Flax residue management without burning or removal

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SUMMARY

Agronomic results

Preharvest glyphosate application did not improve our ability to chop the straw in either year. Application of glyphosate to standing flax in the previous fall resulted in intact flax stems being pressed to the soil surface by the sprayer wheels. These stems were the major source of flax residue being caught on the openers in the spring of 2002. When glyphosate is applied after the flax crop has reached maturity, when application of preharvest glyphosate is recommended, there is limited time for the product to work and the moisture content of the straw is low. In addition the standing material dries more quickly limiting microbial action. Thus glyphosate application should be used to control weeds and eliminate green straw but should not be expected to improve chopping to a greater extent than swathing.

Removal of the straw resulted in the most appealing looking field after seeding. However the bunches of straw that did occur were small and did not contain soil. It should be noted that the flax straw was dry at seeding in both season and it is likely that seeding would have been more difficult in moist conditions. Likewise it has been observed that vertical opener shanks clear residue more easily than the "C shanks" used on most air seeders. Most air seeders have wheels inside the frame and these wheels are where plugging is most common. Spring chopping, just prior to seeding, spread the residues above the surface and improved trash clearance slightly.

We were able to seed into flax stubble without any straw being caught on the openers in any treatment in 2001. In 2002, the amount flax residue which was caught on the openers ranged from a low of 23 kg/ha to 113 kg/ha and in no case did the openers plug. This result of this was that the plant populations were identical in all treatments in both years. In 2001 there were significant differences in wheat yield due to the interaction of seeding direction, straw management and herbicide application but since there were no differences in plant population it is probable that this was chance.

If producers are going to chop flax rather than remove it by burning or baling the following principles should improve success: 1) do not attempt if the crop has been lodged since this crop will have to be cut very short 2) direct seed under dry conditions 3) use a vertical opener shank 4) use an aggressive chopper at harvest.

Decomposition and retting of flax residue

A field study was established in 2000, near Brandon Manitoba, to determine the effect of tillage on soil moisture and temperature, and to determine the potential for management of flax residue through fertility management. Decomposition and retting of flax straw was not affected by seeding rate or nitrogen fertility of the crop from which the residue was obtained. The diameter of flax stems and nitrogen content was significantly higher in flax fertilized at 133% compared to 0% of soil test nitrogen recommendations. Future research should focus on rates of nitrogen fertility in excess of 0% to 166% of soil test recommendations for nitrogen, and seeding rates in excess of 67 kg ha^{-1}.

PART I Agronomic Results

Objective: To evaluate agronomic methods of improving the trash clearance when flax residue has been chopped and returned to the field

Factors to be investigated

1. Cutting height 20 cm with straw chopped and retained, cutting height of 20 cm with straw removed, straw dropped in fall and then chopped in the spring prior to seeding (this could be done in the real world by mounting a chopper on a tractor instead of a combine). Chopping in the spring will allow time for the straw to breakdown over winter and not settle to the soil and stay wet hence making seeding difficult.
2. Seeding between rows or across rows year 1
3. Swathing vs direct cutting and time from application of preharvest Roundup until harvest.

Methods

These trials was located at the AFIF spoke site in Redveers. The trial was designed as 3 replicate split plot with the main plots being direction (dir) of seeding and straw management (straw) and herbicide (herb) arranged as a factorial within the seeding direction. The seeding direction for the flax were between the flax rows or at right angles to the flax stubble (cross). The seeder used 3.2 m wide with Seed Hawk openers on 26.7 cm row spacings. This drill has vertical rather than "C" shanks. In both seasons the between row seeding was accomplished using the Smart Hitch™ which tracks the previous season's seed row and plants between the crop rows.

Flax Agronomy

2000

CDC Normandy flax was planted May 29-31 Plots were 40 x 40 m to ensure that there was the opportunity for the residue to bridge between openers in the subsequent crop season. Urea (46-0-0) and phosphate (monoammonium phosphate) were sidebanded to supply 80 kg N ha^{-1} and 28 kg P_20_5 ha^{-1}. Flax was sprayed with a tank mix of Select and Buctril M at recommended rates for weed control. Preharvest Roundup at 1.0 L ac^{-1} was applied to the required plots. Straw was removed from the plots on Oct 17 using a round baler. Plots were 40 x 40 m to ensure that there was the opportunity for the residue to bridge between openers. Plots were harvested with a commercially used combine fitted with a chopper at a height of 20 cm. Where the straw was removed by baling the chopper was removed as it was on plots where the chopping was to be done in the spring of 2001. In the spring of 2001 the flax residue in the spring chop plots was chopped with the combine used in the fall.

