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"Increasing Flax Yields: A closer look at fertilizer utilization and weed management."

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Table of Contents

Executive Summary

The overall objective of this project is to determine how to increase flax yields through more efficient use of fertilizers and better weed control and management. The executive summary will discuss each study separately.

Field Study #1: N and P Management

The objective of this study was to determine the effects of P placement on flax yields and the implications of dual bands of N&P using different nitrogen sources for a one- pass seeding and fertilizing system. A summary of the results from 1996 are given in Tables E1 and E3 and from 1997 in Tables E2 and E4.

In 1996, at Indian Head, Brandon and Morden, when P was placed with the nitrogen in a dual band, nitrogen form had no effect. At Melfort, ammonium nitrate in the dual band gave a better yield than urea or ammonium sulphate. The current understanding is that ammonium sulphate gives a better response to P when it is placed in a dual band. When ammonium sulphate was put down as a spring band and the P side-banded, there was no difference with urea except at Melfort where it was significantly lower. We can conclude that urea is an appropriate source of nitrogen for flax, especially in a dual banded situation as is the case for a one-pass seeding and fertilizing system. The use of the urease inhibitor, NBPT, did not improve the response to P fertilizer at any of the locations. At Melfort, it actually reduced the yields. When urea was spring banded, it didn't matter whether the P was placed with the seed or side-banded or spring banded with the nitrogen, there was no significant effect on yield, regardless of the location. When phosphorus was dual banded with the urea, it gave a better yield than the control at two of the locations, Indian Head and Morden, no difference at Brandon and Melfort. Spreading the spring banded N and P over a 3-4" area did not improve yields over a 1" spread. A response to P was observed at two of the four locations, providing the P was dual banded with the nitrogen in a side-banded configuration. At three of the four locations, plant populations were lower when urea was used in a side-band situation. Ammonium nitrate and ammonium sulfate in a dual band situation had no effect on plant populations.

In 1997, plant population were affected by N and P management at two of the locations. However, the trend was for urea to have a larger negative effect on plant populations than ammonium sulfate or ammonium nitrate. Grain yield was affected by N management at three of the four locations. At Brandon, the highest yields were obtained with the dual bands of N and P using ammonium sulfate and ammonium nitrate. Although the yields were not significant at Indian Head, the trend was for better yields with dual bands of N and P, especially with urea, even if the plant populations were reduced. At Melfort, there was no clear winning combination although the highest yield was recorded with the N and P dual band with urea treated with a urease inhibitor. At Morden, the highest yield was obtained with a dual band of N and P banded ahead of seeding and scattered over a 3-4 inch area.

After two years and eight locations of information, we can recommend that from an opportunity point of view, it is better to dual band the N&P together in a side-banding operation for flax because of the greater likelihood of getting a yield response to P, however urea can be a problem in certain cases and caution has to be exercised to ensure proper separation at all times between seed and fertilizer to minimize damage.

Table E1. Summary of plant populations (plants/m^2) for the N&P Management Study in 1996.

N - Forms	N - Placement	P - Placement	Indian Head	Melfort	Brandon	Morden
Urea	Spring Band	Side-Band	512a	442ab	310	833ab
Urea	Spring Band	Seed-Placed	441bc	425ab	350	745bc
Amm Sulf	Spring Band	Side-Band	499ab	397abc	320	907a
Urea	Side-Band	Side-Band	431c	353c	360	717bc
Amm Nitr	Side-Band	Side-Band	474abc	466a	380	788abc
Amm Sulf	Side-Band	Side-Band	481abc	436ab	375	759bc
Urea+NBPT	Side-Band	Side-Band	421c	381bc	365	691c
Urea	Spring Band	Spring Band	508ab	445ab	345	715bc
Urea	Spring-Band (3-4" spread)	Spring Band	-	452a	325	835ab
Urea	Spring Band	Control-No P	500ab	454a	350	797abc

Notes: Spring band means that the fertilizer was banded in a separate operation while side-banding means that the fertilizer was placed to the side and below the seed during the seeding operation.

Table E2. Summary of plant populations (plants/m^2) for the N&P Management Study in 1997.

N - Forms	N - Placement	P - Placement	Indian Head	Melfort	Brandon	Morden
Urea	Spring Band	Side-Band	465	369	372b	393bc
Urea	Spring Band	Seed-Placed	493	400	392b	361bc
Amm Sulf	Spring Band	Side-Band	491	403	459a	395bc
Urea	Side-Band	Side-Band	383	326	335b	437bc
Amm Nitr	Side-Band	Side-Band	505	365	455a	475ab
Amm Sulf	Side-Band	Side-Band	518	-	439a	361bc
Urea+NBPT	Side-Band	Side-Band	451	380	344b	308c
Urea	Spring Band	Spring Band	513	382	366b	576a
Urea	Spring-Band (3-4" spread)	Spring Band	-	370	352b	464ab
Urea	Spring Band	Control-No P	491	367	339b	388bc

Notes: Spring band means that the fertilizer was banded in a separate operation while side-banding means that the fertilizer was placed to the side and below the seed during the seeding operation.

Table E3. Summary of yield results (bus/ac) for the N&P Management Study in 1996.

N - Forms	N - Placement	P - Placement	Indian Head	Melfort	Brandon	Morden
Urea	Spring Band	Side-Band	31.7 bc	35.5 ab	37.7	33.4 bc
Urea	Spring Band	Seed-Placed	29.9 c	36.0 ab	41.3	33.9 abc
Amm Sulf	Spring Band	Side-Band	31.2 c	32.6 c	36.9	33.9 abc
Urea	Side-Band	Side-Band	33.8 ab	33.8 bc	42.1	35.3 a
Amm Nitr	Side-Band	Side-Band	35.1 a	36.9 a	39.5	34.1 abc
Amm Sulf	Side-Band	Side-Band	34.3 a	34.1 bc	39.0	33.9 abc
Urea+NBPT	Side-Band	Side-Band	33.6 a	33.9 bc	40.0	35.3 a
Urea	Spring Band	Spring Band	30.6 c	36.8 a	39.4	32.8 c
Urea	Spring-Band (3-4" spread)	Spring Band	-	34.9 ab	37.3	33.2 bc
Urea	Spring Band	Control-No P	30.1 c	36.0 ab	39.8	33.4 bc

Notes: Spring band means that the fertilizer was banded in a separate operation while side-banding means that the fertilizer was placed to the side and below the seed during the seeding operation.
Yields followed by the same letter are significantly different at the 5% level.

Table E4. Summary of yield results (bus/ac) for the N&P Management Study in 1997.

