

SK-18

1998

**Final Report  
1996-1999**

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

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## Acknowledgment

This project was made possible with funding from Agriculture and Agri-Food Canada, Agriculture and Agri-Food Canada's Matching Investment Initiative, the Flax Council of Canada, the Potash and Phosphate Institute of Canada and Agrium.

## **1.0 Title:**

INCREASING FLAX YIELDS: A closer look at fertilizer utilization and weed management.

## **2.0 Background:**

### **2.1 Introduction**

A meeting was held in October of 1995 in Winnipeg which involved the Flax Council and researchers, mainly agronomists from Agriculture and Agri-Food Canada (AAFC) and representatives from each of the University of Manitoba and Saskatchewan. Participants from the Flax Council included management, the board of directors and members of the Research and Technology Committee.

The purpose of the meeting was to identify opportunities for increasing flax production both in terms of grain yield and acres under production. The meeting attempted to narrow down the areas of research where rapid improvements in grain yields could be achieved i.e. a greater likelihood of success given the limited dollars available for research. It was agreed that the Flax Council would work directly with the researchers present at the meeting in developing a proposal that would meet the needs of all parties involved.

### **2.2 Agronomist Perspective**

Short presentations were given by the researchers present summarizing their research on flax production. Issues such as seeding date, crop water use, depth and extent of soil water use, row spacing and seeding rates, N&P fertilizer management and utilization, yield performance relative to other crops, impact of nitrogen timing and placement on weeds, impact of micro-nutrients, impact of herbicide timing, were discussed. From these summaries, it was possible to develop a direction as to what flax agronomy research should be focussed on in the three years.

### **2.3 Producer Perspective**

A round table discussion allowed the producers the opportunity of identifying what they considered limitations to flax production. Issues pertaining to seeding date, soil temperature and crop emergence, fertility, plant nutrition, fertilizer management, maturity, ease of harvesting, straw management, lodging, chemical weed control, risks of spring frosts, crop establishment as a function of seeding technology were discussed. Several producers expressed the need to determine the true yielding potential of flax and the need to develop a production system capable of producing more consistent yields of 35-45 bus/acre in the black soil zone. It was felt that if yields could be enhanced through improvements in production practises, this in turn would stimulate increases in production acres. The role of basal branching on grain yield has to be researched more fully as well as the production of an accurate plant development scale to allow better timing of applications of various treatments, especially herbicides.

### **2.4 Priorities for Agronomy Research**

In order to establish the priorities, the researchers met independently of the board of directors in order to develop a list of immediate research needs.

## **2.4.1 Areas identified by the Flax Council**

### **a. Fertilizer utilization as it relates to:**

- Placement/rates/type/form/amount
- Review of flax research pertaining to fertilizer and plant nutrition. Is the information still relevant today?
- Impact of plant nutrition on lodging.
- Interaction of seeding rate with lodging and plant nutrition.

### **b. Chemical weed control as it relates to:**

- Timing of herbicide application relative to the stage of crop and weeds.
- Impact of weed regrowth on flax yield.
- Tolerance of flax to the main herbicides in use.
- Interactions of herbicides with climatic factors.
- Reduced rates of herbicides.

### **c. Seeding technology and crop establishment:**

- impact of various seed openers on crop establishment

### **d. Variety development:**

- better lodging resistance
- larger seed size

## **2.4.2 Areas identified by Researchers.**

The researchers present came up with two important areas of research activity:

### **a. Fertilizer utilization/plant nutrition:**

It was agreed that based on the work presented by Dr. Geza Racz of the University of Manitoba that attention should be focused on phosphorus fertilizer. He felt that proper P placement could lead to a 1-3 bushel/acre increase. He also felt that certain micro-nutrients should be investigated, more specifically zinc. It was agreed as well that flax is very sensitive to fertilizer and that seeding rates may require further investigations to offset potential damage to flax stands as a result of fertilizer management.

In terms of P fertilizer, the current evidence is that it should be banded to the side and below the seed (2" x 2"). The crop needs to have early access to P fertilizer. However, the current practise of placing the fertilizer N (urea) and P (MAP) in the same band can lead to ammonia toxicity which can delay P uptake by up to 23 days, negating any advantage from side-banding the P fertilizer. It was suggested that replacing urea with ammonium nitrate or ammonium sulphate would greatly reduce this problem. These facts question the feasibility of a one-pass seeding and fertilizing system being recommended and promoted at this time. We need to

develop N&P principles for fertilizer management in flax. There is also need to do some work on potassium and sulfur as well.

**b. Weed control and management in flax:**

Although herbicide weed control options in flax are good, it was felt that the poor timing of herbicide applications, especially late applications may in fact result in poor weed control and crop injury. Producers are reluctant to spray when the crop is small because of the fear of missing a later flush of weeds. The lack of competitiveness of the flax crop is such that waiting for a later flush of weeds may in fact result in more yield loss because the first flush of weeds may in fact be more competitive against the crop, not to mention more injury to the flax plant with the later herbicide applications.

The specific issues identified for weed management in flax were:

- Tolerance of flax to herbicides as a function of timing and climatic conditions.
- Management of certain broadleaf weeds in flax.
- Controlling volunteer flax in a subsequent crop.
- Stage of weed relative to stage of crop and density of weeds on reductions in flax yield.

**2.5 Research Priorities**

In the last session of the meeting, a process of cooperation was established and the council agreed in principle to develop an agronomy research effort. The overall vision of the Flax Council is to have 5 million acres of flax being produced in Western Canada by the year 2000. Their goal is to be able to promote a crop that has good yielding potential, good returns and producer acceptance. In order to meet these objectives, there is urgent need in developing a comprehensive production system for flax for Western Canada.

Following is the agreed upon list of agronomy research priorities:

**a. Fertilizer utilization:**

- N&P fertilizer management
- Implications of N&P in a single fertilizer band at seeding time.
- Potential of micro-nutrients. It was agreed that this would initially be investigated at only one location with Morden identified as the initial location.
- Review of previous unpublished research work on flax done by Harry Ukrainetz.

**b. Weed control and management in flax:**

- Tolerance of flax to herbicides as a function of timing and climatic conditions.
- Comprehensive review of ECW database.
- Competitiveness of weeds in flax.
- Control of specific broadleaf weeds.
- Control of flax in subsequent crops.

### **3.0 Objectives**

To increase flax yields through more efficient use of fertilizers and better chemical weed control and management.

### **4.0 Research plans 1996-1998**

#### **4.1 Research on fertilizer utilization for 1996-99**

##### **Part A: Review of literature on flax nutrition & production and summary of unpublished research on flax nutrition**

-Conduct an in-depth review of scientific literature on production and nutrition in flax and as it applies to the Canadian Prairies.

-Summarize all field research in flax performed by Harry Ukrainetz pertaining to fertilizer utilization. Analyze and prepare a summary of findings in a report form.

##### **Part B: Field Research**

-Conduct three consecutive years of field studies on the impact of side-banding P in flax and the implications of dual N&P bands using urea, ammonium sulphate and ammonium nitrate on P uptake as currently used in a one-pass direct seeding and fertilizing system. The sites were Morden, Brandon, Melfort and Indian Head.

-Conduct studies at Morden on the potential of the micro-nutrient zinc for increasing flax yield and alleviating the problems with chlorosis.

##### **Study #1: N&P Management Study (1996-1998)**

**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.

**Rates:** Only one rate of N and P were used

70 kg/ha for N

20 kg/ha for P<sub>2</sub>O<sub>5</sub>

**Variety:** Norlin

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

**Location(s):** Morden, Brandon, Melfort, Indian Head (1996-1998)

**List of treatments:**

1. Early spring band of N (urea) and side-band P at seeding time.

2. Early spring band of N (ammonium nitrate) and side-band 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 (2x 1 meter of row per plot).
7. Plant height (2 measurements per plot)
8. Lodging (score of 1-10 with 10 being completely lodged)

#### **Study #2 Zinc Management (1996-1998)**

**Objectives:** Conduct studies 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.

#### **Rates:**

1. N 100 kg/ha (urea) mid-row banded at seeding time
2. P<sub>2</sub>O<sub>5</sub> 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

**Location:** Morden (1996-1998)

**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

**Study #3: N and P rate studies (1996-1998).**

**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 and Melfort.

**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

**Location:** Indian Head, Melfort (1996-1998), Lemberg (1996-1997)

**List of treatments:**

1. N0 P0
2. N1 P0
3. N2 P0
4. N3 P0
5. N0 P1
6. N1 P1
7. N2 P1
8. N3 P1
9. N0 P2
10. N1 P2
11. N2 P2
12. N3 P2
13. N0 P3
14. N1 P3
15. N2 P3
16. N3 P3

**Experimental Design:**

Randomized complete block design with 4 replicates.

**Measurements:**

1. Plant counts (2x - 1m 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

**Study #4: N&P&K&S Study (1996-1998).**

**Objective(s):** To determine the effects of nitrogen, phosphorus, potassium and sulfur on flax yields.

**Variety:** Norlin

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

**Rates:** P<sub>2</sub>O<sub>5</sub> using MAP 35 kg/ha

Nitrogen using urea N: 120 kg/ha

Sulfur (S) using ammonium sulfate: 20 kg/ha

Potassium (K<sub>2</sub>O): 35 kg/ha

**Location:** Indian Head, Melfort (1996-1998), Lemberg (1996-1997)

**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 - 1m 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

### **Study #5. Nitrogen Management (1996-1997).**

**Objectives:** To compare fall banding, spring banding and early spring broadcast of urea, ammonium nitrate and urea treated with Agrotain™.

**Variety:** Norlin

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

**Rates:** P<sub>2</sub>O<sub>5</sub>: MAP 20 kg/ha

**Nitrogen:** 70 kg/ha

**Location(s):** Indian Head (1996-1997)

**Fertilizer Form:** urea, ammonium nitrate and urea treated with Agrotain.

#### **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 - 1m of row)
2. Plant height
3. Grain Yield
4. Oil content using NMR
5. Fatty acid composition

## 4.2 Chemical Weed Control in Flax 1996-1998

### Part A: Review of Expert Committee on Weeds Database

**Objective:** To review all research conducted in western Canada as reported in ECW from 1976 to 1994 on flax tolerance to Buctril M with particular reference to the impact of cultivar, growth stage, tank-mixtures, herbicide timing and climatic conditions on flax growth, development and grain yield. Based on the results of the database study, review current recommendations and establish new recommendations (if possible) for reducing the risks of crop injury when applying Buctril M, and assess future research needs.

**Review procedures:** WEEDTRIEV software was used to search the ECW database (1976-1994) for all references to research conducted on bromoxynil plus MCPA ester (Buctril M) in flax. The search parameters were narrowed to only those studies that evaluated the EC formulation of Buctril M applied at the commercial rate of 560 g ai/ha and provided information on both crop injury and yield. Quattro Pro (spreadsheet) was used to create a "general purpose" database for experiments meeting the following criteria:

- ◆ Tolerance (injury) ratings conducted within four weeks of application (only the earliest rating date was used if more than one rating was done).
- ◆ Poast (sethoxydim) rate of 200 to 300 g ai/ha plus Assist or Merge at 0.5 to 1% v/v as a tank-mix partner with Buctril M.
- ◆ Select (clethodim) rate of 30 to 90 g ai/ha plus Amigo at 0.5 to 1% as a tank-mix partner with Buctril M.
- ◆ Assure (quizalofop) rate of 95 to 150 g ai/ha plus Canplus 411 at 0.5 to 1% v/v as a tank-mix partner with Buctril M.