2001

CDC Bethune flax was planted at a seeding rate of 45 kg ha^{-1} on May 24, 2002 in another location at Redveers using the SeedHawk seeding system previously described. Nitrogen, as urea, was sidebanded at 33 kg N ha^{-1} at seeding along with 22 kg P_20_5 ha^{-1}. An additional 40 kg N ha^{-1} was broadcast 3 weeks later. Flax Max was applied for weed control. Flax residue management was identical to 2000.

Wheat agronomy

As mentioned in the 2000 flax agronomy trial the flax straw dropped in swaths in the fall of 2000 was chopped just prior to planting in the spring of 2001. This treatment left the straw on top of the stubble instead of on the soil surface as was the case in plots where the straw was chopped in the fall of 2000.

The Smart Hitch™ was used to plant 50% of each plot with the hitch being turned on or off over areas where the swath had been the previous year.

The area was sprayed with Roundup at 0.5 l ac^{-1} in prior to zero tillage planting of AC Cadillac hard red spring wheat . Planting occurred May 25, 2001 at 100 kg/ha at a depth of 5 cm using the SeedHawk planting system previously described. Nitrogen, as urea, was sidebanded at 73 kg N ha^{-1}at seeding along with 20 kg P_2O_5 ha^{-1}. Weed control was with a tank mix of Achieve and Buctril M

2002.
The area was sprayed with Roundup at 0.5 l ac^{-1} in prior to zero tillage planting of McKenzie hard red spring wheat at 100 kg ha^{-1} . Planting occurred May 25, 2001 at 100 kg/ha at a depth of 5 cm using the SeedHawk planting system previously described. Nitrogen, as urea, was sidebanded at 83 kg N ha^{-1} at seeding along with 20 kg P_2O_5 ha^{-1}.

The table below indicates the treatments flax straw management treatments in year 1 and the seeding treatments in year 2

Residue management (straw)	Preharvest treatment (herb)	direction of seeding in the subsequent wheat crop (dir)
chop fall	Roundup	Acrossrows
chop fall	Swath	Acrossrows
Remove	Roundup	Acrossrows
Remove	Swath	Acrossrows
chop in spring	Roundup	Acrossrows
chop in spring	Swath	Acrossrows
chop fall	Swath	between2000rows
chop fall	Roundup	between2000rows
chop in spring	Swath	between2000rows
chop in spring	Roundup	between2000rows
Remove	Swath	between2000rows
Remove	Roundup	between2000rows

Results and Discussion

Flax Yields

2000
Yield averaged over the entire test was only 16 bu/ac in 2000 and thus the residue levels are relatively low and lodging did not occur increasing the potential for easy planting in 2001. Chopping in the fall of 2001 was very good (see picture)

2001
Flax plant populations were 439 m-^{2}. Rainfall exceeded 560 mm and temperatures were about average for the growing season. Flax yields were 1481 kg ha^{-1} (23 bu ac^{-1}) over the test area. The flax straw was cut 22-25 cm tall (9-10 inches). The loose flax straw measured on the plot area was 1286 kg/ha or 1144

lb/ac (0.5 tonnes ac^{-1}). Chopping worked reasonably well in the fall but there was a significant amount of bunching.

Effect of flax straw management in the previous year on wheat agronomy

In this trial flax was planted with a zero tillage Seed Hawk opener. This opener has vertical shanks which limits plugging potential. The row spacing was 26.7 cm (10.5") which allowed us to harvest the flax at least 20 cm tall. This reduced the total amount of flax straw which was on the surface and needed to be passed between the openers.

There was no discernable impact of residue management or fall herbicide application on the number of wheat plants emerging in either season(Table 1 and Table 2). The protocol for the trial called for the flax straw caught on the openers to be weighed at the end of each plot but no straw was caught in any treatments in 2001. We observed that the spring chopped straw remained on top of the standing stubble and flowed easily between the openers. This allowed us to seed into a 9 m wide swath which was chopped over an area of only 3-4 m without plugging.

In 2001 highest wheat yields occurred with cross seeding and chopping in the spring. However, this was similar to removal of straw and the overall mean of treatments indicated that straw removal In 2002 wheat yields were very similar for all treatments. It would appear that there may have been some perennial weed control benefits from preharvest control with glyphosate in the fall of 2000 on the 2001 crop.

