and season, likely due to growing conditions, mainly rainfall.

Impact of seeding date on seed and fiber yields

There was no clear impact of seeding date on seed yield except under conditions such as 2004 at Indian Head where an early frost significantly reduced late seeded crop in 2003 at Canora where drought had the same impact. Fiber yield was significantly higher from late seeding at Canora in 2003 and at all sites in 2004 (Table 1-5). In every case late seeding had higher fiber yields ranging from 20 to 50% higher with an average of 35% more fiber yield. A nine year study at Minot North Dakota found that early maturing cultivars such as Norlin performed better at late seeding dates (Thompson et al 1988). Crops planted in the first week of June yielded 21% less than crops planted in the first week of May. In a recent unpublished trial conducted at Indian Head, Brandon, Morden and Melfort the impact of seeding date on flax seed yield was not as clear. The shortest crops were obtained from early planting. Thus there would seem to be some trade off between seed yield and fiber yield with later seeding resulting in improved fiber yields at the expense of seed yield in some seasons. There may be the potential to breed for better seed yields from delayed planting of flax as flax is commonly planted in the later part of May. There has been a consistent effort to test all potential flax cultivars at a late planting date.

Interaction of seeding method and cultivar on seed and fibre

Seed yields did not differ significantly due to seeding tool at any site in either year but the arithmetic mean of the percent yield was 6% greater for sweep seeded plots (tables 6-10). This is similar to the results of Stevenson and Wright (1996) and Alessi and Power (1970) who found a 9% yield improvement when flax was planted on 7.5 cm vs 15 cm or wider row spacing. The sweeps are not exactly equivalent to narrow row spacings but do spread out the plants over a larger area and as a result create the potential for more light interception early in the growing

season. The small and non significant impact of sweep planting in this trial differs from the result of a another trial where seed yields were increased by the use of the Sweep seeder.

There were no significant interactions between seeding method, seeding date and cultivar in any site year for seed yield. The fiber cultivar Evelyn had lower seed yields than Flanders or Taurus at all locations and in both years (Tables 6-10).

The 2004 Redvers site, was the only site year where the number of stems was significantly impacted by seeding method and in this case the hoe seeding had slightly greater number of stems than the sweep (Tables 6-10). Stem diameter was not affected by seeding method at any site Likewise variability in stem diameter, as indicated by the standard deviation of the stem diameter, was not affected by seeding method at any site in either season.

There was a significant impact of seeding tool on fiber content at Indian Head in 2003 and Redvers in 2004 (Tables 7, 10) with sweeps resulting in slightly higher fiber contents. When all sites were considered sweep seeding have fiber yields ranging from 12% less to 16% more than the hoe openers (Tables 6-10). Thus there is no clear advantage to using sweeps to plant flax for fiber either in terms of fiber yield or stem quality. However, since there was a clear advantage to higher seeding rates it may be necessary to use sweeps or narrower row spacing to allow more plants to establish. Narrow row spacings are difficult to obtain under direct seeding conditions unless 2 drills are slightly offset and pulled in tandem or sweeps are used to spread the seed as in this case.

While there were several significant impacts of seeding date and its interaction with seeding tool these interactions were not found at all sites and as such are of limited interest at this time.

References

- Alessi, J. and Power, J. F. 1970. Influence of row spacing, irrigation and weeds on dryland flax yield, quality and water use. *Agron. J.*62:635-637.
- Easson, D.L. and Molloy, R.M. 2000. A study of the plant, fibre and seed development in flax and linseed (*Linum usitatissimum*) grown at a range of seed rates. *J. of Agric. Sci. Cambridge* 135:361-369.
- Stevenson, F.C. and Wright A.T.. 1996. Seeding rate and row spacing affect flax yields and weed interference. *Can. J. Plant Sci.* 76:537-544.
- Thompson, C. R., Hoag, B. K. and Lukach, J. R. 1988. Flax variety response to planting date. *North Dakota Farm Research.* 45(5):22-26.