The following information was recorded for those studies meeting the above criteria: year, experiment number, cultivar, growth stage at application (cm), water volume, application date, whether the trial was conducted under weedy or weed-free conditions, trial objective (weed control or crop tolerance), seasonal precipitation (mm in May, June and July), total precipitation for the first week after application, crop injury (0 to 100%), yield of the weedy and weed-free checks, best yield (despite treatment), treatment yields for Buctril M, Buctril M + Poast + Merge, Buctril M + Poast + Assist, Buctril M + Select + Amigo, and Buctril M + Assure + Canplus 411, Buctril + other graminicides and/or other adjuvants.

"Specific purpose" databases were also constructed to investigate cultivar, tank-mixtures, staging, time of day, rate, as factors affecting flax tolerance to Buctril M.

### Part B: Field Studies on chemical weed control in flax.

#### Study #1: Chemical weed control in flax - 1996

**Objective:** Since this survey was completed just before crop seeding in 1996, new research was initiated to start answering some questions raised by the review. A study was conducted at Morden to investigate the effects of crop growth stage and time of day on flax tolerance to Buctril- M.

**Study Protocol:** NorLin flax was seeded with a double disc-drill on May 28 at 47 kg/ha. Plots were 2 x 8 m and consisted of 7 crop rows spaced 18 cm apart. Prior to seeding, 150 kg/ha of 34-0-0 was broadcast and incorporated. The experimental design was a split-split-plot with 4 replicates. Main and sub- and sub-subplots consisted of growth stages (2.5 to 5 cm or 12.5 to 15 cm tall) time of day of Buctril M application (morning or afternoon) and herbicide rate, respectively. Buctril M was applied at 0, 140, 280, 560 and 1120 g ai/ha plus Select (clethodim) at 45 g ai/ha plus Amigo at 0.5% v/v with a self-propelled sprayer in 139 L/ha of total solution at 262 kPa between 0800 and 0900h (morning) or at 1430 h (afternoon).

Crop injury was rated visually 2, 4 and 6 weeks after treatment on a 0 to 100% scale, where 0% corresponds to no visible injury and 100% corresponds to complete crop mortality. Days to 50% bloom and 75% brown boll (mature) was assessed visually for each plot. Flax was harvested on September 13, 1996.

### **Study #2: Chemical Weed Control - 1997**

**Objective:** Study the effect of formulation on flax tolerance to Bromoxynil application.

**Study Protocol:** 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 ( $\text{g}/\text{m}^2$ ) 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  $P=0.05$ .

### **Study #3: Chemical Weed Control - 1997**

**Objective:** Study the effect of growth stage, time of application and dosage on flax tolerance to Bromoxynil + MCPA ester.

**Study Protocol:** 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 ( $\text{g/m}^2$ ) determined at the end of the experiment. In addition, plant stand (plants/ $\text{m}^2$ ) 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.

#### **Study #4: Chemical Weed Control - 1998**

**Objective:** Study the effect of formulation on flax tolerance to Bromoxynil application at different growth stages and different times of day.

**Study Protocol:** Impact of time crop growth stage and time of day on injury to flax by various rates of Buctril M and Select applied as a Tank Mix. The seeding date was June 23, (reseeded since rain and frost caused the first application date to be missed on the May 18 seeding date). The design of the trial was a complete factorial with 4 replicates. Seeder row spacing was 25 cm; plot size was 1.8 m wide by 5 m long; seeding depth was 2-3 cm. Norlin flax was planted at 45 kg/ha into soil which had grown canola in 1997. Weed free conditions were maintained by one weed hoeing and 2 hand weedings but the overall weed populations were low. Stage 1 growth stage of 5 cm was sprayed on July 9 at 0730 and 1330 with a 3 nozzle bicycle sprayer. XR8001 nozzles were used to deliver a spray volume of 100 L/ha at 30 psi. The nozzles were 47 cm above the flax. There was a 20% cloud cover with sunshine at 0730 and 60% to 100% cloud at 1330. Stage 2 growth stage of 16 cm was sprayed on July 23 at 0745 and 1315. All other factors were the same other than it was clear and there was heavy dew at 0745. The harvest date was October 15 and 22.

## **5.0 Results and Discussion**

### **5.1 Results on fertilizer management for 1996-99**

#### **Part A: Review of literature on flax nutrition & production and summary of unpublished research on flax nutrition.**

The literature review on flax production was completed in the spring of 1996 and was included with the 1996-97 annual report. Please refer to that report for a copy of the literature review.

The summary of results pertaining to the work conducted by Harry Ukrainetz of the Saskatoon Research Center on various aspects of flax agronomy was included with the 1996-97 annual report.

Please refer to that report for a copy of the results from those studies.

## Part B: Field Research

### Study #1: N&P Management Study (1996-1998)

The objective of this study was to determine the impact of side-banding P in flax and the implications of dual N&P bands using urea, ammonium sulfate and ammonium nitrate on P uptake, grain yield and grain quality as currently used in a one-pass direct seeding and fertilizing system. The current understanding is that phosphorus fertilizer placed a few inches below the seed provides a yield benefit. In practical terms, this is very difficult to do. This study examined the potential of side-banding as well as other placement and timing options for obtaining the same results as banding below the seed.

#### S1.0 Morden

Combined analysis over years shows that adding P-fertilizer as a seed placed band resulted in a yield depression compared to the P-fertilizer side-band placement when urea-N was spring banded. The seed placed P-fertilizer compared to the P-fertilizer side band also reduced plant stand. The comparison of the seed placed P-Fertilizer band with the no P-fertilizer check was not made, however, seed placed P resulted in a lower yield. Seed placed P increased the P content of the whole plant 14 days after seeding, but not at any other time.

A spring urea-N band with a 3-4" band in combination with a narrow band of P-fertilizer resulted in an average 5.5% yield advantage compared a spring band with both N and P-fertilizer.

Table 1.1.1. Nitrogen and Phosphorus Management Study-Agronomic Information - Morden.

	1996	1997	1998
Seeding Date	May 29	May 29	May 21
Dry Matter - Sampling Date			
Day 7	-	-	-
Day 14	June 21	June 23	June 12
Day 21	-	-	-
Day 28	July 3	July 4	June 26
Flowering	July 10	July 14	July 8
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	19.5	22.7	38.5
Phosphorus (kg/ha) PO <sub>4</sub> -P	63.7	2.2	52.8

	Harvest Date	Sept 13	Sept 4	Aug 24
Spring Fertilizer Banding Date	May 16	May 16	May 8	
Seeder Model and Row Spacing	O-till disc 25 cm	O-till disc 25 cm	O-till disc 25 cm	

Table 1.1.2 . The effects of nitrogen form and placement and phosphorus placement on various agronomic variables in flax at Morden (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	Plants/m <sup>2</sup>	Plant Height (cm)	Grain Yield (kg/ha)	Grain Yield (bus/ac)
Urea	Spring Band	Side-Band	1	570.7	68.3	1972	31.36
Urea	Spring Band	Seed-Placed	2	490.9	68.3	1886	29.99
Amm Sulf	Spring Band	Side-Band	3	604	67.4	1982	31.53
Urea	Side-Band	Side-Band	4	504.7	68.4	2013	32.02
Amm Nitr	Side-Band	Side-Band	5	571.8	69.4	1994	31.72
Amm Sulf	Side-Band	Side-Band	6	522	68.3	1954	31.08
Urea+NBPT	Side-Band	Side-Band	7	489.1	70.2	2005	31.87
Urea	Spring Band	Spring Band	8	572	67.7	1982	31.53
Urea	Spring-Band (3-4" spread)	Spring Band	9	587.3	66.9	2097	33.34
Urea		Control-No P	10	581.6	67.9	1981	31.49
		cv	15.7	4.3	5.1	5.1	

		s.e.	21.082	0.6896	23.748	0.3775
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ANOVA	Source	df				
	Year	2	Mean sq. -	2386777 (0.0001)	5252.02 (0.0001)	1068825 (0.0059)
	Rep(Year)	15	Probability -			269.91 (0.0059)
	Treatment	9	48373 (0.0001)	28.66 (0.0001)	144905 (0.0001)	36.69 (0.0001)
	Year x Treatment	18	33456 (0.0001)	15.91 (0.0633)	49560 (0.0001)	12.46 (0.0001)
			24750 (0.0001)	18.42 (0.0070)	46185 (0.0001)	11.67 (0.0001)

Contrasts				
Control	vs rest	0.1102	0.6112	0.7855
1	vs 2	0.0084	0.9547	0.0115
1	vs 4	0.0285	0.9095	0.2218
4	vs 7	0.6027	0.0705	0.7968
4	vs 8	0.0255	0.4954	0.3491
1+4	vs 3+6	0.2316	0.4696	0.3085
4	vs 5	0.026	0.307	0.5703
				0.5751

	8 vs 9	0.8466	0.281	0.0007	0.0007
	5 vs 7	0.0063	0.4265	0.7563	0.7712

Table 1.1.3. The effects of nitrogen form and placement and phosphorus placement on dry matter accumulation (kg/ha) collected at different times (7, 14, 21 and 28 days after emergence and at flowering ) at Morden (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	150			744	1880
Urea	Spring Band	Seed-Placed	2	148			725	1777
Amm Sulf	Spring Band	Side-Band	3	132			711	1870
Urea	Side-Band	Side-Band	4	175			910	2231
Amm Nitr	Side-Band	Side-Band	5	180			960	2153
Amm Sulf	Side-Band	Side-Band	6	167			869	2035
Urea+NBPT	Side-Band	Side-Band	7	181			923	2087
Urea	Spring Band	Spring Band	8	143			745	1948
Urea	Spring-Band (3-4" spread)	Spring Band	9	144			787	2014
Urea		Control-No P	10	148			719	1903
				cv	15.2		18.4	16.2
				s.e.	5.784		32.369	71.721
ANOVA	Source	df						

	Year	2	248376 (0.0001)	4130499 (0.0001)	19877967 (0.0001)
Rep(Year)	15	2612 (0.0001)	137868 (0.0001)	343393 (0.0001)	
Treatment	9	4689 (0.0001)	165793 (0.0001)	355183 (0.0002)	
Year x Treatment	18	3171 (0.0001)	34494 (0.0276)	153577 (0.0546)	

Contrasts	
Control vs Rest	0.1282
1 vs 2	0.8868
1 vs 4	0.0026
4 vs 7	0.4245
4 vs 8	0.0001
1+4 vs 3+6	0.0302
4 vs 5	0.5355
8 vs 9	0.5649
5 vs 7	0.8575

Table 1.1.4. The effects of nitrogen form and placement and phosphorus placement on % nitrogen in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Morden (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	-	4.48	-	4.021	3.067
Urea	Spring Band	Seed-Placed	2	-	4.96	-	3.893	3.147
Amm Sulf	Spring Band	Side-Band	3	-	4.591	-	4.001	3.03
Urea	Side-Band	Side-Band	4	-	4.829	-	4.163	3.076
Amm Nitr	Side-Band	Side-Band	5	-	4.966	-	4.337	2.955
Amm Sulf	Side-Band	Side-Band	6	-	5.113	-	4.448	3.114
Urea+NBPT	Side-Band	Side-Band	7	-	4.987	-	4.252	2.896
Urea	Spring Band	Spring Band	8	-	4.646	-	4.136	3.161
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	4.702	-	4.266	3.196
Urea		Control-No P	10	-	4.55	-	4.109	2.983
				cv	-	8.5	-	8.7
				s.e.	-	0.0969	-	0.0823
								0.0807
	ANOVA	Source	df					