Table 1. Effect of seeding direction, straw management and preharvest management on crop emergence and wheat yields 2001								
			Plant counts m^{-2}				Wheat yield	
Direction of seeding	Straw management	Herbicide	over the swath hitch on	over the swath hitch off	Outside the swath hitch on	Outside the swath hitch off	kg ha^{-1}	bu ac^{-1}
		Roundup	163	166	166	172	2811	41.70
		swath	170	168	162	173	2673	39.65
	chop fall		170	183	164	174	2585	38.34
	chop in spring		170	160	161	172	2726	40.43
	remove		160	159	168	172	2919	43.30
	chop fall	Roundup	171	195	165	168	2875	42.64
	chop fall	swath	169	177	163	177	2440	36.19
	chop in spring	Roundup	165	165	164	174	2617	38.82
	chop in spring	swath	175	155	159	169	2856	42.37
	remove	Roundup	158	153	169	173	2925	43.38
	remove	swath	165	170	166	171	2909	43.15
across			170	167	159	170	2831	41.99
between			163	167	170	175	2662	39.49
across		Roundup	172	168	157	168	3053	45.29
across		swath	169	167	160	172	2675	39.68
between		Roundup	157	165	172	175	2657	39.41
between		swath	173	170	166	175	2670	39.60
across	chop fall		170	186	159	164	2399	35.59
across	chop in spring		180	158	154	179	3222	47.79
across	remove		163	158	161	169	2977	44.16
between	chop fall		169	179	168	183	2771	41.10
between	chop in spring		163	162	166	166	2442	36.23
between	remove		156	160	177	177	2839	42.11
across	chop fall	Roundup	170	208	150	138	3061	45.40
across	chop fall	swath	170	181	161	170	2267	33.63
across	chop in spring	Roundup	194	169	147	184	2906	43.10
across	chop in spring	swath	171	150	159	176	3537	52.47
across	remove	Roundup	162	157	163	168	3125	46.35
across	remove	swath	165	159	158	171	2780	41.23
between	chop fall	Roundup	171	190	170	177	2813	41.73
between	chop fall	swath	167	169	165	189	2728	40.47
between	chop in spring	Roundup	151	164	172	170	2472	36.67
between	chop in spring	swath	180	160	159	162	2402	35.64
between	remove	Roundup	154	149	174	179	2725	40.42
between	remove	swath	166	204	190	168	3296	48.89

Table 2. Effect of seeding direction, straw management and preharvest management on crop emergence and wheat yields 2002

			Flax straw caught on openers kg ha^{-1}		Plant counts m-2 Plant counts m^{-2}		Wheat yield			
							kg ha^{-1}		bu ac^{-1}	
Direction of seeding	Straw management	Herbicide	mean	SE	mean	SE	mean	SE	Mean	SE
			53.3	12.9	168.3	3.2	2269	61	33.7	0.9
		Roundup	70.9	21.6	167.7	4.3	2338	87	34.7	1.3
		swath	35.7	13.5	169.0	4.8	2199	84	32.6	1.2
	chop fall		76.0	29.6	161.7	4.5	2243	102	33.3	1.5
	chop in spring		60.8	22.4	176.6	4.0	2295	110	34.0	1.6
	remove		23.1	8.6	166.7	7.0	2269	111	33.7	1.6
	chop fall	Roundup	113.1	54.5	166.2	5.0	2296	188	34.1	2.8
	chop fall	swath	38.9	18.4	157.2	7.5	2190	98	32.5	1.4
	chop in spring	Roundup	70.3	29.2	175.1	6.1	2320	80	34.4	1.2
	chop in spring	swath	51.4	36.3	178.2	5.7	2269	217	33.7	3.2
	remove	Roundup	29.4	14.7	161.8	10.3	2399	183	35.6	2.7
	remove	swath	16.8	9.6	171.7	10.1	2138	116	31.7	1.7
across			59.0	22.0	167.2	4.5	2174	58	32.2	0.9
between			47.6	14.0	169.5	4.6	2364	103	35.1	1.5
across		Roundup	77.5	37.0	162.7	6.5	2205	84	32.7	1.2
across		swath	40.6	24.6	171.8	6.1	2143	85	31.8	1.3
between		Roundup	64.4	24.3	172.7	5.4	2472	142	36.7	2.1
between		swath	30.8	12.9	166.2	7.7	2255	148	33.5	2.2
across	chop fall		80.5	57.3	163.9	7.9	2114	91	31.4	1.4
across	chop in spring		65.4	34.4	168.9	3.9	2228	120	33.1	1.8
across	remove		31.1	15.1	169.0	11.2	2179	104	32.3	1.5
between	chop fall		71.4	23.8	159.5	5.1	2371	176	35.2	2.6
between	chop in spring		56.3	31.8	184.4	5.7	2362	193	35.0	2.9
between	remove		15.0	8.4	164.5	9.5	2358	200	35.0	3.0
across	chop fall	Roundup	142.4	111.7	163.6	10.8	2109	142	31.3	2.1
across	chop fall	swath	18.6	11.1	164.2	13.9	2120	146	31.4	2.2
across	chop in spring	Roundup	45.1	13.8	170.1	8.4	2297	95	34.1	1.4
across	chop in spring	swath	85.7	73.0	167.7	1.4	2159	240	32.0	3.6
across	remove	Roundup	44.9	25.4	154.5	16.3	2207	216	32.7	3.2
across	remove	swath	17.4	17.4	183.4	12.2	2151	81	31.9	1.2
between	chop fall	Roundup	83.7	38.8	168.8	0.5	2482	348	36.8	5.2
between	chop fall	swath	59.1	34.2	150.1	6.5	2260	146	33.5	2.2
between	chop in spring	Roundup	95.5	58.7	180.1	9.6	2344	148	34.8	2.2
between	chop in spring	swath	17.1	8.8	188.6	7.3	2380	406	35.3	6.0
between	remove	Roundup	13.9	13.9	169.1	14.6	2591	291	38.4	4.3
between	remove	swath	16.2	12.7	159.9	14.8	2125	247	31.5	3.7