N - Forms	N - Placement	P - Placement	Indian Head	Melfort	Brandon	Morden
Urea	Spring Band	Side-Band	15.7a	23.3bcd	33.2b	29.2c
Urea	Spring Band	Seed-Placed	15.5a	22.8bcd	34.0b	27.1d
Amm Sulf	Spring Band	Side-Band	15.1a	25.7ab	35.5a	28.7cd
Urea	Side-Band	Side-Band	16.8a	22.4bcd	33.2b	29.7bc
Amm Nitr	Side-Band	Side-Band	16.0a	24.8abc	36.1a	31.3b
Amm Sulf	Side-Band	Side-Band	15.7a	-	36.4a	29.6bc
Urea+NBPT	Side-Band	Side-Band	14.9a	27.6a	35.6a	29.4bc
Urea	Spring Band	Spring Band	15.0	23.9abcd	33.4b	29.4bc
Urea	Spring-Band (3-4" spread)	Spring Band	-	20.4d	34.8b	34.6a

Urea	Spring Band	Control-No P	14.3a	21.1cd	33.1b	28.8cd

Notes: Spring band means that the fertilizer was banded in a separate operation while side-banding means that the fertilizer was placed to the side and below the seed during the seeding operation.
Yields followed by the same letter are significantly different at the 5% level.

Field Study #2: Zinc Management Study

The objective was to determine the effects of source and placement of zinc on the yield of flax at one site in Manitoba. No significant improvements in grain yield or effects on plant populations were observed with zinc for the last two years (Table E5).

Table E5. Zinc Management Study

Treatment	Plants/m^2		Grain Yield	
	1996	1997	1996	1997
Zn SO4-broad	720	405	886	1519
Zn-SO4-band	749	517	793	1453
EDTA-broad	743	500	706	1652
EDTA-band	759	459	776	1515
Zn-SO4-sausage	773	538	787	1188
EDTA-sausage	755	445	768	1496
Control	730	414	750	1523
Pr>F				
Treatment	ns	ns	ns	ns
CV	9	25	13	18

Field Study #3: N and P Rate Study

The objective was to evaluate the response of flax to different rates of nitrogen (urea) and phosphorus (mono-ammonium phosphate) in a dual banding method using a one-pass seeding and fertilizing system at three locations in Saskatchewan i.e. Indian Head, Lemberg and Melfort.

In 1996, a response to nitrogen was observed at all locations with the response leveling off at 80 kg N /ha at all sites. A response to P was observed at only one site, Melfort. A nitrogen x phosphorus interaction was also observed at Melfort. The nature of the interaction was such that at the higher nitrogen rates, the response to phosphorus disappeared. In all locations, as rate of nitrogen increased, plant populations decreased (Table E6). Phosphorus had no effect on plant populations. In 1997, a response to N was observed at all locations and a response to P at two of the three locations.

Table E6. N x P rate study - Effects on plant populations in 1996 and 1997.

Treatment	Plants/m² -1996			Plants/m² -1997		
	Indian Head	Lemberg	Melfort	Indian Head	Lemberg	Melfort
N Rate						
0	527	353	469	561	601	399
40	478	303	406	474	573	418
80	418	308	337	388	458	361
120	384	260	314	333	397	349
P Rate						
0	450	298	385	397	527	382
15	448	289	375	420	473	372
30	446	323	384	494	508	375
45	463	314	381	436	521	398
Pr>F						
N rate	***	***	***	**	**	**
P rate	ns	ns	ns	"*"	ns	ns
N x P	ns	**	**	ns	ns	ns
CV	13.7	13.5	18	21	15.3	12

Table E7. N x P rate study - Effects on grain yields in 1996 and 1997.

Treatment	bus/acre -1996			bus/acre -1997		
	Indian Head	Lemberg	Melfort	Indian Head	Lemberg	Melfort
N Rate						
0	17.1	11.0	21.6	14.8	12.8	12.6
40	27.1	15.5	30.4	15.6	18.2	20.5
80	30.5	22.7	35.2	16.1	19.2	25.5
120	33.7	24.4	34.0	16.0	18.1	25.2
P Rate						
0	27.9	18.4	28.5	14.8	15.3	20.0
15	27.9	17.7	29.9	15.8	17.4	20.8
30	25.5	18.1	31.4	15.6	17.4	21.8
45	27.1	19.4	31.3	16.3	18.1	21.3
Pr>F						
N rate	***	***	***	"*"	**	***
P rate	ns	ns	***	"*"	**	ns
N x P	ns	ns	0.06"*"	ns	ns	ns
CV	12.5	17.8	7	9	9	11

Field Study #4: N & P & K & S Study

The objective was to determine the potential response to different combinations of N, P, K and S using one rate for each nutrient and the feasibility of putting all these nutrients in a single band as would be the case in a one-pass seeding and fertilizing system. The study was conducted at Indian Head, Melfort and Lemberg.

Plant populations were affected by fertilizer at three of the six station years (Table E8). In all site years, plant populations were the same between the N treatment alone and the treatment where N-P-K-S was present. In some situations, adding other nutrients tended to alleviate the negative effects of urea nitrogen on plant populations. It would appear that the urea form of nitrogen was the only contributing factor to reductions in plant populations. As well, adding P, K and S to the fertilizer band does not appear to have a negative effect on plant populations thus indicating the feasibility of a one pass seeding and fertilizing system when all the macro-nutrients are being used.

A response to N was observed for all site years and a response to P in two of the six site years. There was some indication of a sulfur response at Lemberg in 1997. No yield benefit from the addition of K.

Table E8. N-P-K-S fertility effects on plant populations.

Treatments	Plants/m² -1996			Plants/m² - 1997		
	Indian Head	Lemberg	Melfort	Indian Head	Lemberg	Melfort
N	391	353	373	353	406	326
N & P	397	311	446	376	419	281
N & P & K	430	316	451	345	490	319
N & P & S	402	349	454	444	473	279
N & P & K & S	385	320	385	467	465	324
Check	513	346	431	589	491	390
Pr>F						
Treatment	***	ns	ns	***	ns	"*"

Table E9. N-P-K-S fertility effects on grain yield.

Treatments	bus/acre -1996			bus/acre - 1997		
	Indian Head	Lemberg	Melfort	Indian Head	Lemberg	Melfort
N	31.1	15.6	36.5	12.9	18.1	25.0
N & P	31.2	16.5	37.0	14.9	20.8	24.9
N & P & K	30.0	14.7	37.6	14.5	18.9	24.1
N & P & S	31.4	14.7	36.0	14.6	21.3	25.6
N & P & K & S	31.1	17.6	36.8	13.8	21.5	26.9
Check	13.6	8.0	24.0	11.7	12.9	10.3
Pr>F						
Treatment	***	***	***	**	**	***

Field Study #5: Nitrogen Management Study

The objective was to compare fall banding of nitrogen using urea and ammonium nitrate to side-banding at seeding or broadcasting immediately after seeding. In 1996, there was no difference between urea and ammonium nitrate and side-banding or broadcasting was better than fall banding for grain yield and no treatment differences in 1997. Plant populations were not affected by any of the treatments.

Table 16. Nitrogen Management at Indian Head.