	Year	2	-	15.8863 (0.0001)	-	19.2385 (0.0001)	23.5249 (0.0001)
Rep(Year)	15	-	0.6013 (0.0001)	-	0.5407 (0.0001)	0.1926 (0.0700)	
Treatment	9	-	0.7300 (0.0001)	-	0.5059 (0.0001)	0.1682 (0.1786)	
Year x Treatment	18	-	0.1007 (0.8100)	-	0.3988 (0.0001)	0.1027 (0.6068)	
	-	-	-	-	-	-	-
	<b>Contrasts</b>						
Control vs Rest	-	0.0127	-	-	0.4936	0.3021	
1 vs 2	-	0.0007	-	-	0.2723	0.4844	
1 vs 4	-	0.0122	-	-	0.2258	0.938	
4 vs 7	-	0.252	-	-	0.4465	0.1117	
4 vs 8	-	0.1829	-	-	0.8192	0.4605	
1+4 vs 3+6	-	0.0441	-	-	0.1091	0.9945	
4 vs 5	-	0.3197	-	-	0.1376	0.2903	
8 vs 9	-	0.2681	-	-	0.1807	0.0643	
5 vs 7	-	0.8794	-	-	0.4666	0.6066	

Table 1.1.5. The effects of nitrogen form and placement and phosphorus placement on % phosphorus in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Morden (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	-	0.3639	-	0.3427	0.3161
Urea	Spring Band	Seed-Placed	2	-	0.4086	-	0.3427	0.3179
Amm Sulf	Spring Band	Side-Band	3	-	0.3773	-	0.3332	0.3046
Urea	Side-Band	Side-Band	4	-	0.358	-	0.3586	0.3161
Amm Nitr	Side-Band	Side-Band	5	-	0.362	-	0.3679	0.3081
Amm Sulf	Side-Band	Side-Band	6	-	0.3822	-	0.3742	0.3118
Urea+NBPT	Side-Band	Side-Band	7	-	0.3757	-	0.3606	0.3081
Urea	Spring Band	Spring Band	8	-	0.3607	-	0.3373	0.3178
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	0.3549	-	0.3363	0.3273
Urea		Control-No P	10	-	0.3483	-	0.3424	0.3099
		cv		-	11.9	-	7.5	11.5
		s.e.		-	0.011	-	0.0061	0.0086

ANOVA		Source	df					
		Year	2	-	0.0322 (0.1115)	-	0.2475 (0.0001)	0.0045 (0.5258)
Rep(Year)	15		-	0.0124 (0.0001)	-	0.0027 (0.0001)	0.0067 (0.0001)	
Treatment	9		-	0.0047 (0.0116)	-	0.0038 (0.0001)	0.0008 (0.7979)	
Year x Treatment	18		-	0.0045 (0.0029)	-	0.0024 (0.0001)	0.0011 (0.6976)	
		Contrasts						
Control vs rest	-	0.0481	-	-	0.2155	0.6363		
1 vs 2	-	0.005	-	-	0.9948	0.8802		
1 vs 4	-	0.7064	-	-	0.0667	1		
4 vs 7	-	0.2596	-	-	0.8157	0.5112		
4 vs 8	-	0.8659	-	-	0.0144	0.8874		
1+4 vs 3+6	-	0.092	-	-	0.6147	0.3599		
4 vs 5	-	0.8008	-	-	0.2749	0.5141		
8 vs 9	-	0.6685	-	-	0.4767	0.1532		
5 vs 7	-	0.3807	-	-	0.3898	0.9964		

Table 1.1.6. The effects of nitrogen form and placement and phosphorus placement on oil content and oil composition (%) in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering at Morden (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	Iodine #	Oil Content	Fatty Acids		
						Palmitic	Stearic	Oleic
Urea	Spring Band	Side-Band	1	187.5	43.7	5.18	2.9	23.6
Urea	Spring Band	Seed-Placed	2	188.2	43.8	5.17	2.88	23.3
Amm Sulf	Spring Band	Side-Band	3	187.8	43.6	5.19	2.88	23.5
Urea	Side-Band	Side-Band	4	187	43.5	5.17	2.88	23.9
Amm Nitr	Side-Band	Side-Band	5	186.8	43.3	5.18	2.88	24
Amm Sulf	Side-Band	Side-Band	6	187.4	43.5	5.19	2.89	23.7
Urea+NBPT	Side-Band	Side-Band	7	187.2	43.5	5.18	2.89	23.8
Urea	Spring Band	Spring Band	8	186.5	43.4	5.19	2.9	23.4
Urea	Spring-Band (3-4" spread)	Spring Band	9	186	43	5.18	2.91	24.5
Urea		Control-No P	10	187.3	43.5	5.22	2.91	23.7
				cv	0.6	0.7	1.4	1.7
				s.e.	0.2857	0.0751	0.0174	0.0119
							0.2197	0.0373
								0.1312

ANOVA		Source	df					
	Year	2	854.565 3.27E-09	69.846 1.52E-07	2.353 2.69E-10	11.805 0.00E+0	167.75 7.50E-07	175.60 1.22E-07
Rep(Year)	15	9.090 9.15E-10	1.309 1.75E-19	0.018 1.45E-04	0.010 4.33E-06	4.025 4.29E-07	0.455 1.63E-25	3.183 5.21E-16
Treatment	9	7.202 1.09E-05	0.795 3.05E-09	0.003 8.03E-01	0.003 3.59E-01	2.415 5.09E-03	0.051 3.88E-02	1.749 1.32E-06
Year x Treatment	18	2.978 1.21E-02	0.383 4.16E-06	0.009 6.81E-02	0.002 5.89E-01	1.645 2.11E-02	0.067 7.20E-04	0.769 1.64E-03

Contrasts							
Control vs rest	0.7235	0.8702	0.0571	0.1165	0.7395	0.5725	0.6756
1 vs 2	0.11	0.274	0.4992	0.1876	0.3015	0.2937	0.0657
1 vs 4	0.1846	0.0618	0.6522	0.3223	0.2852	0.8333	0.102
4 vs 7	0.5554	0.4341	0.8217	0.5089	0.5561	0.8333	0.4204
4 vs 8	0.1891	0.7148	0.4992	0.3223	0.0789	0.5281	0.9049
1+4 vs 3+6	0.2533	0.9706	0.524	0.8152	0.3576	0.6027	0.1101
4 vs 5	0.6022	0.1932	0.6522	0.7411	0.7346	0.9162	0.5705
8 vs 9	0.0025	0	0.1776	1	0.0057	0.0037	0
5 vs 7	0.2674	0.0383	0.8217	0.3223	0.3541	0.7523	0.1708

## S1.2 Brandon

At the Brandon location, application of phosphate fertilizer had no influence on final grain yield, when results were averaged over the three years of the study. The average yield with the control, which received no phosphate was within 0.9 bushels/acre of the highest yielding treatment. Only in 1997 was there a tendency towards higher yields with certain treatments as compared to the control. In this year, yields were higher in treatments which received a nitrogen source other than urea as compared to treatments, including the control, which received urea. The differential therefore appeared to be due to problems with the urea application rather than to a response to P fertilization.

Urea damage was also indicated by difference in stand density. Stand density was higher with nitrogen sources other than urea. The major effect occurred in 1997, but a similar pattern occurred in the other two years of the study. Early season dry matter accumulation, from 7 to 21 days after emergence was also lower in treatments receiving urea than in treatments receiving other sources of N fertilizer.

Method of phosphorus application had little impact on the concentration of P in the tissue in the early growing period, when P has the greatest impact on plant growth. The wide fertilizer band appeared to reduce early season P availability at day 7. By day 14, the P treatments contained higher levels of P than the control, with the highest levels occurring where the P was placed near or in the seed-row. By 21 days after emergence, there was no difference between treatments that had received P and the control, and concentration was slightly lower in the ammonium nitrate treatment than in the urea treatment, possibly due to dilution. By day 28, concentration of P in the treatments that had received ammonium sulphate or ammonium nitrate was lower than in treatments that received urea. This may be due to dilution/concentration effects, where higher dry matter production results in lower nutrient concentration. By flowering, there was no difference among treatments in P concentration.

In summary, major effects at Brandon were due to impacts of nitrogen source as opposed to phosphorus application. Response of flax to phosphorus application was minimal at this location.

**Table 1.2.1. Nitrogen and Phosphorus Management Study - Agronomic Information- Brandon.**

	1996	1997	1998
Seeding Date	June 4	May 15	May 22
Dry Matter - Sampling Date			
Day 7	June 20	June 6	June 16
Day 14	June 27	June 13	June 23
Day 21	July 4	June 20	June 30
Day 28	July 11	June 27	July 8
Flowering	Aug 2	July 17	July 16
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	28	30	78

Phosphorus (kg/ha) PO <sub>4</sub> -P	35	37	42
Harvest Date	Oct 4	Sept 15	Sept 22
Spring Fertilizer Banding Date	June 4	May 15	May 8
Seeder Model and Row Spacing	Seed-Hawk 8"	Seed-Hawk 8"	Seed-Hawk 8"

Table 1.2.2. The effects of nitrogen form and placement and phosphorus placement on various agronomic variables in flax. In Brandon (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	Plants/m <sup>2</sup>	Plant Height (cm)	Grain Yield (kg/ha)	Grain Yield (bus/ac)
Urea	Spring Band	Side-Band	1	374	62.3	1671	26.6
Urea	Spring Band	Seed-Placed	2	386	64.3	1748	27.8
Amm Sulf	Spring Band	Side-Band	3	409	63.2	1742	27.8
Urea	Side-Band	Side-Band	4	370	62.7	1734	27.6
Amm Nitr	Side-Band	Side-Band	5	430	63.7	1750	27.9
Amm Sulf	Side-Band	Side-Band	6	442	65.0	1758	28.0
Urea+NBPT	Side-Band	Side-Band	7	375	64.0	1759	28.0
Urea	Spring Band	Spring Band	8	395	63.5	1721	27.4
Urea	Spring-Band (3-4" spread)	Spring Band	9	359	63.3	1651	26.3
Urea		Control-No P	10	388	62.5	1701	27.1
			cv	17.9	3.8	10.7	10.7

		<b>s.e.</b>	17	2.4	43	0.7
<b>ANOVA</b>						
	<b>Source</b>	<b>df</b>				
	Year	2	0.0001	0.0001	0.0001	0.0001
	Rep(Year)	15	ns	0.0001	0.0001	0.0001
	Treatment	9	0.0086	ns	ns	ns
	Year x Treatment	18	ns	0.0031	ns	ns

Contrasts						
Control vs rest	ns	ns	ns	ns	ns	ns
1 vs 2	ns	0.0541	ns	ns	ns	ns
1 vs 4	ns	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns	ns
4 vs 8	ns	ns	ns	ns	ns	ns
1+4 vs 3+6	0.0017	0.0215	ns	ns	ns	ns
4 vs 5	0.0121	ns	ns	ns	ns	ns
8 vs 9	ns	ns	ns	ns	ns	ns
5 vs 7	0.0216	ns	ns	ns	ns	ns