Table 3 ANOVA for plant counts and wheat yields in 2001 on 2000 flax stubble

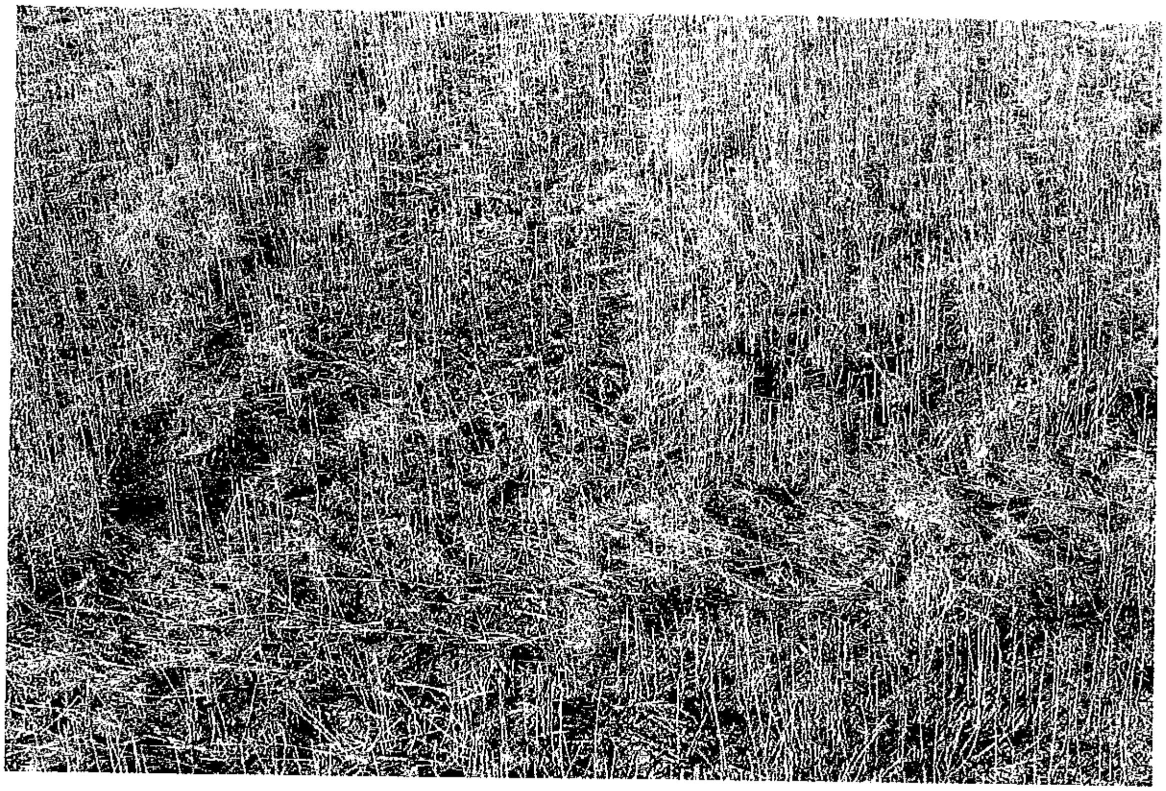
Source	DF	Plants m^{-2} Swath ON Mean Sq	Swath ON Pr > F	Swath OFF Mean Sq	Swath OFF Pr > F	outside swath_on Mean Sq	outside swath_on Pr > F	outside swath_off Mean Sq	outside swath_off Pr > F	wheat yield kg ha^{-1} Mean Sq	wheat yield Pr > F
REP	2	454	0.363	1383	0.055	1011	0.108	485	0.357	105969	<.0001
DIR	1	400	0.410	9	0.816	1780	0.125	385	0.780	73343	0.756
REP*DIR	2	379	0.425	125	0.740	272	0.524	3076	0.005	581026	0.000
STRAW	2	224	0.599	1268	0.068	542	0.286	312	0.509	161182	0.040
HERB	1	6	0.910	82	0.660	152	0.548	369	0.374	8651	0.656
STRAW*HERB	2	83	0.824	799	0.169	104	0.776	325	0.495	47400	0.346
DIR*HERB	1	291	0.418	131	0.578	464	0.298	63	0.711	2734	0.802
DIR*STRAW	2	121	0.755	677	0.217	96	0.792	443	0.388	42429	0.386
DIR*STRAW *HERB	2	236	0.583	307.4	0.486	381	0.408	310.3	0.511	170782	0.034
CV%		12.4		12.2		12.3		12.2		7.5	