Table 1 Impact of seeding rate on seed and fiber yield Canora 2003

seeding date	Cultivar	seeding rate kg ha ⁻¹	Seed yield kg ha ⁻¹	straw yield kg ha ⁻¹	Salvageable straw kg ha ⁻¹	Number of stems m ⁻²	Stem diameter mm	stem diameter std	Fiber %	Fiber yield kg ha ⁻¹
		40	1337	5893	1665	529	1.54	0.50	18.0	454
		80	1328	5823	1782	663	1.29	0.48	18.3	504
		120	1436	5865	1775	819	1.29	0.44	18.0	500
Lsd seedrate			158	664	47	75	0.11	0.02	2.1	116
	Evelyn		831	5493	1972	588	1.44	0.51	20.4	608
	Flanders		1688	6172	1607	806	1.27	0.44	18.1	456
	Taurus		1582	5917	1644	617	1.41	0.48	15.8	394
Lsd cult			158	664	47	75.4	0.11	0.02	2.1	116
Early			1471	5830	1604	701	1.28	0.45	17.0	419
Late			1263	5890	1878	639	1.46	0.50	19.2	553
Cv			17.3	16.7	26.6	17	12.00	18.50	17.5	25

Table 2 Impact of seeding rate on seed and fiber yield Indian Head 2003

Seeding date	Cultivar	seeding rate kg ha ⁻¹	Seed yield kg ha ⁻¹	straw yield kg ha ⁻¹	Salvageable straw kg ha ⁻¹	Number of stems m ⁻²	Stem diameter mm	stem diameter std	Fiber %	Fiber yield kg ha ⁻¹
		40	708	3582	982	272	1.35	0.49	15.6	159
		80	706	3370	1017	389	1.25	0.43	15.2	161
		120	681	3245	977	540	1.11	0.43	15.7	156
LSD			93	289	133	70	0.09	0.04	0.9	27
	Evelyn		387	3203	1335	393	1.38	0.50	18.1	241
	Flanders		874	3377	793	435	1.13	0.43	14.2	114
	Taurus		833	3617	847	373	1.21	0.41	14.2	121
LSD			93	289	133	70	0.09	0.04	0.9	27
Early			686	3130	900	341	1.21	0.44	15.0	140
Late			710	3670	1090	460	1.26	0.45	16.0	177
CV			11.4	12.6	19.7	17	10.44	13	8.5	25.2

Seeding date	seeding rate kg ha ⁻¹	seed yield kg ha ⁻¹	straw yield kg ha ⁻¹	Salvageable straw kg ha ⁻¹	Number of stems m ⁻²	Stem diameter mm	stem diameter std	Fiber yield %	Fiber yield kg ha ⁻¹	
	40	1142	4402	939	259	1.68	0.52	18.1	265	
	80	1189	4678	1033	352	1.43	0.43	18.4	294	
	120	1189	4670	1009	498	1.35	0.42	18.1	287	
Lsd seedrate		54	589	133	52	0.09	0.04	0.9	27	
	Evelyn		584	4175	1262	314	1.65	0.50	21.3	410
	Flanders		1470	4703	900	440	1.34	0.40	17.4	239
	Taurus		1467	4872	819	355	1.48	0.47	15.9	197
Lsd cult		54	589	133	52	0.09	0.04	0.9	27	
Early			1093	4110	766	258	1.47	0.48	17.3	203
Late			1254	5050	1221	481	1.51	0.43	19.1	361
Cv			11.4	9.5	18.9	21	8.50	19.20	6.7	23

seed Date	Cultivar	seed rate kg ha ⁻¹	seed Yield Kg ha ⁻¹	stems m ⁻²	height cm	stem diameter mm	Stem diameter std	Salvageable Straw Yield kg ha ⁻¹	Fiber Content (%)	Fiber Yield kg ha ⁻¹
		40	665	402		1.7	0.53	2369	23.4	576
		80	582	653		1.5	0.47	2625	23.5	641
		120	606	925		1.3	0.53	2838	23.3	691
LSD Cult			103	47		0.1	0.05	262	0.7	76
	Evelyn		398	864		1.4	0.49	3625	27.7	1009
	Flanders		863	395		1.6	0.53	2056	21.5	444
	Taurus		591	722		1.4	0.51	2152	21.1	455
LSD rate			103	47		0.1	0.05	262	0.7	76
Early			626	565		1.5	0.54	2227	22.8	529
Late			608	754		1.4	0.48	2995	24.0	743
Cv			24.6	18		11.8	15.50	15	4.1	18