Table 1.2.3. The effects of nitrogen form and placement and phosphorus placement on dry matter accumulation (kg/ha) collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Brandon (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	54.4	154.0	422.5	915.0	2482
	Spring Band	Seed-Placed	2	59.3	134.2	426.3	854.1	2212
Amm Sulf	Spring Band	Side-Band	3	59.2	140.4	447.4	905.3	2335
	Side-Band	Side-Band	4	57.4	125.1	472.5	940.3	2244
Amm Nitr	Side-Band	Side-Band	5	64.6	186.0	493.5	945.3	2443
	Side-Band	Side-Band	6	73.3	185.7	609.0	1129.5	2356
Urea+NBPT	Side-Band	Side-Band	7	59.4	154.4	456.9	888.2	2322
	Spring Band	Spring Band	8	57.2	131.4	433.1	859.7	2368
Urea	Spring Band (3-4" spread)	Spring Band	9	59.6	127.2	376.1	748.2	2324
	Control-No P	Control-No P	10	61.3	144.0	388.8	954.9	2357
				cv	34.25	37.03	28.29	25.86
				s.e.	4.89	4.1	30.18	55.71
								346.17
<b>ANOVA</b>		<b>Source</b>	<b>df</b>					
		Year	2	0	0	0	0	0.0001
		Rep(Year)	15	ns	0.0397	0.0275	0.001	0.0001
		Treatment	9	ns	0.0034	0	0.0025	ns

	Year x Treatment	18	ns	ns	ns	0.0496	ns
	Contrasts						
Control vs Rest	ns	ns	0.0274	ns	ns	ns	ns
1 vs 2	ns	ns	ns	ns	ns	0.0836	ns
1 vs 4	ns	ns	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns	ns	ns
4 vs 8	ns	ns	ns	ns	ns	ns	ns
1+4 vs 3+6	0.0362	0.0727	0.0084	ns	ns	ns	ns
4 vs 5	ns	0.0012	ns	ns	ns	ns	ns
8 vs 9	ns	ns	ns	ns	ns	ns	ns
5 vs 7	ns	0.0881	ns	ns	ns	ns	ns

Table 1.2.4. The effects of nitrogen form and placement and phosphorus placement on % nitrogen in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Brandon (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	5.24	4.76	4.66	4.07	2.91
Urea	Spring Band	Seed-Placed	2	5.10	4.84	4.45	3.91	2.77
Amm Sulf	Spring Band	Side-Band	3	5.08	4.93	4.43	3.93	2.88
Urea	Side-Band	Side-Band	4	5.05	4.93	4.57	4.05	2.79
Amm Nitr	Side-Band	Side-Band	5	5.21	4.85	4.45	3.95	2.92
Amm Sulf	Side-Band	Side-Band	6	5.18	4.94	4.49	3.92	2.64
Urea+NBPT	Side-Band	Side-Band	7	5.14	4.87	4.44	4.17	2.85
Urea	Spring Band	Spring Band	8	4.97	4.77	4.67	4.08	3.12
Urea	Spring-Band (3-4" spread)	Spring Band	9	5.05	4.79	4.71	4.25	2.97
Urea	Control-No P	Control-No P	10	5.11	4.70	4.64	3.95	2.95

ANOVA	Source	df	Mean % Nitrogen					
			CV	7.83	6.25	9.7	9.48	16.26
	Year	2		0	0	0.0001	0	0.0115
Rep(Year)	15	0	ns	ns	ns	0	0.0001	
Treatment	9	ns	ns	ns	ns	ns	ns	
Year x Treatment	18	ns	ns	ns	ns	ns	ns	

Contrasts					
Control vs Rest	ns	0.0401	ns	ns	ns
1 vs 2	ns	ns	ns	ns	ns
1 vs 4	ns	0.0997	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns
4 vs 8	ns	ns	ns	ns	0.063
1+4 vs 3+6	ns	ns	ns	ns	ns
4 vs 5	ns	ns	ns	ns	ns
8 vs 9	ns	ns	ns	ns	ns
5 vs 7	ns	ns	ns	ns	ns

Table 1.2.5. The effects of nitrogen form and placement and phosphorus placement on % phosphorus in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Brandon (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	0.53	0.54	0.43	0.39	0.34
Urea	Spring Band	Seed-Placed	2	0.51	0.53	0.43	0.38	0.33
Amm Sulf	Spring Band	Side-Band	3	0.50	0.53	0.42	0.37	0.32
Urea	Side-Band	Side-Band	4	0.52	0.52	0.43	0.39	0.33
Amm Nitr	Side-Band	Side-Band	5	0.50	0.50	0.40	0.37	0.32
Amm Sulf	Side-Band	Side-Band	6	0.50	0.50	0.42	0.37	0.32
Urea+NBPT	Side-Band	Side-Band	7	0.50	0.52	0.41	0.40	0.33
Urea	Spring Band	Spring Band	8	0.51	0.48	0.43	0.38	0.33
Urea	Spring-Band (3-4" spread)	Spring Band	9	0.45	0.49	0.43	0.39	0.33
Urea		Control-No P	10	0.47	0.47	0.42	0.37	0.33

  

	cv	16.81	12.23	12.94	11.49	10.42
	s.e.	0.0197	0.0147	0.0129	0.0103	0.0081

ANOVA	Source	df						
	Year	2	0	0	0.0001	0.0021	0.0001	
	Rep(Year)	15	0	0	0.0001	0	0.006	
	Treatment	9	ns	0.0044	ns	ns	ns	
	Year x Treatment	18	0.008	ns	ns	ns	ns	

Contrasts					
Control vs rest	ns	0.0046	ns	ns	ns
1 vs 2	ns	ns	ns	ns	ns
1 vs 4	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns
4 vs 8	ns	0.0611	ns	ns	ns
1+4 vs 3+6	ns	ns	ns	0.0455	ns
4 vs 5	ns	ns	0.0709	0.0988	ns
8 vs 9	0.0252	ns	ns	ns	ns
5 vs 7	ns	ns	ns	0.064	ns

Table 1.2.6. The effects of nitrogen form and placement and phosphorus placement on oil content and oil composition (%) in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Brandon (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	Iodine #	Oil Content	Fatty Acids					
						Palmitic	Stearic	Oleic	Linoleic	Linolenic	
Urea	Spring Band	Side-Band	1	182.5	42.2	5.2	3.5	25.7	13.0	52.7	
Urea	Spring Band	Seed-Placed	2	181.7	42.1	5.2	3.5	26.1	13.0	52.3	
Amm Sulf	Spring Band	Side-Band	3	181.4	41.9	5.2	3.5	26.2	13.0	52.1	
Urea	Side-Band	Side-Band	4	182.7	42.2	5.2	3.5	25.5	13.1	52.8	
Amm Nitr	Side-Band	Side-Band	5	181.7	42.0	5.2	3.5	26.0	13.0	52.3	
Amm Sulf	Side-Band	Side-Band	6	181.7	41.9	5.2	3.5	26.0	13.0	52.3	
Urea+NBPT	Side-Band	Side-Band	7	183.0	42.3	5.1	3.4	25.4	13.1	52.9	
Urea	Spring Band	Spring Band	8	181.8	41.9	5.2	3.4	26.0	13.1	52.3	
Urea	Spring-Band (3-4" spread)	Spring Band	9	182.5	42.3	5.2	3.5	25.6	13.1	52.7	
Urea		Control-No P	10	182.0	42.1	5.2	3.4	25.9	13.1	52.4	
				cv	0.74	1.02	1.24	1.97	2.82	1.42	1.38
				s.e.	0.551	0.1757	0.026	0	0.2973	0.076	0.2956
ANOVA		Source	df								
		Year	1	0	0	0	0	0	0	0.059	

	Rep(Year)	10	0	0	0.012	0	0	0	0
Treatment	9	0.059	ns	0.05	ns	0.066	ns	0.092	
Year x Treatment	9	ns	ns	ns	ns	ns	ns	ns	

Contrasts									
Control vs rest	ns	ns	0.092	ns	ns	ns	ns	ns	ns
1 vs 2	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 4	ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 8	0.083	ns	ns	ns	0.064	ns	0.064	ns	0.075
1+4 vs 3+6	0.01	0.023	ns	ns	0.01	ns	0.01	ns	0.011
4 vs 5	0.068	ns	0.058	ns	0.072	ns	0.072	ns	0.094
8 vs 9	ns	0.0611	ns	ns	ns	ns	ns	ns	ns
5 vs 7	0.022	0.055	0	ns	0.038	ns	0.038	ns	0.035

### S1.3 Melfort

Flax was found to be very sensitive to side band application of 70 kg/ha of urea N on this loam textured soil near Melfort (Table 1.3.2). Using ammonium sulphate, ammonium nitrate or urea with a urease inhibitor in the side band at seeding resulted in flax seedling stands that were similar to the random pre-plant banding of the N. However, the impact on seedling establishment was not reflected in final grain yield, with no difference recorded between the 10 treatments in this study. The negative impact of side banded urea was observed on flax dry matter yield and tissue N% early (7 to 14 days after emergence) in the growing season (Table 1.3.3 and 1.3.4). Given the variability in the crop stand at this early time in the growing season, these recorded differences in seedling dry matter were large. However, any early season effect was gone by flowering for both dry matter and N%. While no effect was observed in grain yield, flax seeded without P fertilizer showed lower plant tissue P levels throughout the growing season (Table 1.3.5). It would appear that tissue P levels were sufficient even in the absence of applying P fertilizer. When urea and P were applied in random pre-plant bands prior to seeding they had lower tissue P than when N and P were side banded at seeding. These results indicate that the positional availability of P in a side band is important to both early and season long plant uptake. Finally, there was no effect of the form of N, or the placement of N or P, on the % of oil in the flax, its iodine content, or the fatty acid composition (Table 1.3.6).

We can conclude from this Melfort data set that flax germination and seedling establishment is very sensitive to side band applied urea fertilizer. However, if an adequate stand is established, this early season negative effect of sideband urea was not observed in crop biomass at flowering or in final grain yield. The absence of P fertilizer, and its placement in random bands with N in the soil, reduced tissue P content. To ensure that optimum P nutrition is maintained with the flax crop, fertilizer P should be either seed row or side band applied. The management of fertilizer N and P was found to have no effect on the percent oil in the flax, its iodine number, or the balance of fatty acids in the oil.

**Table 1.3.1 . Nitrogen and Phosphorus Management Study - Agronomic Information - Melfort.**

	1996	1997	1998
Seeding Date	May 24	May 16	May 2
Dry Matter - Sampling Date			
Day 7	June 10	June 10	June 2
Day 14	June 17	June 19	June 9
Day 21	June 24	June 26	June 17
Day 28	July 2	July 3	June 23
Flowering	July 17	July 16	July 10
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	35.2	36.6	32.7
Phosphorus (kg/ha) PO <sub>4</sub> -P	23.8	50.8	28.7
Harvest Date	36435	Sept 11	Sept 1
Spring Fertilizer Banding Date	36303	36295	36281
Seeder Model and Row Spacing	CPAK 9"	CPAK 9"	CPAK 9"

Table 1.3.2. The effects of nitrogen form and placement and phosphorus placement on various agronomic variables in flax at Melfort, 1996-98.