Swath ON in the area where swath was in 2000 Smart Hitch on
Swath OFF in the area where swath was in 2000 Smart Hitch off
outside swath_on outside the area where the swath was in 2000 Smart Hitch on
outside swath_off outside the area where the swath was in 2000 Smart Hitch off

Table 4. ANOVA for wheat agronomic traits 2002 planting on 2001 flax straw

Source	DF	straw caught kg ha^{-1} Mean Sq	straw caught Pr >F	plants m^{-2} Mean Sq	plants Pr >F	wheat yield kg ha^{-1} Mean Sq	wheat yield Pr >F
REP	2	12025	0.160	70	0.817	543004	0.004
dir	1	1176	0.674	44	0.828	267410	0.209
REP*dir	2	4953	0.452	727	0.148	79910	0.363
straw	2	8896	0.250	695	0.159	1880	0.975
herb	1	11175	0.187	15	0.838	24184	0.576
straw*herb	2	3444	0.572	274	0.465	27088	0.701
dir*herb	1	26	0.949	541	0.225	26167	0.561
dir*straw	2	49	0.992	397	0.336	63614	0.442
dir*straw*herb	2	9308	0.236	459	0.287	20351	0.765
CV		145.0		11.0		12.7	

Chopped flax straw fall 2001



Part II Decomposition and retting of flax residue

Objectives

The objectives of this study are:

1. To measure soil moisture and temperature under heavy harrow, low and high disturbance systems.
2. To measure the decomposition of flax residue as affected by nitrogen and tillage management in the flax crop year.

Methods:

Agronomic

All plots were planted using a Conservapak drill using best management practices and the bags placed on the soil surface after planting. The crop was wheat planted into flax residue as at the Redveers site.

Soil Moisture

Volumetric soil moisture was measured in 0 to 15 cm depth with time domain reflectrometry sensors (E.S.I. Environmental Sensors Inc.) logged at 1 hour intervals for the period from after seeding (June 1, 2001) to prior to harvest (August 17, 2001). Three treatments in four replicates were instrumented, heavy harrow, high disturbance and low disturbance management. Accuracy of TDR sensors was assessed with gravimetric data collected in August 2000.

Soil Temperature

Soil temperature was measured at a 2.5 cm depth with thermistors (Onset Computer Corporation) logged at 1 hour intervals for the period from after seeding (June 1, 2001) to prior to harvest (August 17, 2001). Flax stubble with heavy harrow, high disturbance and low disturbance management in four replicates were instrumented,.

Residue measurement

Samples were obtained from the seeding rate*nitrogen application rate trial at Indian Head to determine the impact of nitrogen level on the rate of breakdown of flax residue. Samples of a known mass were placed in standing flax stubble after harvest and are being collected over time to determine mass loss. Residue bags with 15 grams of flax residue were placed in plots, which were previously grown to flax and managed with a heavy harrow. Flax residue was obtained from treatments with 0, 67, 100, 133% of soil test N recommendation at 45 kg/ha seeding rate, and 22, 45 and 67 kg/ha seeding rates at a 100% soil test N recommendation.

Flax retting

Retting was measured with the Fried hot water test by technical staff at Biolin Research Inc. Flax stems (8.9 cm in length) were shaken for 40 seconds and categorized into retted and not retted components. Six sub samples were analysed for flax samples from each collection date. Flax ratings in the Fried hot water test were combined in two classes, class 1 no retting and partially retted, class 2 retted and over retted.

Flax carbon and nitrogen content

Flax carbon and nitrogen content were measured with a Carlo Erba 2500 elemental analyser.