Treatments	Plants/m^2		Grain Yield (bus/acre)	
	1996	1997	1996	1997
Check	463	503	18.1	10.0
UR-FB	488	648	29.0	10.0
AN-FB	494	561	29.7	10.1
UR-Side BD	489	511	33.4	9.8
AN-Side BD	435	558	31.4	11.2
UR-Broadcast	485	350	32.9	11.7
AN-Broadcast	479	481	32.4	12.6
Pr>F				
Check vs rest	ns	ns	***	0.08*
Banding vs Broadcast	ns	ns	"*"	ns
Fall Banding vs Side Banding	ns	ns	**	ns
Urea vs Ammonium Nitrate	ns	ns	ns	ns

[1] Values followed by ***, **, * or ns are significant at the 1%, 5% and 10% level and no significant, respectively.

Field Study #6: Chemical Weed Control

1996

The results of the database search suggested the following:

1. Buctril M phytotoxicity does not increase when graminicides are added to the spray-mix nor does phytotoxicity differ among graminicides applied as tank-mix partners.
2. There was no difference in Buctril M phytotoxicity when Merge or Assist was added to the spray-mix.
3. Buctril M phytotoxicity may differ among cultivars. However, most comparative varietal testing was done in the mid-1970's on varieties no longer recommended or less popular. While recent studies included newer varieties there has been little or no comparative testing with newly developed varieties.
4. Usually, Buctril M applied at recommended rates did not affect flax seed yields. In only 1 of 13 trials did Buctril M applied at recommended rates reduce flax yields. Application of Buctril M at rates 25% higher than label rates may not affect flax yields.
5. Water volume may not be a factor affecting Buctril M phytotoxicity.
6. Morning and late evening application of Buctril M caused more injury to flax than when it was applied at midday. This is contradictory to provincial recommendations that suggest evening applications may reduce risks of crop injury. All trials were conducted under weedy growing conditions and it was not possible to determine whether yield differences were related to crop injury.

1997

The studies conducted in 1997 showed that: 1) there is no apparent difference in phytotoxicity to flax among emulsifiable concentrate, dry and gel formulations of bromoxynil, 2) severe injury to flax may occur when more than the recommended rate of bromoxynil + MCPA ester is applied especially when herbicide applications take place in the early morning hours, 3) flax at early growth stages is more susceptible to injury from bromoxynil + MCPA ester than are later growth stages, and 4) application of more than the recommended dosage may delay flax maturity. The effects of bromoxynil + MCPA ester on flax yield are less clearly defined and additional research is needed. The only conclusion that could be drawn based on the existing data is that bromoxynil + MCPA ester at dosages greater than the current recommended rate may reduce crop yield. Careful calibration of field sprayers is essential when applying bromoxynil + MCPA ester and sprayer overlap should be avoided where possible.

Field Study #1: N & P Management

Objective(s): To conduct field studies on the impact of side-banding P in flax and the implications of dual N & P bands using urea and ammonium nitrate on P uptake and grain yield as currently used in a one-pass direct seeding and fertilizing system.

Person(s) Responsible: Cindy Grant, Adrian Johnston, Guy Lafond and Dave McAndrew.

Experimental Protocol:

Rates:

70 kg/ha for N
20 kg/ha for P_2O_5

Variety: Norlin

Seeding Rate: 62 kg/ha or 1 bus/ac

List of Treatments:

1. Early spring band of N (urea) and side-band P at seeding time.
2. Early spring band of N (urea) and seed-placed P at seeding time
3. Early spring band of N (ammonium sulphate) and side-band P at seeding time.
4. Dual N & P (urea + MAP) side-banded at seeding time.
5. Dual N & P (ammonium nitrate + MAP) side-banded at seeding time.
6. Dual N & P (ammonium sulphate + MAP) side-banded at seeding time.
7. Dual N & P (urea + MAP) using a urease inhibitor.
8. Spring pre-plant dual band of N (urea) & P(MAP) Band width of 1".
9. (Optional) Spring pre-plant dual band of N (urea) & P(MAP) Band width of 3-4" (if equipment available).
10. Control N (urea) only applied pre-plant in a banding operation.

Experimental Design:

Randomized complete block design with **6 replicates.**

Measurements:

1. Dry matter production and N & P tissue content at 7, 14, 21, and 28 days after emergence and at flowering (2x one meter of row per plot)
2. Cd content of grain (sample size ... send to Brandon c/o C. Grant)
3. Oil content and fatty acid composition and iodine values of grain using NMR (50 g sample size ... send to Morden)
4. Soil N & P content, pH and conductance before seeding (depth increments ... send to Brandon c/o C. Grant)
5. Grain yield (whole plot yields as much as possible but excluding rows where dry matter sampling occurred).
6. Plant populations (2 x 1 meter of row per plot).
7. Plant height (2 measurements per plot).
8. Lodging (score of 1-10 with 10 being completely lodged).

Other relevant agronomic information is provided in Table 1.

Results and Discussion

Indian Head

The growing conditions at Indian Head in 1997 were very dry. We started with above average soil moisture conditions but proceeded to experience the second driest growing season in the last 100 years. The end result was much below average yields.

The trends for plant populations was such that urea tended to reduce plant populations in a dual band situation relative to ammonium nitrate and ammonium sulfate (Table 2). This was reflected in the lower dry matter accumulation at all sampling dates. However the trend for grain yield was for an increase with dual band regardless of the fertilizer source. Ammonium nitrate and sulfate were the least damaging to plant populations with greatest dry matter accumulation observed with these forms. The results emphasize the importance of ensuring proper separation between seed and fertilizer, especially when urea is the nitrogen form used. It also shows the potential benefits of putting the nitrogen and phosphorus in a dual band situation.

Table 1. Nitrogen and Phosphorus Management Study - Agronomic Information - 1997.

	Indian Head	Melfort	Brandon	Morden
Seeding Date	May 5/97	May 16/97	May 15/97	May 29/97
Dry Matter - Sampling Date				
Day 7	June 3/97	June 10/97	June 6/97	-
Day 14	June 10/97	June 19/97	June 13/97	June 23/97
Day 21	June 17/97	June 26/97	June 20/97	July 4/97
Day 28	June 24/97	July 3/97	June 27/97	-
Flowering	June 26/97	July 16/97	July 17/97	July 14/97
Soil Fertility				
Nitrogen (kg/ha) NO_3-N 0-24"	29.8	32.7	30	24.2
Phosphorus (kg/ha) PO_4-P	10.1(0-6)	45.3	37.4	2.5
Harvest Date	Sept. 3/97	Sept. 11/97	Sept. 15/97	Sept. 4/97
Spring Fertilizer Banding Date	May 2/97	May 16/97	May 15/97	May 16 - 1,2,3 May 29 - 8,9,10

Table 2. Indian Head 1997 - N-P Management Study

Treatment	Plants/m^2	Height	7 day DM	14 day DM	21 day DM	28 day DM	Flower DM	Grain Yield	
								Kg/ha	Bus/acre
Bd U - Sb P	465	46	71	126	198	378a	1894	978	15.7
Bd U - Sr P	493	48	70	168	176	335abc	1939	971	15.5
Bd AS - Sb P	491	47	80	154	204	301abc	1968	943	15.1
Sb U + P	383	51	53	114	170	289bc	1418	1051	16.8
Sb AN + P	505	49	63	144	188	365ab	1899	998	16.0
Sb AS + P	518	48	65	143	217	376a	1943	979	15.6
Sb Ua + P	451	47	67	151	151	262c	1674	929	14.9
Bd 1" U + P	513	43	68	141	173	312abc	1575	940	15.0
Bd 8" U + P (Sweep)	-	-	-	-	-	-	-	-	-
Bd 1" U + check P	491	46	72	138	190	311abc	1692	892	14.3
Pr>F									
Treatment	ns	ns	ns	ns	ns	0.05	ns	ns	ns
CV	21.0	10.0	29.4	20	22	20.6	24.7	16.6	16.6

Brandon

Relatively wet, cool conditions at seeding and during early July were followed by a long period of hot, dry conditions, leading to drought stress. Seed yield was maintained at relatively high levels in spite of the drought during flowering and seed fill.