N - Forms	N - Placement	P - Placement	Treatment #	Plants/m <sup>2</sup>	Plant Height (cm)	Grain Yield (kg/ha)	Grain Yield (bus/ac)
Urea	Spring Band	Side-Band	1	392	62	1691	26.9
Urea	Spring Band	Seed-Placed	2	390	63	1691	26.9
Amm Sulf	Spring Band	Side-Band	3	379	61	1670	26.6
Urea	Side-Band	Side-Band	4	329	62	1623	25.9
Amm Nit	Side-Band	Side-Band	5	399	62	1726	27.5
Amm Sulf	Side-Band	Side-Band	6	410	62	1469	23.4
Urea+NBPT	Side-Band	Side-Band	7	377	63	1750	27.9
Urea	Spring Band	Spring Band	8	408	63	1741	27.8
Urea	Spring-Band (3-4" spread)	Spring Band	9	395	61	1619	25.8
Urea		Control-No P	10	390	62	1648	23.4
		cv	16	3	12	12	
		s.e.	12.6	0.7	80.5	1.3	
ANOVA	Source	df					
	Year	2	0.004	0.0001	0.0001	0.0001	0.0001
	Rep(Year)	15	0.0197	0.0003	0.0001	0.0001	0.0001
	Treatment	9	0.014	0.3047	0.4458	0.4429	
	Year x Treatment	18	0.8004	0.0095	0.0001	0.0001	
	Contrasts						
	Control vs rest	0.7949	0.9968	0.8499	0.8566		

	1 vs 2	0.8822	0.4429	0.9995	0.9976
1 vs 4	0.0022	0.8519	0.5589		0.5581
4 vs 7	0.0149	0.2598	0.2791		0.2774
4 vs 8	0.0003	0.4907	0.3111		0.3105
1+4 vs 3+6	0.0148	0.3421	0.2908		0.2908
4 vs 5	0.001	0.8939	0.3759		0.3739
8 vs 9	0.4757	0.0396	0.2977		0.2983
5 vs 7	0.2329	0.2104	0.8375		0.8375

Table 1.3.3. The effects of nitrogen form and placement and phosphorus placement on dry matter accumulation (kg/ha) collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Melfort, 1996-98.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	70	164	291	651	2410
Urea	Spring Band	Seed-Placed	2	67	133	365	688	2637
Amm Sulf	Spring Band	Side-Band	3	70	165	340	980	2702
Urea	Side-Band	Side-Band	4	57	107	244	548	2388
Amm Nitr	Side-Band	Side-Band	5	61	152	323	683	2709
Amm Sulf	Side-Band	Side-Band	6	89	153	326	602	2403
Urea+NBPT	Side-Band	Side-Band	7	59	136	269	610	2645
Urea	Spring Band	Spring Band	8	84	163	340	733	2620
Urea	Spring Band (3-4" spread)	Spring Band	9	62	123	303	685	2389
Urea		Control-No P	10	65	123	250	572	2305
		cv		34	35	30	37	18
		s.e.		8.9	14.5	40.7	131.9	169.6

ANOVA			Source			df		
Year			2	0.0006	0.0001	0.0001	0.0008	0.2827
Rep(Year)			15	0.0497	0.0373	0.0001	0.0023	0.0001
Treatment			9	0.2576	0.1037	0.464	0.5801	0.5986
Year x Treatment			18	0.0009	0.0776	0.0001	0.0001	0.0013
						Contrasts		

	Control vs Rest	0.701	0.1951	0.1708	0.4179	0.1977
1 vs 2	0.8189	0.1426	0.2163	0.8478	0.3565	
1 vs 4	0.2906	0.0118	0.4186	0.5871	0.9272	
4 vs 7	0.8352	0.1741	0.6687	0.7426	0.2965	
4 vs 8	0.0446	0.0126	0.1105	0.3341	0.3458	
1+4 vs 3+6	0.0854	0.1227	0.1246	0.1639	0.378	
4 vs 5	0.7334	0.04	0.1862	0.4786	0.1966	
8 vs 9	0.1028	0.0672	0.5224	0.7974	0.349	
5 vs 7	0.8942	0.4348	0.3601	0.701	0.7932	

Table 1.3.4. The effects of nitrogen form and placement and phosphorus placement on % nitrogen in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Melfort, 1996-98.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	4.62	4.52	4.78	3.75	2.4
Urea	Spring Band	Seed-Placed	2	4.52	4.67	4.51	3.72	2.32
Amm Sulf	Spring Band	Side-Band	3	4.39	4.58	4.46	3.67	2.41
Urea	Side-Band	Side-Band	4	4.58	4.79	4.7	3.93	2.63
Amm Nit	Side-Band	Side-Band	5	4.82	4.75	4.8	3.91	2.54
Amm Sulf	Side-Band	Side-Band	6	4.71	4.67	4.2	3.5	2.27
Urea+NBPT	Side-Band	Side-Band	7	4.77	4.86	4.81	4.02	2.4
Urea	Spring Band	Spring Band	8	4.53	4.72	4.53	3.78	2.39
Urea	Spring-Band (3-4" spread)	Spring Band	9	4.34	4.76	4.48	3.65	2.48
Urea		Control-No P	10	4.32	4.62	4.42	3.66	2.44
			cv	8	7	13	10	14
			s.e.	0.08	0.08	0.17	0.21	0.1

ANOVA	Source	df	Contrasts							
			Year	Rep(Year)	Treatment	Year x Treatment	Control vs Rest	0.3859	0.3703	0.6187

	1 vs 2	0.3717	0.226	0.2636	0.9212	0.556
1 vs 4	0.731	0.0362	0.713	0.551		0.1152
4 vs 7	0.0969	0.5573	0.6362	0.7529		0.1049
4 vs 8	0.6506	0.5448	0.4896	0.6335		0.0975
1+4 vs 3+6	0.4903	0.734	0.0254	0.2463		0.0878
4 vs 5	0.0422	0.7274	0.6708	0.962		0.4974
8 vs 9	0.1034	0.6925	0.8593	0.6596		0.5377
5 vs 7	0.6685	0.3537	0.9614	0.7172		0.3236

Table 1.3.5. The effects of nitrogen form and placement and phosphorus placement on % phosphorus in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Melfort, 1996-98.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	0.48	0.52	0.48	0.38	0.28
Urea	Spring Band	Seed-Placed	2	0.48	0.52	0.46	0.36	0.27
Amm Sulf	Spring Band	Side-Band	3	0.48	0.53	0.47	0.37	0.27
Urea	Side-Band	Side-Band	4	0.41	0.54	0.5	0.4	0.28
Amm Nitr	Side-Band	Side-Band	5	0.45	0.51	0.46	0.38	0.28
Amm Sulf	Side-Band	Side-Band	6	0.45	0.52	0.47	0.41	0.29
Urea+NBPT	Side-Band	Side-Band	7	0.45	0.53	0.52	0.38	0.27
Urea	Spring Band	Spring Band	8	0.45	0.5	0.44	0.36	0.26
Urea	Spring Band (3-4" spread)	Spring Band	9	0.44	0.54	0.46	0.36	0.27
Urea		Control-No P	10	0.41	0.5	0.44	0.34	0.25
			cv	12	11	12	13	11
			s.e.	0.01	0.01	0.01	0.01	0.01

ANOVA	Source	df	Contrasts					0.0001
			Year	Rep(Year)	Treatment	Year x Treatment	Control vs rest	
		2	0.0001	0.0003	0.075	0.6371	0.0014	0.0002
							0.0826	0.0001
							0.0445	0.0138
							0.1751	0.0017
								0.5913

	1 vs 2	0.672	0.9362	0.3374	0.3866	0.5041
1 vs 4	0.0019	0.0673	0.3659	0.2257	0.347	0.347
4 vs 7	0.0452	0.4509	0.3105	0.312	0.1424	0.1424
4 vs 8	0.0802	0.0041	0.0131	0.034	0.0398	0.0398
1+4 vs 3+6	0.1455	0.5178	0.2499	0.8478	0.7219	0.7219
4 vs 5	0.0424	0.0302	0.0643	0.2852	0.3754	0.3754
8 vs 9	0.922	0.0119	0.2976	0.7404	0.6955	0.6955
5 vs 7	0.974	0.1311	0.0074	0.9519	0.5399	0.5399

Table 1.3.6. The effects of nitrogen form and placement and phosphorus placement on oil content and oil composition (%) in the grain at Melfort, 1996-98.

N - Forms	N - Placement	P - Placement	Treatment #	Iodine #	Oil Content	Fatty Acids				
						Palmitic	Stearic	Oleic	Linoleic	Linolenic
Urea	Spring Band	Side-Band	1	192.9	43.8	5.1	2.8	20.2	14.2	57.6
Urea	Spring Band	Seed-Placed	2	192.5	43.8	5.1	2.8	20.5	14.1	57.5
Ammonium Sulf	Spring Band	Side-Band	3	192.5	43.6	5.2	2.8	20.4	14.1	57.5
Urea	Side-Band	Side-Band	4	192.4	43.7	5.1	2.8	20.5	14.2	57.4
Ammonium Nitro	Side-Band	Side-Band	5	192	43.5	5.1	2.8	20.8	14.1	57.2
Ammonium Sulf	Side-Band	Side-Band	6	194	44.2	5.2	2.7	19.6	14.1	58.4
Urea+NBPT	Side-Band	Side-Band	7	192.6	44	5.1	2.8	20.4	14.2	57.5
Urea	Spring Band	Spring Band	8	192.5	43.8	5.1	2.8	20.5	14.1	57.5
Urea	Spring-Band (3-4" spread)	Spring Band	9	192.5	43.8	5.1	2.8	20.5	14.2	57.4
Urea		Control-No P	10	192.8	44	5.1	2.8	20.3	14.3	57.6

cv	1	1	2	2	3	1	1
s.e.	0.5	0.33	0.03	0.02	0.31	0.06	0.3

ANOVA		Source	df	F			
Year	Rep(Year)			1	2	3	4
2	15	0.0001	0.0001	0.1637	0	0	0
0.0001	0.0001	0.0001	0	0	0	0	0
0.4369	0.9402	0.6699	0.4691	0.4683	0.1073	0.3698	
0.0001	0.0001	0.0034	0	0.0235	0		

	Contrasts						
Control vs rest	0.8147	0.5444	0.2464	0.3137	0.8528	0.0563	0.9958
1 vs 2	0.6167	0.9052	0.8174	0.347	0.5479	0.0416	0.8032
1 vs 4	0.5229	0.962	1	0.5695	0.5479	0.6119	0.5741
4 vs 7	0.7905	0.6431	1	1	0.863	0.9493	0.8235
4 vs 8	0.9118	0.9052	0.8174	0.7038	0.9902	0.2131	0.8133
1+4 vs 3+6	0.2373	0.6927	0.102	0.3256	0.2436	0.0631	0.1378
4 vs 5	0.6065	0.6687	0.908	0.7038	0.5319	0.1106	0.7137
8 vs 9	0.9941	0.9715	0.645	0.849	0.941	0.0776	0.8235
5 vs 7	0.4376	0.3767	0.908	0.7038	0.4272	0.124	0.5566

## S1.4 Indian Head

The pertinent agronomic information is given in Table 1.4.1. The combined analysis for various agronomic variables is provided in Table 1.4.2. Plant populations were lowered when urea was placed in a side-band situation (below and to the side of the seed). An average 12% reduction in plant stand was observed during the three year study. Grain yield was affected by N and P management with an overall positive response to P observed and placing the P in a side-band was better than placing it in a random band with nitrogen prior to seeding. Placing the P with the seed was as effective as placing it in a side-band situation. Varying the nitrogen form did not impact the response to P in the side-banded situation.

With respect to dry matter production (Table 1.4.3), all sampling dates showed sensitivity to urea fertilizer when placed in a side-banded situation. This effect was observed till flowering but did not have an effect on final grain yield. When tissue N concentration was measured, the treatments where N was side banded at seeding tended to have a greater tissue N concentration (Table 1.4.4). At flowering, this effect disappeared. With tissue P concentration, the two earlier sampling dates showed higher P concentration but these disappeared at the later seeding dates (Table 1.4.5). At the flowering stage, the only difference was the higher P concentration with urea & Agrotain together with P, both in a side-banded situation.