Statistical analyses

Statistical analysis was conducted in JMP software version 5.01a. Decomposition equations were calculated with polynomial and nonlinear regression. Significance of tillage effects on soil temperature and moisture was calculated with analysis of variance. Retting data were analysed with logistic analysis and maximum likelihood.

Results

Soil temperature and Moisture

Soil temperature

No significant differences were observed for soil temperature between low and high disturbance tillage treatments (Table 1).

Table 1. Soil temperature (degrees C), wheat stubble

Level	Mean	Std Error
High disturbance	12.89	0.151
Heavy harrow LD	12.97	0.151
Low disturbance	12.82	0.185

Table 2. Soil moisture on wheat stubble, June 2, 2001

Level	Mean	Std Error
HD	14.8271	2.1150199
LD	16.1271	2.1150199

Soil moisture

No significant differences were observed for soil moisture between low and high disturbance tillage treatments. Soil moisture trends were closely related to precipitation during the growing season.

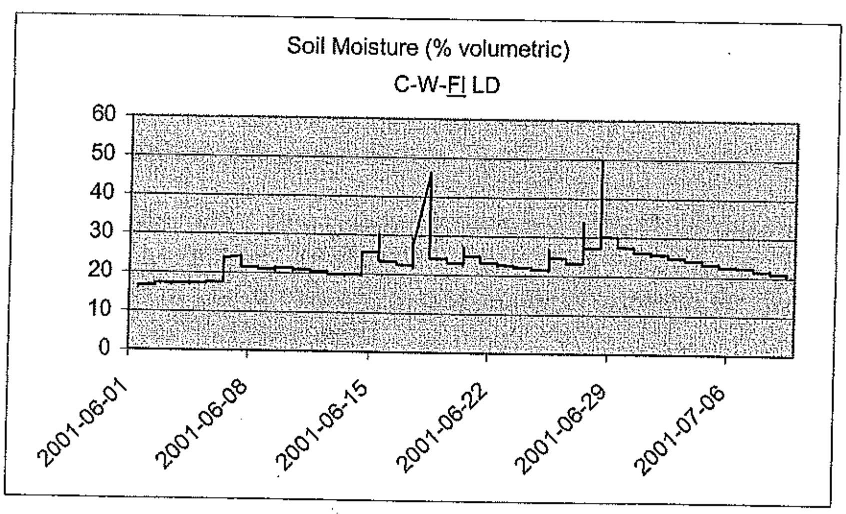


Figure 1. Soil moisture (% volumetric) for the period from June 1 to August 7, 2001. Low disturbance seeding in flax residue.

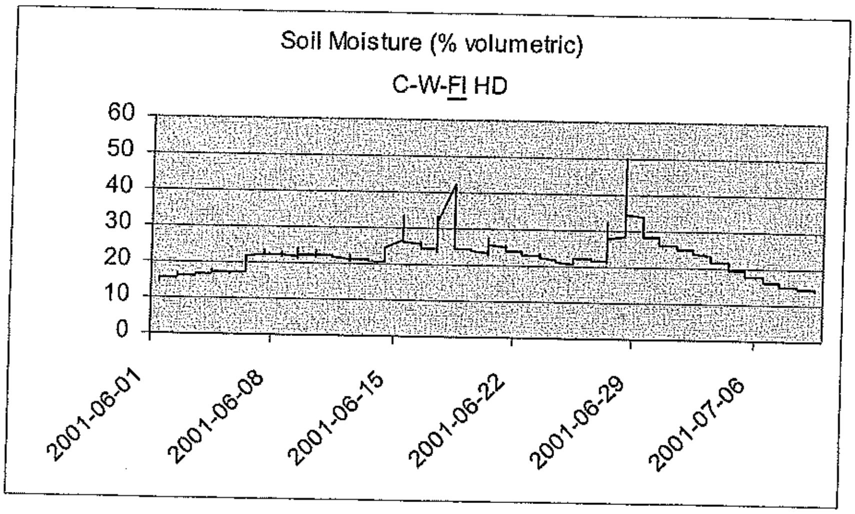


Figure 2. Soil moisture (% volumetric) for the period from June 1 to August 7, 2001. High disturbance seeding in flax residue.

Flax properties prior to placement in field

Flax carbon and nitrogen

Carbon content in flax samples, prior to placement in the field in 2000 to 2002, was similar in all seeding rates. Nitrogen content was significantly (P=0.0384) higher in flax residue grown at 133% (0.96%) compared to 0% (0.83%) of recommended fertilizer rates.