Ammonium sulphate increased flax emergence and growth relative to urea, when used in bands with mono-ammonium phosphate (Table 3). Substituting ammonium sulphate for urea in the pre-plant band when the MAP was side-banded or in the dual band increased stand density and growth at each stage, except for the 28 day and the heading harvests. Seed yield was increased by use of ammonium sulphate instead of urea. Ammonium nitrate in the dual band with MAP also produced higher stand density, higher 14 day dry matter yield and higher seed yield than dual banding urea with MAP when using orthogonal contrasts.

Urea appeared to negatively influence growth of flax, even when used as a pre-plant band, in spite of the wet conditions at time of seeding (Table 3). Stand density was lower with all treatments including urea as an N source than treatments using either ammonium sulphate or ammonium nitrate and the effect on growth was maintained through the growing season. At harvest, seed yield was significantly higher with ammonium sulphate as an N source than with urea, as either a pre-plant band or side-band with monoammonium phosphate. Seed yield also tended to be higher ($p<0.0540$) with ammonium nitrate as an N source, side-banded with the phosphate than with urea.

Phosphorus fertilizer alone did not influence stand density or subsequent crop growth in this study (Table 3). Placement of P fertilizer also did not affect flax emergence or growth. Moisture conditions at time of seeding and through crop emergence were favourable, which would reduce the likelihood of seedling damage from seed-placed P. Stand density, crop growth through the growing season and final grain yield were similar with seed-placed and side-banded phosphate. Crop height was lower when phosphate was side-banded alone and urea was pre-plant banded than when P was seed-placed and N was pre-plant banded, or when urea and phosphate side-banded together at the time of seeding.

In conclusion, ammonium nitrate or ammonium sulphate are more effective N sources for flax than urea. Urea appeared to be damaging to flax, reducing stand density even when used as a pre-plant band. Stand density, crop growth during the season and final seed yield were better with alternate source of N fertilizer. Stand density, crop growth through the growing season and final grain yield were similar with seed-placed and side-banded phosphate. Under the moisture conditions experienced during the 1997 growing season, seed-placed P did not lead to seedling toxicity. Phosphorus fertilizer did not increase crop yield at this location.

Table 3. Brandon N-P Management Study

Treatment	Plants/m^2	Height	7 day DM	14 day DM	21 day DM	28 day DM	Flower DM	Grain Yield	
								kg/ha	bus/acre
Bd U - Sb P	372	55	84	204	409	1145	3810	2073	33.2
Bd U - Sr P	392	57	85	207	387	1165	3800	2125	34.0
Bd AS - Sb P	459	55	89	219	437	1380	4165	2216	35.5
Sb U + P	335	57	75	144	362	1240	3750	2078	33.2
Sb AN + P	455	59	78	228	422	1045	3575	2254	36.1
Sb AS + P	439	59	104	254	618	1515	4035	2276	36.4
Sb Ua + P	344	59	79	142	413	850	3615	2227	35.6
Bd 1" U + P	366	58	84	148	344	860	3590	2085	33.4
Bd 8" U + P (Sweep)	352	58	77	153	329	1070	3310	2176	34.8
Bd 1" U + check P	339	57	77	175	370	1020	3075	2069	33.1
Pr>F									
Treatment	0.02	0.01	Ns	0.02	0.03	Ns	0.03	Ns	-
CV	19.4	3.7	28.4	29.8	32.1	37.9	14.2	7.2	-

Morden:

The results indicate that yield can be changed by fertilizer management (Table 4). The treatment #7 (Dual N&P (urea + MAP) using a urease inhibitor (side-banded at seeding)) in both years caused a stand reduction, however, in 1996 this was the highest yielding treatment. In 1996, there was no effect of treatment on oil or iodine number. In 1997 two treatments caused a reduction in the iodine number and total oil content (Treatments #5 (Dual N&P (ammonium nitrate + MAP) side-banded at seeding time) & 9 (Spring Pre-plant dual band of N(urea)&P(MAP) Band width of 3-4")). Treatment #9 also caused an increase in the Oleic acid content, and a decrease in both the Linoleic and Linolenic acid contents. Treatment #5also caused a slight increase in the Oleic acid content. Treatment #3 ((Early spring band of N (ammonium sulphate) and side-band P at seeding time)) resulted in a decrease in the Oleic oil content which was not offset by significant increases in other fatty acids.

The results from this study in 1997 are not sufficient to reach any conclusions in the performance of flax with increased levels of nitrogen fertilizer from different sources and in different combinations with phosphorus fertilizer.

Table 4. Morden 1997 - N-P Management Study

Treatment	Plants/m^2	Height(cm)	7 day DM	14 day DM	21 day DM	28 day DM	Flower DM	Grain Yield	
								kg/ha	bu/ac
Bd U - Sb P	393bc	76bc	-	125bc	794bcd	-	2135bcd	1825c	29.2
Bd U - Sr P	361bc	77abc	-	93c	695d	-	1887d	1694d	27.1
Bd AS - Sb P	395bc	73c	-	124bc	756cd	-	2105cd	1793cd	28.7
Sb U + P	437bc	77abc	-	171a	108a	-	2774a	1858bc	29.7
Sb AN + P	475ab	79ab	-	168a	109a	-	2675a	1954b	31.3
Sb AS + P	361bc	77abc	-	162a	95abc	-	2367abc	1849bc	29.6
Sb Ua + P	308c	81a	-	179a	108a	-	2430abc	1837bc	29.4
Bd 1" U + P	576a	74c	-	170a	95abc	-	2584ab	1836bc	29.4
Bd 8" U + P (Sweep)	464ab	73c	-	155ab	99ab	-	2556abc	2160a	34.6
Bd 1" U + check P	388bc	74c	-	148ab	82bcd	-	2153bcd	1800cd	28.8
Pr>F									
Treatment	0.003	0.002	-	0.0001	0.0002	-	0.008	0.0001	-
CV	24	4	-	18	18	-	15	5	-

Melfort:

Environmental conditions were good at the Star City test location in 1997. Rainfall amounted to 26 mm in May, 80 mm in June, 43 mm in July and 42 mm in August. High air temperatures hastened flax flowering in late-July and early August. High wild oat pressure from a second flush was recorded on the trial and no doubt reduced yield potential.