Some differences due to N & P management were observed for oil concentration and oil composition but the differences were very small in absolute terms (Table 1.4.6). Overall, oil content and oil composition are very stable.

Based on the results of this three year study, flax does respond to P, both in a side-banded situation and seed-placed situation and placing the N and P together in a side-banded situation gave the highest yields. Nitrogen form did not influence the response.

**Table 1.4.1. Nitrogen and Phosphorus Management Study - Agronomic Information -Indian Head.**

	1996	1997	1998
Seeding Date	36293	36284	36291
Dry Matter - Sampling Date			
Day 7	36317	36313	36314
Day 14	36322	36320	36322
Day 21	36329	36327	36332
Day 28	36336	36334	36353
Flowering	36345	36336	36353
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	12.2	29.8	71.9
Phosphorus (kg/ha) PO <sub>4</sub> -P	33.9	10.1	30.1
Harvest Date	Sept 12	Sept 3	Sept 1
Spring Fertilizer Banding Date	36289	36281	36287
Seeder Model and Row Spacing	Conserva-Pak 12"	Conserva-Pak 12"	Conserva-Pak 12"

Table 1.4.2. The effects of nitrogen form and placement and phosphorus placement on various agronomic variables in flax at Indian Head (1996-1998).

N - Forms	N - Placement	P - Placement	Treatment #	Plants/m <sup>2</sup>	Plant Height (cm)	Grain Yield (kg/ha)	Grain Yield (bu/ac)
Urea	Spring Band	Side-Band	1	442	57	1691	27
Urea	Spring Band	Seed-Placed	2	410	58	1634	26.1
Amm Sulf	Spring Band	Side-Band	3	444	56	1606	25.7
Urea	Side-Band	Side-Band	4	393	60	1715	27.4
Amm Nit	Side-Band	Side-Band	5	462	59	1725	27.6
Amm Sulf	Side-Band	Side-Band	6	457	58	1720	27.5
Urea+NBPT	Side-Band	Side-Band	7	414	58	1673	26.8
Urea	Spring Band	Spring Band	8	461	56	1595	25.5
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	-	-	-
Urea		Control-No P	10	449	58	1566	25.1
			c.v	17.9	7.6	8.9	8.9
			s.e.	18.4	1.1	34.3	0.5
ANOVA							
	Source	df					
	Year	2	**	**	**	**	**
	Rep(Year)	15	-	-	-	-	-
	Treatment	8	ns	ns	**	**	**
	Year x Treatment	16	ns	ns	ns	ns	ns
	Contrasts						

Control vs rest	ns	ns	ns	**	**
1 vs 2	ns	ns	ns	ns	ns
1 vs 4	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns
4 vs 8	**	*,**	**	**	**
1+4 vs 3+6	ns	ns	ns	ns	ns
4 vs 5	**	ns	ns	ns	ns
8 vs 10	ns	ns	ns	ns	ns
5 vs 7	ns	ns	ns	ns	ns

Table 1.4.3. The effects of nitrogen form and placement and phosphorus placement on dry matter accumulation (kg/ha) collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Indian Head.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	86	132	453	764	1904
Urea	Spring Band	Seed-Placed	2	71	158	324	718	1648
Amm Sulf	Spring Band	Side-Band	3	84	141	454	840	2060
Urea	Side-Band	Side-Band	4	69	125	387	675	1652
Amm Nitr	Side-Band	Side-Band	5	79	126	380	826	1838
Amm Sulf	Side-Band	Side-Band	6	91	169	438	871	2189
Urea+NBPT	Side-Band	Side-Band	7	86	146	345	770	1936
Urea	Spring Band	Spring Band	8	70	125	382	652	1511
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	-	-	-	-
Urea	Control-No P	Control-No P	10	73	130	432	683	1634
		cv		32	27	46	32	23
		s.e.		5.9	8.7	39.7	53.1	96
ANOVA								
	Source	df						
	Year	2	**	**	**	**	**	**
	Rep(Year)	15	-	-	-	-	-	-
	Treatment	8	ns	**	ns	ns	ns	**
	Year x Treatment	16	**	**	ns	ns	ns	**
	Contrasts							

	Control vs Rest	ns	ns	ns	ns	ns	ns
1 vs 2	ns	*,**	*,**	ns	ns	ns	ns
1 vs 4	*,**	ns	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns	ns	ns
4 vs 8	ns	ns	ns	ns	ns	ns	ns
1+4 vs 3+6	ns	**	ns	*,**	*,**	**	**
4 vs 5	ns	ns	ns	ns	ns	ns	ns
8 vs 10	ns	ns	ns	ns	ns	ns	ns
5 vs 7	ns	ns	ns	ns	ns	ns	ns

Table 1.4.4. The effects of nitrogen form and placement and phosphorus placement on % nitrogen in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Indian Head.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	3.3	3.5	3.5	2.9	2.6
	Spring Band	Seed-Placed	2	3.6	3.8	3.5	2.9	2.7
Amm Sulf	Spring Band	Side-Band	3	3.7	3.6	3.3	2.8	2.5
	Side-Band	Side-Band	4	3.8	4.1	3.7	3.1	2.7
Amm Nit	Side-Band	Side-Band	5	3.9	3.9	3.7	2.9	2.6
	Side-Band	Side-Band	6	3.7	3.9	3.6	3	2.6
Amm Sulf	Side-Band	Side-Band	7	3.8	3.9	3.7	3.1	2.9
	Side-Band	Spring Band	8	3.5	3.7	3.5	3	2.8
Urea+NBPT	Spring Band	Spring Band	9	-	-	-	-	-
	Spring-Band (3-4" spread)	Spring Band	10	3.4	3.6	3.5	2.9	2.7
Urea	Control-No P							
				cv	11.2	10.8	9.5	11.5
				s.e.	0.1	0.1	0.1	0.1
<b>ANOVA</b>								
		Source	df					
		Year	2	**	**	**	**	**
		Rep(Year)	15	-	-	-	-	-
		Treatment	8	**	**	ns	ns	ns
		Year x Treatment	16	ns	**	ns	ns	ns
<b>Contrasts</b>								

	Control vs Rest	*,	ns	ns	ns	ns	ns
1 vs 2	ns		ns	ns	ns	ns	ns
1 vs 4	**		**	**	*,*	ns	ns
4 vs 7	**		**	**	*,*	ns	ns
4 vs 8	*,		**	ns	ns	ns	ns
1+4 vs 3+6	ns		ns	ns	ns	ns	ns
4 vs 5	ns		ns	ns	ns	ns	ns
8 vs 10	ns		ns	ns	ns	ns	ns
5 vs 7	ns		ns	ns	ns	ns	ns

Table 1.4.5. The effects of nitrogen form and placement and phosphorus placement on % phosphorus in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Indian Head.

N - Forms	N - Placement	P - Placement	Treatment #	7	14	21	28	Flowering
Urea	Spring Band	Side-Band	1	0.29	0.33	0.34	0.28	0.3
Urea	Spring Band	Seed-Placed	2	0.36	0.37	0.37	0.28	0.31
Amm Sulf	Spring Band	Side-Band	3	0.32	0.33	0.32	0.25	0.29
Urea	Side-Band	Side-Band	4	0.31	0.33	0.36	0.28	0.31
Amm Nitr	Side-Band	Side-Band	5	0.32	0.33	0.35	0.28	0.28
Amm Sulf	Side-Band	Side-Band	6	0.31	0.34	0.34	0.27	0.31
Urea+NBPT	Side-Band	Side-Band	7	0.31	0.33	0.35	0.31	0.32
Urea	Spring Band	Spring Band	8	0.29	0.31	0.35	0.26	0.31
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	-	-	-	-
Urea	Control-No P	Control-No P	10	0.28	0.31	0.34	0.27	0.29
				cv	13.1	14.6	14.3	15.9
				s.e.	0.01	0.01	0.01	0.01
ANOVA								
		Source	df					
		Year	2	**	**	**	**	**
		Rep(Year)	15	-	-	-	-	-
		Treatment	8	**	**	ns	ns	ns
		Year x Treatment	16	ns	ns	ns	ns	ns
Contrasts								

	Control vs rest	**	*, **	ns	ns	ns	ns
1 vs 2	**	**	ns	ns	ns	ns	ns
1 vs 4	ns	ns	ns	ns	ns	ns	ns
4 vs 7	ns	ns	ns	ns	ns	ns	ns
4 vs 8	ns	ns	ns	ns	ns	ns	ns
1+4 vs 3+6	ns	ns	ns	ns	ns	ns	ns
4 vs 5	ns	ns	ns	ns	ns	ns	ns
8 vs 10	ns	ns	ns	ns	ns	ns	ns
5 vs 7	ns	ns	ns	ns	ns	ns	ns

Table 1.4.6. The effects of nitrogen form and placement and phosphorus placement on oil content and oil composition (%) in the plant tissues collected at different times (7, 14, 21 and 28 days after emergence and at flowering) at Indian Head.

N - Forms	N - Placement	P - Placement	Treatment #	Iodine #	Oil Content	Fatty Acids				
						Palmitic	Stearic	Oleic	Linoleic	Linolenic
Urea	Spring Band	Side-Band	1	191	43.8	4.97	2.97	21.5	14	56.9
Urea	Spring Band	Seed-Placed	2	191	44	4.96	2.96	21.4	14	56.9
Amm Sulf	Spring Band	Side-Band	3	191	43.6	4.98	2.98	21.6	14	56.8
Urea	Side-Band	Side-Band	4	190	43.3	4.97	2.96	21.8	14	56.5
Amm Nitr	Side-Band	Side-Band	5	190	43.5	4.98	2.98	21.9	14	56.5
Amm Sulf	Side-Band	Side-Band	6	190	43.3	4.93	2.98	21.9	14	56.5
Urea+NBP T	Side-Band	Side-Band	7	191	43.2	4.96	2.98	21.6	14	56.7
Urea	Spring Band	Spring Band	8	191	43.6	4.98	2.97	21.5	14	56.6
Urea	Spring-Band (3-4" spread)	Spring Band	9	-	-	-	-	-	-	-
Urea		Control-No P	10	191	44	4.95	2.96	21.2	14	57
				cv	0.3	0.5	1.2	1.9	1.5	1.5
				s.e.	0.2	0.1	0	0	0.1	0.1
<b>ANOVA</b>										
	Year	2	**	ns	ns	**	**	**	**	**
	Rep(Year)	15	-	-	-	-	-	-	-	-
	Treatment	8	**	**	ns	ns	**	ns	**	
	Year x Treatment	16	ns	ns	ns	ns	ns	ns	ns	ns
				Contrasts						
				Control vs rest	**	**	ns	ns	**	**
				1 vs 2	ns	ns	ns	ns	ns	ns
				1 vs 4	**	**	ns	ns	**	*

	4 vs 7	ns	**	ns	ns	ns	ns	ns
	4 vs 8	ns	ns	ns	ns	**	ns	ns
	1+4 vs 3+6	ns						
	4 vs 5	ns						
	8 vs 10	ns	**	ns	ns	**	**	**
	5 vs 7	ns	ns	ns	ns	**	ns	ns

### 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.

The study had no clear responses to the treatments applied due to the year to year variability of the research sites. The conditions that cause flax chlorosis are highly variable. The conditions that induce flax chlorosis are high soil pH and saturated soil moisture. These conditions were evident in the field sites in 1996 and 1997. In 1996 the flax cultivar used in the study was Norlin. Norlin is one of the most sensitive cultivars to chlorosis. In 1997 and 1998 the cultivar AC Emerson was used. This is the least sensitive cultivar to flax chlorosis. In 1997 one treatment, the  $ZnSO_4$  sausage treatment resulted in a yield depression compared to the check and other Zn plus treatments. In 1998 the  $ZnSO_4$  sausage and Zn-EDTA sausage treatments resulted in a yield increase relative to the check and the Zn-EDTA sausage also resulted in an increase compared to the other Zn plus treatments. This inconsistency makes it impossible to make a recommendation.