Seed Date	seed rate	seed Yield	stems m ⁻²	height cm	stem diameter mm	stem diameter std	Salvageable Straw Yield kg ha ⁻¹	Fiber Content (%)	Fiber Yield kg ha ⁻¹
Cultivar	kg ha ⁻¹	Kg ha ⁻¹							
	40	1011	132	64	1.6	0.5	2049	21.0	458
	80	1123	154	64	1.4	0.5	2401	21.3	531
	120	1094	172	63	1.2	0.5	2748	21.5	612
LSD rate		135	17	2	0.1	0.0	211	0.7	52
Evelyn		851	283	75	1.5	0.6	3268	25.6	840
Flanders		1239	273	72	1.4	0.5	1769	19.6	355
Taurus		1139	259	69	1.3	0.5	2162	18.6	407
LSD Cult		135	17	2	0.1	0.0	211	0.7	52
Early		1002	274	52	1.17	0.44	1643	20.6	358
Late		1150	233	75	1.63	0.56	3156	21.9	710
CV		19	10	4	14	12.00	13	5	14.4

seeding date	cultivar	seeding tool	Seed yield kg ha ⁻¹	straw yield kg ha ⁻¹	Salvageable straw kg ha ⁻¹	Number of stems m ⁻²	Stem diameter mm	stem diameter std	Fiber %	Fiber yield kg ha ⁻¹
Early	Evelyn	Hoe	653	537	2398	431	1.57	0.57	21.6	519
Early	Evelyn	Sweeps	857	504	2612	453	1.63	0.52	21.7	567
Early	Flanders	Hoe	1778	606	1690	544	1.27	0.45	16.9	287
Early	Flanders	Sweeps	1624	558	1861	514	1.23	0.43	16.6	311
Early	Taurus	Hoe	1555	569	1831	502	1.29	0.42	14.2	264
Early	Taurus	Sweeps	1665	695	2799	511	1.42	0.46	15.3	422
Late	Evelyn	Hoe	487	594	2646	498	1.58	0.53	20.1	529
Late	Evelyn	Sweeps	688	512	2653	441	1.73	0.62	18.7	493
Late	Flanders	Hoe	1636	553	2332	507	1.43	0.48	18.7	436
Late	Flanders	Sweeps	1813	713	2827	835	1.61	0.47	19.6	561
Late	Taurus	Hoe	1044	506	1804	419	1.48	0.53	16.7	307
Late	Taurus	Sweeps	1374	554	2229	419	1.60	0.52	16.3	368
		Hoe	1192	561	2117	483	1.44	0.49	18.0	390
		Sweeps	1337	589	2497	529	1.54	0.50	18.0	453
CV			22.5	18.1	20.4	16.4	11.9	13.1	11.7	21.9

seeding date	cultivar	seeding tool	Seed yield kg ha ⁻¹	straw yield kg ha ⁻¹	Salvageable straw kg ha ⁻¹	Number of stems m ⁻²	Stem diameter mm	stem diameter std	Fiber %	Fiber yield kg ha ⁻¹
Early	Evelyn	Hoe	424	3155	1188	241	1.47	.57	17.3	207
Early	Evelyn	Sweeps	375	3032	1187	243	1.41	.54	18.7	221
Early	Flanders	Hoe	909	3269	635	249	1.31	.61	13.1	83
Early	Flanders	Sweeps	864	3567	663	243	1.29	.47	13.4	89
Early	Taurus	Hoe	921	3505	684	218	1.34	.47	13.3	91
Early	Taurus	Sweeps	867	3410	680	250	1.26	.45	13.8	94
Late	Evelyn	Hoe	400	3443	1526	309	1.48	.55	19.7	301
Late	Evelyn	Sweeps	394	3427	1532	295	1.55	.56	18.7	287
Late	Flanders	Hoe	876	5123	1012	379	1.25	.55	12.9	130
Late	Flanders	Sweeps	900	4134	928	335	1.27	.46	14.8	139
Late	Taurus	Hoe	791	4420	935	298	1.45	.51	13.4	126
Late	Taurus	Sweeps	844	3917	902	264	1.33	.44	13.9	126
		Hoe	720	3819	997	282	1.39	0.54	15.0	156
		Sweeps	708	3581	982	271	1.35	0.49	15.5	159
CV			15.8	10.1	11.2	11.4	9.4	17.8	5.2	12.5