The 10 fertilizer treatments considered were found to have no effect on crop establishment or harvest height in 1997 (Table 5). Pre-seeding banded ammonium sulphate, with P side banded (Tmt 3), consistently produced the highest dry matter yield in the study. Pre-seeding band application of urea N without P (Tmt 10) produced the lowest dry matter yield, and was grouped with the lowest grain yield treatments. Those grain yield treatments which yielded best included side banded urea + urease inhibitor and P (Tmt 7), pre-seeding banded AS and side banded P (Tmt 3), side banded ammonium nitrate and P (Tmt 5), and pre-seeding dual banded urea and P (Tmt 8). Dual banding the urea N and P prior to seeding in a wide (8" spread) band (Tmt 9) resulted in the lowest grain yields, similar to no P (Tmt 10). This result indicates that to be effective P should be placed either with the seed or close to the seed at seeding.

Table 5. Flax emergence, dry matter, crop height and grain yield response to fertilizer N and P management at Melfort, 1997.

Treatment	Plant Stand	Height	7 day DM	14 day DM	21 day DM	28 day DM	Flower DM	Grain Yield
	plants/m²	cm	---------- kg/ha ----------					
1. Bd U - Sb P†	369	55.1	65.6	188.5 abc‡	358.0 bc	903.0 b	2132.2 c	1456 bcd§
2. Bd U - Sr P	400	55.9	62.3	155.3 bc	478.3 ab	956.5 b	2582.4 abc	1425 bcd
3. Bd AS - Sb P	403	54.3	92.3	239.1 a	570.5 a	1955.0 a	2958.2 a	1606 ab
4. Sb U + P	326	55.9	70.4	136.7 c	350.3 bc	781.2 b	2323.9 bc	1399 bcd
5. Sb AN + P	365	56.7	67.8	205.2ab	443.3 ab	984.3 b	2720.5 ab	1548 abc
6. Sb AS + P	-	-	-	-	-	-	-	-
7. Sb Ua + P	380	57.4	66.7	181.5 abc	372.6 bc	924.1 b	2871.8 ab	1722 a
8. Bd 1" U + P	382	55.9	89.3	198.7 ab	435.6 ab	929.6 b	2746.8 ab	1495 abcd
9. Bd 8" + P (Sweep)	370	53.4	69.6	162.6 bc	441.1 ab	993.0 b	2580.9 abc	1275 d
10. Bd 1" U + check P	367	55.9	62.0	134.2 c	275.6 c	675.5 b	2123.8 c	1318 cd
Pr>F								
Treatment	0.5463	0.1062	0.2915	0.0145	0.0095	0.0002	0.0274	0.0770
CV	16	4	34	28	29	39	19	17

† See materials and methods for a description of treatments.
‡ Numbers followed by the same letter are not significantly different using $LSD_{0.05}$.
§ Numbers followed by the same letter are not significantly different using $LSD_{0.10}$.

Field Study #2: Zinc Management Study

Objective(s): Conduct studies at Morden on the potential of the micro-nutrient zinc for increasing flax yield and to determine the effects of source and placement of zinc on plant uptake at one location, Morden, MB.

Experimental Protocol:

Rates:

1. N 100 kg/ha (urea) mid-row banded at seeding time.
2. P_2O_5 25 kg/ha (map) side-banded at seeding time.
3. Zinc 10 kg/ha as zinc sulphate.
4. Zinc 2 kg/ha as zinc EDTA.

Variety: Norlin

Seeding Rate: 62 kg/ha or 1 bus/ac

List of Treatments:

1. Zinc sulphate broadcast prior to seeding.
2. Zinc sulphate banded with P at seeding time
3. Zinc EDTA broadcast prior to seeding.
4. Zinc EDTA banded with P at seeding time
5. Micro-plot using zinc sulphate and the sausage method for application
6. Micro-plot using zinc EDTA and the sausage method for application
7. Control (no zinc)

Experimental Design: Randomized complete block design with 6 replicates

Measurements:

1. Zn, N & P tissue content at 7, 14, 21 and 28 days after emergence and at flowering.
2. Cd content of grain.
3. Oil content and iodine values of grain.
4. Soil Zn, N & P content, pH and conductance.
5. Grain yield
6. Plant populations
7. Grain N, P and Zn content

Other pertinent agronomic information is provided in Table 6.

Table 6. Zinc Management Study - Agronomic Information- 1997

	Morden
Seeding Date	May 30
Dry Matter- Sampling Date	
Day 7	-
Day 14	June 25
Day 21	-
Day 28	July 9
Flowering	July 22
Soil Fertility	
Nitrogen (kg/ha) NO_3-N 0-6" 6-24"	 47 47
Phosphorus (kg/ha) PO_4-P 0-6"	 2.0
pH 0-6" 6-12"	 8 8
Conductance 0-6" 6-12"	 1.0 ms/cm 2.0 ms/cm
Harvest Date	Oct. 6
Broadcast Application Date	May 23
Zinc (kg/ha)	2

Results and Discussion

The site selected in 1996 was an excellent site to evaluate the effects of chlorosis on flax. The chlorosis was so sever that the cultivar, Norlin, selected for the study barely survived. There was no response to treatments in 1996. The cultivar selected in 1997 was AC Emerson, a chlorosis tolerant cultivar recently released from the Morden breeding program. This cultivar preformed adequately, however, the chlorosis condition delayed maturity by 31 days compared to flax studies conducted on the Morden Research Centre site. The crop was sprayed with Reglone Pro at 1.25 liters/acre at 118 days after planting and combined at 129 days after planting. The normal number of days to maturity for AC Emerson is approximately 105 days. The ANOVA of data analyzed to date does not indicate any effect of treatments. Means comparison by Duncan's indicates some differences, but these should be used with caution (Table 7).

Table 7. Morden 1997 - Zinc Management Study

Treatment	Plants/m^2	Height	Grain Yield	% Oil
Zn SO4-broad	405	61	1519	44.3
Zn-SO4-band	517	59	1453	44.1
EDTA-broad	500	60	1652	44..3
EDTA-band	459	58	1515	44.1
Zn-SO4-sausage	538	58	1188	43.8
EDTA-sausage	445	57	1496	44.2
Control	414	60	1523	44.0
Pr>F				
Treatment	ns	ns	ns	ns
CV	25	4	18	1

Field Study #3: N & P Rate Studies

Objective(s): To evaluate the response of flax to different rates of nitrogen and phosphorus at two locations in a one-pass seeding and fertilizing system consisting of a dual band of nitrogen and phosphorus at Indian Head, Lemberg and Melfort.

Experimental Protocol:

Rates:

Nitrogen Rate: N0=0 kg/ha; N1=40 kg/ha; N2=80 kg/ha; N3=120 kg/ha. Urea will be used.

Phosphorus rate (P_2O_5): P0=0 kg/ha; P1=15 kg/ha; P2=30 kg/ha; P3=45 kg/ha. MAP will be used as the fertilizer source.