The current cost of fertilization with  $ZnSO_4$  fertilizer ( $\$840\text{ Mg}^{-1}$  at a rate of  $10\text{ kg Zn ha}^{-1}$ ) is  $\$46.67\text{ ha}^{-1}$ . Zn-EDTA is valued at  $\$70\text{ ha}^{-1}$  ( $\$3500\text{ Mg}^{-1}$  at a rate of  $2\text{ kg Zn ha}^{-1}$ ). The current value of flax is  $\$275\text{ Mg}^{-1}$ . The average yield over the three years of this study was  $1480\text{-kg ha}^{-1}$ . A yield increase of 7.7% (as occurred in 1998) or  $113\text{ kg ha}^{-1}$  has a current value of  $(0.113\text{ Mg} * \$275) \$31.40$ . The  $ZnSO_4$  sausage treatment averaged over the three yields resulted in an average yield loss of 4.9%. Based on these results fertilization with Zn can not be justified.

Table 2.1. Zinc Management Study - Agronomic Information

	1996	1997	1998
Seeding Date	May 24	May 30	May 25
Dry Matter- Sampling Date			
Day 7	-	-	-
Day 14	June 20	June 25	June 16
Day 21	-	-	-
Day 28	July 3	July 9	June 30
Flowering	July 10	July 22	July 13

Soil Fertility				
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-6"	18.7		44.9	70.4
6-24"	19.8		22.1	26.4
Phosphorus (kg/ha) PO <sub>4</sub> -P 0-6"	55		1.5	70.4
pH 0-6"	7.8		8.0	7.7
6-12"	8.2		8.0	8.1
Conductance 0-6"	0.6		1.0	0.8
6-12"	0.8		2.0	0.8
Harvest Date	Sept 11		36438	Sept 3
Broadcast Application Date	36302		36302	36301
Zinc (ppm)	0.9		0.1	1.5
Seeder Model and Row Spacing	O-till disc 25 cm		O-till disc 25 cm	O-till disc 25 cm

Table 2.2. The effects of Zinc and methods of application on plant establishment and crop yield.

Treatment	Plants/m <sup>2</sup>			Grain Yield (bu/ac)		
	1996	1997	1998	1996	1997	1998
Zn SO <sub>4</sub> -broad	720	405	646ab	14.2	24.3	34.7bc
Zn-SO <sub>4</sub> -band	749	517	632ab	12.7	23.3	34.5bc
EDTA-broad	743	500	596b	11.3	26.4	34.6bc
EDTA-band	759	459	627ab	12.4	24.2	34.5bc
Zn-SO <sub>4</sub> -sausage	773	538	581b	12.6	19.0	35.9ab
EDTA-sausage	755	445	615b	12.3	23.9	36.8a
Control	730	414	712a	12.0	24.4	33.4c
Pr>F						
Treatment	ns	ns	0.0960	ns	ns	0.0315
CV	9	25	11	13	18	5

Table 2.3. Zinc Management Table 2: Effect of Zinc fertilizers on flax plant nutrient composition at Emerson (1996-1998).

Treatment	% nitrogen	% phosphorus	ppm zinc	ppm nitrogen	% phosphorus	ppm zinc	% nitrogen	% phosphorus	ppm zinc
Control									

1996

	June 20			July 3			July 10		
1.ZnSO <sub>4</sub> broad	3.90 <sub>a</sub>	0.60 <sub>a</sub>	38.12 <sub>ab</sub>	2.78 <sub>a</sub>	0.35 <sub>a</sub>	32.43 <sub>a</sub>	2.05 <sub>ab</sub>	0.25 <sub>ab</sub>	20.25 <sub>a</sub>
2.ZnSO <sub>4</sub> -band	3.52 <sub>a</sub>	0.59 <sub>a</sub>	32.98 <sub>c</sub>	2.61 <sub>a</sub>	0.34 <sub>a</sub>	32.70 <sub>a</sub>	1.97 <sub>b</sub>	0.23 <sub>b</sub>	18.40 <sub>ab</sub>
3.EDTA-broad	3.78 <sub>a</sub>	0.64 <sub>a</sub>	34.40 <sub>bc</sub>	2.62 <sub>a</sub>	0.36 <sub>a</sub>	30.07 <sub>a</sub>	2.05 <sub>ab</sub>	0.25 <sub>ab</sub>	17.10 <sub>ab</sub>
4.EDTA-band	3.56 <sub>a</sub>	0.60 <sub>a</sub>	39.30 <sub>a</sub>	2.55 <sub>a</sub>	0.32 <sub>a</sub>	31.37 <sub>a</sub>	2.24 <sub>ab</sub>	0.24 <sub>ab</sub>	20.68 <sub>a</sub>
5.ZnSO <sub>4</sub> -sausage	3.72 <sub>a</sub>	0.60 <sub>a</sub>	31.72 <sub>c</sub>	2.73 <sub>a</sub>	0.35 <sub>a</sub>	26.17 <sub>a</sub>	2.12 <sub>ab</sub>	0.26 <sub>a</sub>	15.37 <sub>b</sub>
6.EDTA-sausage	3.86 <sub>a</sub>	0.61 <sub>a</sub>	33.60 <sub>c</sub>	2.72 <sub>a</sub>	0.34 <sub>a</sub>	25.92 <sub>a</sub>	2.05 <sub>ab</sub>	0.25 <sub>ab</sub>	17.72 <sub>ab</sub>
7.Control	3.66 <sub>a</sub>	0.60 <sub>a</sub>	32.87 <sub>c</sub>	2.52 <sub>a</sub>	0.35 <sub>a</sub>	27.18 <sub>a</sub>	2.22 <sub>a</sub>	0.26 <sub>a</sub>	15.77 <sub>b</sub>
C.V.%	12	11	10	11	12	19	9	7	16
Probability	0.6871	0.9132	0.0067	0.656	0.7505	0.1446	0.2189	0.0476	0.022

1997

	June 25			July 9			July 22		
1.ZnSO <sub>4</sub> broad	4.69 <sub>a</sub>	0.45 <sub>de</sub>	24.8 <sub>a</sub>	2.99 <sub>a</sub>	0.28 <sub>ab</sub>	14.5 <sub>ab</sub>	2.36 <sub>a</sub>	0.31 <sub>c</sub>	16.0 <sub>a</sub>
2.ZnSO <sub>4</sub> -band	4.75 <sub>a</sub>	0.47 <sub>cd</sub>	24.7 <sub>a</sub>	3.04 <sub>a</sub>	0.30 <sub>ab</sub>	13.9 <sub>b</sub>	2.49 <sub>a</sub>	0.32 <sub>bc</sub>	12.6 <sub>a</sub>
3.EDTA-broad	4.84 <sub>a</sub>	0.48 <sub>bcd</sub>	34.8 <sub>a</sub>	3.00 <sub>a</sub>	0.29 <sub>ab</sub>	11.6 <sub>b</sub>	2.52 <sub>a</sub>	0.38 <sub>ab</sub>	12.8 <sub>a</sub>
4.EDTA-band	4.64 <sub>a</sub>	0.42 <sub>e</sub>	32.2 <sub>a</sub>	2.90 <sub>a</sub>	0.25 <sub>b</sub>	18.2 <sub>a</sub>	2.73 <sub>a</sub>	0.34 <sub>bc</sub>	13.3 <sub>a</sub>
5.ZnSO <sub>4</sub> -sausage	4.74 <sub>a</sub>	0.51 <sub>abc</sub>	20.8 <sub>a</sub>	3.03 <sub>a</sub>	0.32 <sub>a</sub>	11.7 <sub>b</sub>	2.62 <sub>a</sub>	0.38 <sub>ab</sub>	12.6 <sub>a</sub>
6.EDTA-sausage	4.73 <sub>a</sub>	0.52 <sub>ab</sub>	27.6 <sub>a</sub>	2.95 <sub>a</sub>	0.30 <sub>ab</sub>	15.4 <sub>ab</sub>	2.57 <sub>a</sub>	0.35 <sub>bc</sub>	23.1 <sub>a</sub>
7.Control	5.01 <sub>a</sub>	0.54 <sub>a</sub>	20.3 <sub>a</sub>	3.09 <sub>a</sub>	0.33 <sub>a</sub>	11.8 <sub>b</sub>	2.82 <sub>a</sub>	0.43 <sub>a</sub>	11.7 <sub>a</sub>
C.V.%	8	8	53	11	16	21	15	12	63
Probability	0.7020	0.0001	0.5064	0.9767	0.0708	0.0046	0.481	0.0016	0.3635

1998

		June 16	June 30	July 13
1.ZnSO <sub>4</sub> broad	6.20a	0.50ab	22.6bc	4.79a
2.ZnSO <sub>4</sub> -band	5.96a	0.51ab	26.1ab	4.98a
3.EDTA-broad	6.44a	0.52ab	23.9bc	4.99a
4.EDTA-band	6.24a	0.53a	28.8a	4.93a
5.ZnSO <sub>4</sub> -sausage	6.55a	0.48b	21.1c	4.89a
6.EDTA-sausage	6.35a	0.53ab	25.9ab	5.17a
7.Control	6.17a	0.49ab	24.5abc	5.19a
C.V.%	10	7	14	10
Probability	0.5732	0.2008	0.0341	0.7916
				0.0414
				0.0001
				0.0225
				0.0113
				0.00035

Study 2..4: Zinc Management Table 2: Effect of Zinc fertilizers on Flax emergence, height, oil content and oil composition at Emerson (1996-1998)