Seeding date	cultivar	seeding tool	Seed		Salvageable		Number		Stem diameter mm	stem diameter r std	Fiber %	Fiber yield kg ha ⁻¹
			yield kg ha ⁻¹	straw yield kg ha ⁻¹	straw kg ha ⁻¹	straw kg ha ⁻¹	of stems m ⁻²	of stems m ⁻²				
Early	Evelyn	Hoe	397	2889	1128	139	1.77	0.72	20.1	225		
Early	Evelyn	Sweeps	502	3421	1236	166	1.78	0.54	20.0	247		
Early	Flanders	Hoe	1240	4483	894	228	1.34	0.57	16.3	145		
Early	Flanders	Sweeps	1278	3952	961	214	1.53	0.49	16.1	154		
Early	Taurus	Hoe	1214	4392	938	192	1.70	0.52	15.7	147		
Early	Taurus	Sweeps	1461	4311	1028	208	1.65	0.61	14.0	146		
Late	Evelyn	Hoe	541	4391	2462	279	1.88	0.52	24.1	593		
Late	Evelyn	Sweeps	496	4260	2284	283	1.92	0.55	22.7	518		
Late	Flanders	Hoe	1573	5447	1544	459	1.55	0.37	18.6	286		
Late	Flanders	Sweeps	1569	5216	1600	386	1.48	0.38	18.4	294		
Late	Taurus	Hoe	1394	5620	1686	353	1.58	0.45	16.9	284		
Late	Taurus	Sweeps	1547	5147	1326	299	1.69	0.52	17.2	227		
		Hoe	1015	4537	1442	275	1.64	0.53	18.6	280		
		Sweeps	1186	4386	1406	259	1.68	0.51	18	264		
CV			12.6	8.3	12.1	12.8	7.9	21.3	5.0	10.9		

Seeding date	Cultivar	Seeding tool	seed		height cm	stem diameter mm	stem diameter std	Salvageable Straw Yield kg ha ⁻¹	Fiber Content (%)	Fiber Yield kg ha ⁻¹
			Yield kg ha ⁻¹	stems m ⁻²						
Early	Evelyn	Hoe	298	496	74	1.8	0.5	2801	26.8	749
Early	Evelyn	Sweeps	416	459	73	1.7	0.6	2997	26.4	790
Early	Flanders	Hoe	945	274	57	1.6	0.5	1630	20.8	339
Early	Flanders	Sweeps	973	243	56	1.8	0.6	1604	20.9	336
Early	Taurus	Hoe	783	495	54	1.4	0.4	1724	21.1	365
Early	Taurus	Sweeps	740	349	54	1.6	0.5	1671	20.7	347
Late	Evelyn	Hoe	378	517	80	1.9	0.5	3356	26.8	904
Late	Evelyn	Sweeps	381	496	81	1.5	0.5	3409	29.1	992
Late	Flanders	Hoe	702	269	63	2.0	0.5	1844	21.1	388
Late	Flanders	Sweeps	860	397	63	1.7	0.5	2372	22.2	528
Late	Taurus	Hoe	671	515	62	1.5	0.5	2355	20.9	492
Late	Taurus	Sweeps	618	467	62	1.7	0.5	2163	21.2	460
		Hoe	692	427	65	1.7	0.5	2285	22.9	539
		Sweeps	664	401	64	1.7	0.5	2369	23.4	575
CV			27.8	22.4	3.4	9.6	9.7	11.2	3.7	13.3

Table 10 Impact of seeding tool and flax seed and fiber at Redvers 2004

Seeding date	Cultivar	Seeding tool	seed		height cm	stem diameter mm	stem diameter std	Salvageable Straw Yield kg ha ⁻¹	Fiber Content (%)	Fiber Yield kg ha ⁻¹
			Yield kg ha ⁻¹	stems m ⁻²						
Early	Evelyn	Hoe	688	197	66	1.5	0.5	1969	24.7	486
Early	Evelyn	Sweeps	807	161	63	1.6	0.6	1865	25.0	466
Early	Flanders	Hoe	1129	134	48	1.3	0.4	1084	18.6	201
Early	Flanders	Sweeps	1177	100	46	1.3	0.4	958	17.1	163
Early	Taurus	Hoe	1273	203	51	1.5	0.4	1439	17.9	258
Early	Taurus	Sweeps	950	157	48	1.3	0.4	1067	16.9	181
Late	Evelyn	Hoe	817	170	89	1.9	0.6	3564	26.0	930
Late	Evelyn	Sweeps	937	133	88	2.0	0.7	3658	26.6	973
Late	Flanders	Hoe	1192	119	66	1.7	0.6	1952	18.7	366
Late	Flanders	Sweeps	1180	89	68	1.6	0.5	2262	21.1	478
Late	Taurus	Hoe	1003	169	69	1.7	0.4	2457	16.7	410
Late	Taurus	Sweeps	1017	154	69	1.8	0.5	2484	19.5	485
		Hoe	1017	165	65	1.6	0.5	2078	20.4	442
		Sweeps	1011	132	64	1.6	0.5	2049	21.0	458
CV			16.8	15.3	2.9	11.9	12.9	14.1	3.6	17.2