Variety: Norlin

Seeding rate: 62 kg/ha or 1 bus/ac.

Experimental Design: Randomized complete block design with 4 replicates

Measurements:

1. Plant counts (2x - 1 m of row)
2. Plant height
3. Lodging
4. Maturity
5. Grain Yield
6. Grain N & P
7. Oil content using NMR
8. Fatty acid composition

Other pertinent agronomic information provided in Table 8.

Table 8. Nitrogen and Phosphorus Rate Study - Agronomic Information - 1997.

	Indian Head	Melfort	Lemberg
Seeding Date	May 5/97	May 16/97	May 8/97
Flowering	June 26/97	-	-
Soil Fertility			
Nitrogen (kg/ha) NO_3-N 0-24"	37.6	32.7	10.5
Phosphorus (kg/ha) PO_4-P 0-6"	11.3	45.3	15.3
Harvest Date	Sept. 3/97	Sept. 11/97	Sept. 5/97

Results:

Indian Head

The growing season conditions, as explained in Field Study #1, were much below average and yield potential greatly reduced. However, we still observed a yield response to nitrogen and phosphorus (Table 9). The best yields were obtained with N rates varying between 40 and 80 kg N/ha and with 15 kg P2O5 /ha. Plant populations were not affected by P but decreased when the rate oif N increased. There was a 40% reduction in plant stand from the 0 nitrogen rate to the highest N rate used.

Table 9. Indian Head 1997 - N x P Study

Treatment	Plants/m^2	Height	Grain Yield	
			kg/ha	bus/acre
N Rate				
0	561	49	924	14.8
40	474	48	974	15.6
80	388	51	1018	16.1
120	333	53	1001	16.0
P Rate				
0	397	50	926	14.8
15	420	52	989	15.8
30	494	50	973	15.6
45	436	50	1019	16.3
N x P Interaction				
0N 0P	488	50	882	14.1
0N 15P	619	51	962	15.4
0N 30P	569	47	899	14.4
0N 45P	571	47	954	15.3
40N 0P	388	48	957	15.3
40N 15P	416	50	955	15.3
40N 30P	605	48	984	15.8
40N 45P	487	48	1001	16.0
80N 0P	370	50	974	15.6
80N 15P	356	51	1009	16.1
80N 30P	436	50	1001	16.0
80N 45P	358	54	1048	16.8
120N 0P	343	52	892	14.3
120N 15P	290	54	1030	16.5
120N 30P	367	54	1007	16.2
120N 45P	331	51	1075	17.2
Pr>F				

N rate	**	**	x	x
P rate	x	ns	x	x
N x P	ns	**	ns	ns
CV	21	8	9	9

Melfort:

Increasing the rate of side banded N resulted in a decline in seedling stand, while crop height and grain yield showed a positive increase to N (Table 10). Maximum grain yields were achieved with 80 kg N/ha at this trial. While crop height showed a positive response to fertilizer P, it had no effect on crop emergence or grain yield. There was a decrease in plant populations with increasing rates of nitrogen, however the reduction was not as severe as the one observed at Indian Head.

Table 10. Melfort 1997 - N x P Study

Treatment	Plants/m^2	Height	Grain Yld	Grn Yld Bu/ac
N Rate				
0	399a	51c	789c	12.6c
40	418a	55b	1282b	20.5b
80	361b	56ab	1592a	25.5a
120	349b	58a	1574a	25.2a
P Rate				
0	382	52b	1247	20.0
15	372	56a	1298	20.8
30	375	56a	1363	21.8
45	398	56a	1329	21.3
N x P Interaction				
0N 0P	388	49	700	11.2
0N 15P	383	50	730	11.7
0N 30P	389	53	856	13.7
0N 45P	436	52	870	13.9
40N 0P	428	54	1167	18.7
40N 15P	413	57	1322	21.2

40N 30P	391	55	1303	20.8
40N 45P	440	56	1337	21.4
80N 0P	362	55	1532	24.5
80N 15P	355	59	1569	25.1
80N 30P	352	56	1623	25.9
80N 45P	374	56	1642	26.3
120N 0P	350	56	1588	25.4
120N 15P	337	58	1570	25.1
120N 30P	366	59	1671	26.7
120N 45P	343	59	1467	23.5
Pr>F				
N rate	0.0003	0.0001	0.0001	0.0001
P rate	ns	0.03	Ns	ns
N x P	ns	ns	ns	ns
CV	12	5	11	11

Lemberg

A response to nitrogen was observed for all variables presented (Table 11) and a response to P was only observed for grain yield. Plant populations decreased by 34% with increasing nitrogen rates from the 0 to highest rate. Plant height increased as nitrogen rate increased. The best yields were obtained with a nitrogen rate of 80 kg/ha and a P2O5 rate of 15 kg/ha.

Table 10. Lemberg 1997 - N x P Study

Treatment	Plants/m^2	Height	Grain Yield	
			kg/ha	bus/acre
N Rate				
0	601	50	799	12.8
40	573	53	1136	18.2
80	458	55	1199	19.2
120	397	56	1129	18.1
P Rate				
0	527	54	958	15.3
15	473	54	1087	17.4
30	508	54	1090	17.4
45	521	53	1129	18.1
N x P Interaction				
0N 0P	675	49	677	10.9
0N 15P	532	49	790	12.7
0N 30P	588	52	850	13.6
0N 45P	609	49	878	14
40N 0P	554	54	1016	17.1
40N 15P	560	54	1119	17.9
40N 30P	601	52	1210	19.4
40N 45P	577	54	1149	18.4
80N 0P	437	57	1073	17.2
80N 15P	404	56	1291	20.7
80N 30P	476	55	1165	18.7
80N 45P	514	54	1268	20.3
120N 0P	441	57	1016	16.3
120N 15P	397	55	1147	18.4
120N 30P	366	56	1133	18.1
120N 45P	382	56	1219	19.5
Pr>F				
N rate	**	**	**	**

P rate	ns	ns	**	**
N x P	ns	ns	ns	ns
CV	15.3	5.4	8.9	8.9

Field Study #4: N & P & K & S

Objective(s): To determine the effects of potassium and sulfur on flax yields at three locations, Melfort, Lemberg and Indian Head.

Description of Study:

Variety: Norlin

Seeding rate: 62 kg/ha or 1 bus/ac

Rates: P_2O_5 using MAP 35 kg/ha
Nitrogen using urea N: 120 kg/ha (soil and fertilizer N)
Sulfur (S) using ammonium sulfate: 20 kg/ha
Potassium (K_2O): 35 kg/ha

Treatments:
1. N only
2. N + P
3. N + P + K
4. N + P + S
5. N + P + K + S
6. Check

Measurements:
1. Plant counts (2x - 1 m of row)
2. Plant height
3. Grain yield
4. Oil content using NMR
5. Fatty acid composition

Other pertinent agronomic information can be found in Table 12.

Table 12. Nitrogen Phosphorus, Potassium and Sulfur Study - Agronomic Information - 1997.