Flax stem diameter and density

Diameter of flax residue grown at 133% (1.69 mm) of soil test N recommendations was significantly higher (P=0.0039) than flax grown at 0% (1.27 mm) of soil test N recommendations. However, management of nitrogen fertilizer did not significantly affect mass-density (g cm^{-3}) of flax stems.

Flax decomposition and retting, 2000-2001 and 2001-2002

2000-2001 Residue mass

Decomposition rates were calculated with mass data from 12 collections from November 2000 to September 2001. Analysis shows, based on one year's data, approximately 575 days are required to decompose 90% of flax residue (Figure 3). Fertility management and seeding rate did not significantly affect decomposition of flax residue.

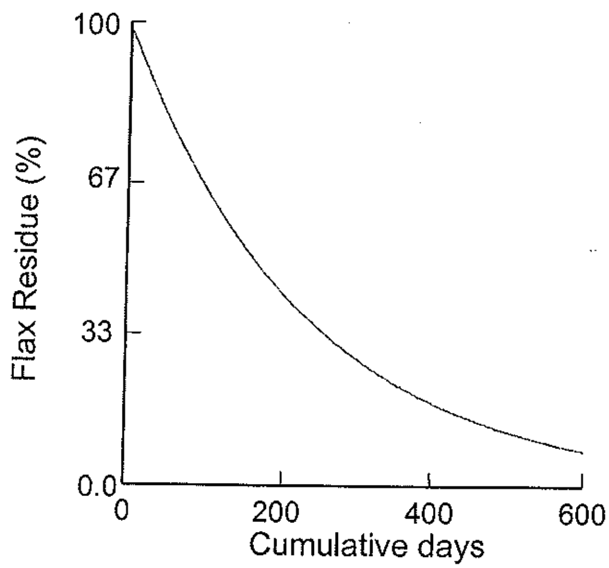


Figure 3. Decomposition of flax residue. Ash content included in calculation

Flax retting

In general flax retting was higher in samples collected in September after 12 months in the field (Figure 4), the trends were not statistically significant. The treatments accounted for a small proportion of the variability in the experiment.

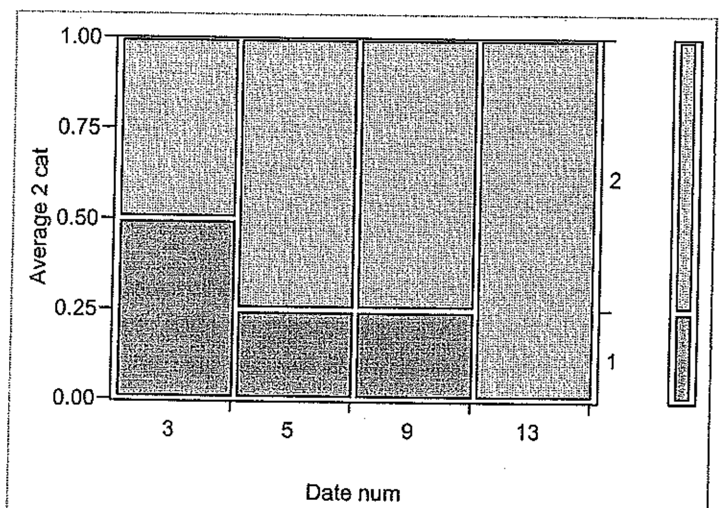


Figure 4 Retting of flax seeded at 22 kg ha^{-1}, left axis represents proportion of samples in class, right axis represent class 1 no retting and partially retted, class 2 retted and over retted.

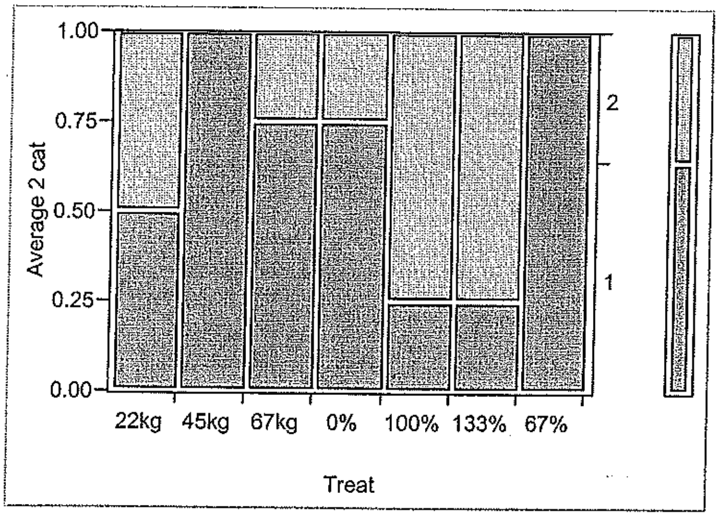


Figure 5. Retting of flax samples collected in November 2000, left axis represents proportion of samples in class, right axis represent class 1 no retting and partially retted, class 2 retted and over retted.