	Indian Head	Melfort	Lemberg
Seeding Date	May 5/97	May 16/97	May 8/97
Flowering	June 26/97	-	-
Harvest Date	Sept. 3/97	Sept. 11/97	Sept. 5/97

Results:

Indian Head

An increase in plant height and grain yield was observed with the addition of nutrients while a reduction in plant numbers was observed (Table 13). The trend was for plant numbers to increase when sulfur was added to the blend. There was a tendency for a yield benefit when P was added.

Table 13. Indian Head Results

Treatments	Plants/m²	Plant height (cm)	Grain Yield	
			kg/ha	bus/acre
N	353	51	809	12.9
N & P	376	48	934	14.9
N & P & K	345	55	908	14.5
N & P & S	444	50	909	14.6
N & P & K & S	467	53	861	13.8
Check	589	46	727	11.7
Contrast[1]				
Check vs rest	***	**	**	**
N vs rest (no check)	ns	ns	ns	ns
N vs N & P only	ns	ns	ns	ns
N vs NPKS	ns	ns	ns	ns
N + P vs rest (no check)	ns	ns	ns	ns
N + P vs NPKS (only)	ns	ns	ns	ns

[1] Values followed by ***, **, * or ns are significant at the 1%, 5% and 10% level and no significant, respectively.

Lemberg

Plant numbers were not affected by the addition of these high rates of nutrients relative to the check. (Table 13). Plant height was greatest when all four nutrients were used. Grain yield were improved when P and S were added thus showing a response sulfur.

Table 13. Lemberg Results

Treatments	Plants/m^2	Plant height (cm)	Grain Yield	
			kg/ha	bus/ac
N	406	55	1133	18.1
N & P	419	55	1298	20.8
N & P & K	490	52	1185	18.9
N & P & S	473	53	1329	21.3
N & P & K & S	465	59	1342	21.5
Check	491	48	805	12.9
Contrast[1]				
Check vs rest	ns	***	***	***
N vs rest (no check)	ns	ns	***	***
N vs N & P only	ns	ns	***	***
N vs NPKS	ns	ns	***	***
N + P vs rest (no check)	ns	ns	ns	ns
N + P vs NPKS (only)	ns	ns	ns	ns

[1] Values followed by ***, **, * or ns are significant at the 1%, 5% and 10% level and no significant, respectively.

Melfort:

The addition of side banded fertilizer significantly reduced flax seedling stand relative to the unfertilized check (Table 14). The negative effect of fertilizer on seedling stand increased as the total amount of fertilizer applied increased, indicating inadequate seed to fertilizer placement with the seeder used in this study. Crop height and grain yield both showed a positive response to the fertilizer treatments, all yielding higher than the unfertilized check. While not significant, it was the N+P+K+S treatment which gave the highest yield.

Table 14.Melfort Results.

Treatments	Plants/m^2	Plant height (cm)	Grain Yield	
			kg/ha	bus/acre
N	326ab	57a	1564a	25.0a
N & P	281b	57a	1555a	24.9a
N & P & K	319b	58a	1507a	24.1a
N & P & S	279b	58a	1597a	25.6a
N & P & K & S	324b	58a	1682a	26.9a
Check	390a	50b	644b	10.3b
cv	14	5	10	10
Pr>F				
Treatment	0.03	0.003	0.0001	0.0001

[1] Values followed by te same letter are not significant at the LSD (5%).

Field Study #5. Nitrogen Management Study

Objectives: Compare fall banding of nitrogen to side banding at seeding and broadcast after seeding.

Description of Study:

Variety: Norlin

Seeding Rate: 62 kg/ha or 1 bus/ac

Rates: P_2O_5 using MAP xx kg/ha
Nitrogen: 70 kg/ha
Fertilizer Form: urea and ammonium nitrate

Treatments:

1. Urea (UR) fall banded
2. Ammonium nitrate (AN) fall banded

3. UR side-banded at seeding
4. AN side-banded at seeding
5. UR with Agrotain broadcast after seeding
6. AN broadcast after seeding
7. Check

Measurements:

1. Plant counts (2x - 1 m of row)
2. Plant height
3. Grain yield
4. Oil content using NMR
5. Fatty acid composition.

Other pertinent agronomic information presented in Table 15.

Table 15. Nitrogen Management Study - Agronomic Information 1997.

	Indian Head
Seeding Date	May 5/97
Flowering	June 26/97
Fall Banding Date	Oct. 18/96
Spring Broadcast	May 6/97

The only significant effect was the addition of fertilizer, regardless of form and timing relative to the no fertilizer check (Table 16). It is interesting to note the lack of an effect due to fertilizer
form .

Table 16. Nitrogen Management at Indian Head.

Treatments	Plants/m^2	Plant height (cm)	Grain Yield	
			kg/ha	bus/acre
Check	503	42	621	10.0
UR-FB	648	45	624	10.0
AN-FB	561	43	631	10.1
UR-Side BD	511	47	617	9.8
AN-Side BD	558	45	698	11.2
UR-Broadcast	350	49	729	11.7
AN-Broadcast	481	47	787	12.6
Contrast[1]				
Check vs rest	ns	0.054*	0.08*	0.08*
Banding vs Broadcast	ns	ns	ns	ns
Fall Banding vs Side Banding	ns	ns	ns	ns
Urea vs Ammonium Nitrate	ns	ns	ns	ns

[1] Values followed by ***, **, * or ns are significant at the 1%, 5% and 10% level and no significant, respectively.

Field Study #6: Chemical Weed Control

I. Effect of Formulation on Flax Tolerance to Bromoxynil Application

Field trials were conducted in 1997 at Morden and Brandon, Manitoba to investigate the tolerance of NorLin flax to various formulations of bromoxynil. Formulations tested included Emulsifiable Concentrate (EC), Gel and dry preparations of bromoxynil. All treatments were applied before flax reached 12.5 cm in height and before 9:00 a.m. Previous research has suggested that this timing of application would produce the greatest potential for visual injury to flax. All treatments were applied with a small plot sprayer delivering 110 L/ha at 40 psi at Morden and 100 L/ha at 30 psi at Brandon. Sprayers were equipped with SS 8002 and SS 8001 flat-fan nozzles at Morden and Brandon, respectively. Treatments were arranged in a randomized complete block design with four replicates. Flax was rated for crop injury at 2, 4 and 6 weeks after treatment (WAT) using a 0 to 100% scale, where 0 is equivalent to no observed crop injury and 100 is complete crop death. Flax seed yields (g/m^2) determined at the end of the experiment. Injury data was transformed using an arcsine(X + 0.05) transformation prior to analysis. All data were analyzed by analysis of variance procedures and the means separated using Duncan's multiple range test at P=0.05.

Dry growing conditions early in the season resulted in uneven growth in the flax crop at Brandon and flax plants ranged in height from 2 to 10 cm at the time of herbicide application. At both locations, although there were significant differences in crop injury among treatments visual, estimates of injury were 10% or less (Table 1). At this level of injury all treatments were considered to fall within the industry norm for acceptable injury, ie. in practical terms injury did not differ markedly among treatments. Flax yields were unaffected by herbicide treatment. Flax yields at Brandon were approximately 25% those recorded at Morden. This was attributed to the dry growing conditions that persisted throughout much of the growing season. None of the flax yields differed significantly from the untreated check.

Results of the two studies conducted in 1997 to examine the effect of formulation on flax tolerance to bromoxynil suggest that formulation did not affect crop tolerance in this year. Since these studies represent the results of only on year, they should not be considered conclusive and would need at least an additional year at two locations to prove that formulation does not significantly affect flax tolerance to bromoxynil.

II. Effect of Growth Stage, Time of Application and Dosage on Flax Tolerance to Bromoxynil + MCPA ester

Field studies were conducted in Morden, Manitoba in 1996 and 1997 and in Brandon, Manitoba in 1997 to investigate the effect of flax growth stage, time of application and dosage on flax tolerance to bromoxynil + MCPA ester. Herbicide treatments were applied when the flax was 2.5 to 5 or 12.5 to 15 cm tall between 7:00 and 9:00 a.m. and 1:00 to 3:00 p.m. An emulsifiable concentrate formulation of bromoxynil + MCPA ester was applied at 0, 140, 280, 560 and 1120 g ai/ha as a tank-mixture with clethodim plus Amigo at 45 g ai/ha plus 0.5% v/v. The experimental design was a split-split-plot with 4 replicates. Main, sub- and sub-sub-plots were growth stage, time of application and dosage, respectively. Treatments were applied with a small plot sprayer delivering 110 L/ha at 40 psi at Morden and 100 L/ha at 30 psi at Brandon. Sprayers were equipped with SS 8002 and SS 8001 flat-fan nozzles at Morden and Brandon, respectively. Flax was rated for crop injury at 2, 4 and 6 weeks after treatment (WAT) using a 0 to 100% scale, where 0 is equivalent to no observed crop injury and 100 is complete crop death. Flax seed yields (g/m^2) determined at the end of the experiment. In addition, plant stand ($plants/m^2$) and days to maturity were determined at Morden. Flax was considered mature when 75% of the bolls had turned brown. Data was analyzed by analysis of variance and the least significant difference (L.s.d.) calculated.

At Morden in both years there was a significant interaction between growth stage, timing of application and dosage for visual injury. The effects of herbicide dosage on crop injury was most pronounced 2 to 4 WAT and at the 560 and 1120 g ai/ha dosages (Table 2). These dosages represented the recommended and twice the recommended dosage for bromoxynil + MCPA ester. At the recommended dosage, crop injury 4 WAT was less than 10% and was considered to be acceptable by commercial standards. However, at twice the recommended rate which can occur under field conditions when spray patterns overlap, injury was severe especially when the herbicides were applied between 7:00 and 9:00 a.m., and when the plants were small (2.5 to 5 cm). Severe injury occurred only when twice the recommended dosage was applied in the early morning hours. Where severe injury occurred, the visual effects persisted throughout much of the growing season. Injury symptoms consisted of reduced crop stand and height and delayed flowering and maturity. At Brandon, there was a significant interaction between timing of application and dosage at 2 and 6 WAT.

At Morden in 1996, there was a significant interaction between growth stage, timing of application and dosage for the effects of bromoxynil + MCPA ester on flax stands. In that year, twice the recommended dosage applied between 7:00 and 9:00 a.m. to flax that was 2.5 to 5 cm tall reduced crop density by approximately 50% compared with the untreated check (Table 3). Crop density was unaffected in 1997.

There was a significant interaction between growth stage, timing of application and dosage for the effects of bromoxynil + MCPA ester on the time to flax maturity at Morden in 1996 (Table 3). For both timings of application flax maturity delayed with increasing herbicide dosage, but the effect was much more pronounced when bromoxynil + MCPA ester was applied in the morning than in the afternoon. In 1997, there was a significant time of day by dosage interaction, with the effects of dosage being much more noticeable following morning applications.

The time of day by dosage interaction was significant for yield at Morden in 1996. However, flax yields were reduced only when bromoxynil + MCPA ester was applied at twice the recommended dosage in the early morning (Table 3). At Morden and Brandon in 1997, there was a significant dosage by time of application interaction. There was no difference in flax yield between morning and afternoon applications of bromoxynil + MCPA ester when the herbicide was applied at either growth stage. However, for the later growth stage, flax yields were significantly lower when the

Table 3. Effect of bromoxynil + MCPA ester time of application and growth stage on flax stand, days to maturity and yield.

Treatment(s)			Flax stand (plants/m2)		Days to maturity		Flax yield (g/m2)		
		Dosage	Morden		Morden		Morden		Brandon
Growth stage	Time of day	(g ai/ha)	1996	1997	1996	1997	1996	1997	1997
2.5 to 5 cm	0700 to 0900	0	692	552	82	93	241	160	116
2.5 to 5 cm	0700 to 0900	140	702	600	81	91	240	152	117
2.5 to 5 cm	0700 to 0900	280	665	653	83	93	244	160	118
2.5 to 5 cm	0700 to 0900	560	624	656	88	93	252	159	111
2.5 to 5 cm	0700 to 0900	1120	354	284	97	101	195	84	67
12.5 to 15 cm	0700 to 0900	0	618	698	83	89	253	206	123
12.5 to 15 cm	0700 to 0900	140	708	668	83	88	245	201	117
12.5 to 15 cm	0700 to 0900	280	725	734	84	89	246	193	119
12.5 to 15 cm	0700 to 0900	560	674	609	85	90	241	203	105
12.5 to 15 cm	0700 to 0900	1120	652	639	96	98	223	167	102
2.5 to 5 cm	1300 to 1500	0	691	518	81	92	243	162	126
2.5 to 5 cm	1300 to 1500	140	686	609	81	93	236	156	122
2.5 to 5 cm	1300 to 1500	280	678	602	83	92	249	150	123
2.5 to 5 cm	1300 to 1500	560	680	665	83	94	257	163	127
2.5 to 5 cm	1300 to 1500	1120	623	602	85	95	249	156	121
12.5 to 15 cm	1300 to 1500	0	702	704	82	92	253	162	61
12.5 to 15 cm	1300 to 1500	140	668	557	82	90	246	108	64
12.5 to 15 cm	1300 to 1500	280	641	621	84	92	251	129	60
12.5 to 15 cm	1300 to 1500	560	680	798	84	91	260	131	59
12.5 to 15 cm	1300 to 1500	1120	665	605	88	92	248	128	56
L.s.d. (0.05)									
Growth stage (GS)			ns	ns*	ns	ns	ns	ns	15
Time of day (T)			ns	ns	2	ns	ns	ns	17
Dosage (D)			41	ns*	1	2	11	22	10
GS x T			ns	ns	ns	ns	ns	54	24
GS x D			58	ns	ns	ns	ns	ns*	ns
T x D			58	ns	2	2	15	ns	14
GS x T x D			82	ns	2	ns	ns	ns	ns

* Significant at p=0.10.