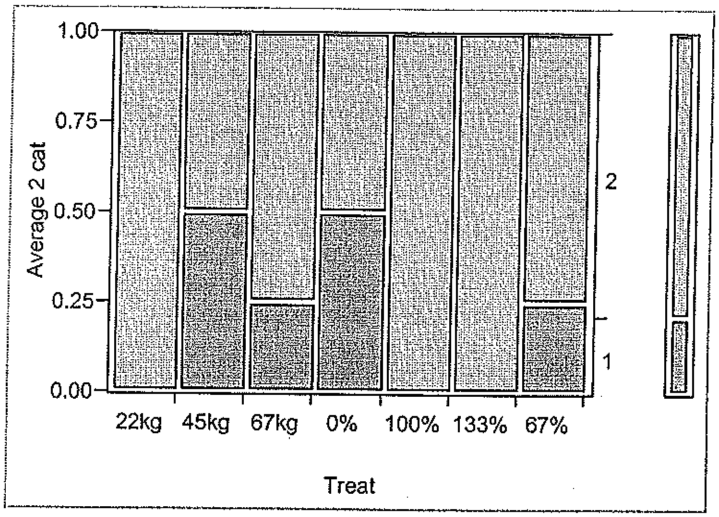


Figure 6. Retting of flax samples collected in September 2001, class 1 no retting and partially retted, class 2 retted and over retted.

2002 Residue mass

Decomposition, calculated with residue including ash from 12 collections from November 2001 to September 2002, was similar to that in 2000 to 2001. Fertility management and seeding rate did not significantly affect decomposition of flax residue.

Flax retting

As in 2001, flax retting in 2002 (Table 3) was higher in samples collected in September after 12 months in the field, the trends were not statistically significant. No significant differences were observed for the effect of fertilizer management or seeding density at the

September sampling date. The treatments accounted for low to moderate proportion of the variability in the experiment depending on the treatment (r^2 0.19 to 0.54).

Table 3. Flax retting values for sampling dates in 2002.

Treatment	Date	Median Rett Class[zy]
22kg	November 21, 2001	1
22kg	January 16, 2002	1
22kg	May 8, 2002	1
22kg	September 25, 2002	1.5
45kg	November 21, 2001	1
45kg	January 16, 2002	1
45kg	May 8, 2002	1
45kg	September 25, 2002	1.5
67kg	November 21, 2001	1
67kg	January 16, 2002	1
67kg	May 8, 2002	2
67kg	September 25, 2002	1.5
0%	November 21, 2001	1
0%	January 16, 2002	1
0%	May 8, 2002	1
0%	September 25, 2002	1.5
67%	November 21, 2001	1
67%	January 16, 2002	1
67%	May 8, 2002	1
67%	September 25, 2002	1
100%	November 21, 2001	1
100%	January 16, 2002	1
100%	May 8, 2002	1
100%	September 25, 2002	2
133%	November 21, 2001	1
133%	January 16, 2002	1.5
133%	May 8, 2002	1
133%	September 25, 2002	1.5

[z]Median value of rett class. Class 1 no retting and partially retted, class 2 retted and over retted.
[y]Number of replications = 4

Discussion

Decomposition of flax residue is a lengthy process, requiring over 500 days for significant reduction of straw placed at the soil surface. Seeding density and nitrogen management of flax crops did not affect subsequent decomposition or retting of flax residue in 2000 to 2001 and 2001 to 2002. However, fertilizer applied at 133% of recommended rates increased nitrogen content and stem diameter of flax residue. Increased nitrogen content may increase microbial activity, retting and decomposition, though this may be offset by an increase in stem diameter.

Seeding densities in this study did not affect stem diameter. However, seeding rates in excess of 67 kg ha^{-1} may reduce stem diameter sufficient to affect retting. This is based on the assumption the surface to volume ratio will be reduced, thus increasing the proportion of flax residue exposed to microbial activity. The influence of increased seeding density on retting may be reduced by high fertilizer rates, which increase stem diameter.

Conclusions

Current recommendations for nitrogen fertility and seeding rates for flax yield in Western Canada, may not be optimum to promote the process of retting. Future research should focus on rates of nitrogen fertility in a range of 0 % to 166% of soil test recommendations for nitrogen, and seeding rates in excess of 67 kg ha^{-1}.

Reference List

1. SAS Institute Inc. 2002. JMP Statistics and Graphics Guide. Version 5.01a. Cary, NC: SAS Institute Inc. 707.