	Plants			Height at			Yield			%			Iodine					
	/sq m	June 20	Aug 16	kg/ha	oil	%	Number	Palmitic	Stearic	Oleic	Linoleic	Linolenic						
Treatment																		
1.ZnSO4 broad	720 a	43.7 ab	886 a	43.2 ab	192.3 c	5.03 a	2.58 a	21.8 a	12.7 a	58.0 b	58.3 a	56.74 a						
2.ZnSO4-band	749 a	43.8 ab	793 ab	43.1 aab	192.7 abc	5.02 a	2.62 a	21.5 ab	12.5 a	58.3 ab	58.3 a	56.83 a						
3.EDTA-broad	743 a	43.8 ab	706 b	43.0 b	193.1 abc	5.03 a	2.62 a	21.4 ab	12.5 a	58.3 ab	58.3 a	56.83 a						
4.EDTA-band	759 a	44.0 ab	776 ab	42.9 b	192.4 bc	5.03 a	2.62 a	21.6 ab	12.7 a	58.1 b	58.1 a	56.83 a						
5.ZnSO4-saus	773 a	43.3 ab	787 ab	43.3 a	193.3 ab	5.08 a	2.58 a	21.3 ab	12.5 a	58.6 a	58.6 a	56.87 a						
6.EDTA-saus	755 a	45.5 ab	768 ab	43.0 b	193.5 a	5.05 a	2.58 a	21.2 b	12.6 a	58.7 a	58.7 a	56.87 a						
7.Control	730 a	42.5 ab	750 ab	43.0 b	192.8 abc	5.05 a	2.60 a	21.5 ab	12.7 a	58.3 ab	58.3 a	56.83 a						
C.V.%	9	5	13	1	1	1	1	1	1	1	1	1						
Probability	0.8602	0.3619	0.1704	0.0577	0.0637	0.7874	0.3696	0.15	0.4075	0.0558								
	<b>-1997-</b>																	
		June 20	Aug 16															
1.ZnSO4 broad	405 a	61.3 a	1519 ab	44.3 a	200.2 ab	5.23 a	2.92 a	15.2 a	15.2 ab	61.4 ab	61.4 ab	61.4 ab						
2.ZnSO4-band	517 a	58.8 ab	1453 ab	44.1 a	199.8 ab	5.25 a	2.92 a	15.3 a	15.2 ab	61.3 ab	61.3 ab	61.3 ab						
3.EDTA-broad	500 a	59.5 ab	1652 a	44.3 a	200.5 a	5.23 a	2.87 a	15.1 a	15.2 b	61.7 a	61.7 a	61.7 a						
4.EDTA-band	459 a	57.8 b	1515 ab	44.1 a	199.7 ab	5.23 a	2.93 a	15.4 a	15.3 ab	61.1 ab	61.1 ab	61.1 ab						
5.ZnSO4-saus	538 a	57.7 b	1188 b	43.8 a	199.5 ab	5.27 a	2.93 a	15.5 a	15.3 ab	61.0 ab	61.0 ab	61.0 ab						
6.EDTA-saus	445 a	57.3 b	1496 ab	44.2 a	200.0 ab	5.25 a	2.85 a	15.4 a	15.2 ab	61.3 ab	61.3 ab	61.3 ab						
7.Control	414 a	59.8 ab	1523 ab	44.0 a	198.8 b	5.28 a	3.03 a	15.5 a	15.6 a	60.6 b	60.6 b	60.6 b						
C.V.%	25	4	18	1	1	1	1	6	6	3	2	1						
Probability	0.3601	0.1197	0.1477	0.6018	0.2929	0.5809	0.5961	0.555	0.308	0.2641								
	<b>-1998-</b>																	
		17-Jun	maturity															
1.ZnSO4 broad	646 ab	70.6 ab	2168 bc	43.6 ab	191.5 a	5.54 a	2.96 a	19.64 ab	15.10 c	56.74 a	56.74 a	56.74 a						
2.ZnSO4-band	632 ab	70.5 ab	2151 bc	43.7 a	191.7 a	5.53 ab	2.95 a	19.50 ad	15.18 bc	56.83 a	56.83 a	56.83 a						
3.EDTA-broad	596 b	71.3 a	2160 bc	43.6 ab	191.8 a	5.53 ab	2.97 a	19.40 b	15.22 bc	56.85 a	56.85 a	56.85 a						
4.EDTA-band	627 ab	70.8 ab	2155 bc	43.6 ab	191.7 a	5.57 a	2.97 a	19.43 b	15.20 bc	56.82 a	56.82 a	56.82 a						
5.ZnSO4-saus	581 b	70.0 b	2246 ab	43.3 c	191.0 a	5.50 ab	2.98 a	19.90 ab	15.30 ab	56.58 ab	56.58 ab	56.58 ab						
6.EDTA-saus	615 b	70.3 ab	2302 a	43.3 bc	190.8 a	5.47 b	2.95 a	19.98 a	15.38 s	56.17 b	56.17 b	56.17 b						
7.Control	712 a	70.2 ab	2085 c	43.5 abc	191.7 a	5.54 a	3.00 a	19.42 b	15.20 bc	56.84 a	56.84 a	56.84 a						
C.V.%	11	1	5	1	1	1	1	2	2	1	1	1						
Probability	0.0960	0.1042	0.0315	0.0214	0.1582	0.0496	0.4535	0.0627	0.0266	0.0501								

## Study #3: N and P rate studies.

**Executive Summary** The objective of this study was to evaluate the response of flax to different rates of nitrogen and phosphorus at three locations in a one-pass seeding and fertilizing system consisting of a dual band of nitrogen and phosphorus at Lemberg, Indian Head and Melfort. In all cases, the fertilizer was placed to the side and below the seed.

### S 3.1 Melfort

Increasing the rate of side banded N with flax resulted in a significant reduction in plant establishment (Table 3.1.2). Plant populations were reduced to 92, 78 and 73% of the 0 N check with 40, 80 and 120 kg N/ha, respectively. However, this added N resulted in an increase in flax grain yield, with yield peaking at 80 kg N/ha. While it is likely that the optimal N rate was actually somewhere between 40 and 80 kg N/ha, the 4.5 bu/ac increase in flax yield between 40 and 80 kg N/ha more than offset the \$10/ac for fertilizer N. Both N and P were found to improve flax height, however, P had little other effect on the flax crop. A year x P rate interaction was recorded for grain yield with the addition of the 15 kg/ha P fertilizer rate providing a positive yield response in one of the three years of the study (1996). While the addition of N reduced plant stand, and appeared to slow crop maturity early in the growing season, the N fertilized flax matured earlier than the unfertilized check in most years. We believe that the high level of water use by the fertilized crop, along with the terminal drought conditions recorded in late-July and August of 1997 and 1998, hastened the maturity of the higher yielding N fertilized flax. Increasing fertilizer N rate resulted in as high as a 4.2% decline in flax oil %, a decline in iodine number, and both the Palmitic and Linolenic acid oil % (Table 3.1.2). Alternatively, Stearic and Oleic acid both showed a positive response to increasing fertilizer N rate. Increasing the rate of fertilizer P was found to have a minor negative effect on Linoleic acid %, however, no effect was observed with any of the other fatty acids.

In summary, these results indicate that flax seedling establishment is sensitive to rates of side banded urea in excess of 40 kg N/ha. While this placement of urea N reduced plant stand, it increased crop yield by up to 77% over the no N check with 80 kg N/ha. The effect of thinning the crop stand with the high urea N rates was offset when it came to maturity with increased water-use by the higher yielding fertilized flax. Total oil content and iodine number were both negatively influenced by increasing N rate. While the fatty acids Palmitic and Linolenic showed a negative response to increasing fertilizer N rate, Stearic and Oleic showed a positive response. In this study, P rate was found to have little influence on crop establishment, yield or oil quality. While a positive response to fertilizer P was recorded in 1997, the effect was small and leveled off at the 15 kg P<sub>2</sub>O<sub>5</sub>/ha rate.

**Table 3.1.1. Nitrogen and Phosphorus Rate Study - Agronomic Information**

	1996	1997	1998
Seeding Date	36302	36295	36281
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	35.2	36.6	32.7
Phosphorus (kg/ha) PO <sub>4</sub> -P 0-6"	23.8	50.8	28.7
Harvest Date	36435	Sept 11	Sept 1
Seeder Model and Row Spacing	Conserva-Pak 9"	Conserva-Pak 9"	Conserva-pak 9"

**Table 3.1.2. Flax (cv. Norlin) agronomic response to N x P fertilization rates at Melfort, 1996 to 1998.**

	Crop Stand (plants /m <sup>2</sup> )	Harvest Height (cm)	Grain Yield (kg/ha)	Oil (%)	Iodine Value	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)
<b>Year</b>										
1996	381	65 a	1892 a	45.0 a	197.0 a	4.9 b	2.4 c	19.0 b	13.7 b	60.0 a
1997	382	55 b	1309 b	44.3 b	191.6 b	5.0 b	2.9 b	20.4 a	15.3 a	56.4 c
1998	373	65 a	1291 b	44.3 b	192.2 b	5.3 a	3.1 a	20.1 a	13.8 b	57.7 b
<b>N Rate (kg/ha)</b>										
0	442 a	57 b	1002 c	46.7 a	197.6 a	5.2 a	2.7 b	17.6 d	14.1	60.4 a
40	406 a	62 a	1496 b	45.6 b	195.3 b	5.1 ab	2.7 b	18.9 c	14.3	59.0 b
80	344 b	64 a	1777 a	43.3 c	191.3 c	5.1 bc	2.8 a	21.0 b	14.4	56.7 c
120	324 b	64 a	1716 a	42.5 d	190.3 c	5.0 c	2.8 a	21.7 a	14.3	56.1 c
<b>P Rate (kg/ha)</b>										
0	389	61 b	1447	44.8	193.8	5.1	2.8	19.7	14.3 a	58.1
15	372	62 ab	1504	44.5	193.5	5.1	2.8	19.9	14.3 a	58.0
30	372	62 a	1513	44.4	193.6	5.1	2.8	19.8	14.3 ab	58.0
45	382	62 a	1527	44.4	193.7	5.1	2.8	19.8	14.2 b	58.1
<b>Study Mean</b>										
	379	62	1497	44.5	193.6	5.1	2.8	19.8	14.3	58.1
<b>Pr &gt; F</b>										
Year	0.9179	0.0001	0.0001	0.0471	0.0001	0.0001	0.0001	0.0009	0.0001	0.0001
N Rate	0.0056	0.0059	0.0001	0.0001	0.0001	0.0226	0.0186	0.0001	0.3317	0.0002
P Rate	0.3493	0.0437	0.5192	0.2362	0.7024	0.5084	0.9526	0.5543	0.0450	0.6551
N Rate x P Rate	0.9820	0.3054	0.3270	0.5140	0.1420	0.9931	0.0454	0.1768	0.1713	0.2084
Year x N Rate	0.1952	0.0001	0.1539	0.0028	0.0001	0.0218	0.0001	0.0001	0.0001	0.0001
Year x P Rate	0.8988	0.4582	0.0322	0.0364	0.0066	0.9598	0.0489	0.0149	0.3404	0.0148
Year x N Rate x P Rate	0.0195	0.6559	0.2985	0.2758	0.8782	0.0032	0.7101	0.8180	0.2935	0.8043
C.V.	16	4	10	1	1	1	2	2	1	1
<b>N Rate contrasts</b>										
linear	0.0010	0.0014	0.0001	0.0001	0.0001	0.0040	0.0042	0.0001	0.1285	0.0001
quadratic	0.6101	0.0595	0.0001	0.5444	0.2754	0.7192	0.8013	0.1805	0.3687	0.2578
cubic	0.3628	0.8385	0.3767	0.0192	0.0727	0.7148	0.1770	0.0243	0.7183	0.0913
<b>P Rate contrast</b>										
linear	0.4931	0.0120	0.1953	0.0769	0.7347	0.2313	0.9113	0.4144	0.0105	0.9567
quadratic	0.1151	0.1560	0.6030	0.3611	0.3254	0.3997	0.6801	0.3222	0.3125	0.2557
cubic	0.8023	0.9720	0.7654	0.7987	0.6742	0.9557	0.7393	0.5705	0.5495	0.7325

### S3.2 Indian Head

The basic agronomic for this study is given in Table 3.2.1 and the results from the analysis of variance is given in Table 3.2.2. An N response was observed for all variables indicated by the linear contrast. With increasing N levels (urea fertilizer), plant populations decreased, plant height increased, yield increased, oil content decreased with minor shifts in the composition of the oil as indicated by the linear contrast (Table 3.2.3). No interaction between N & P were observed for all the variables measured. Phosphorus responses were slightly negative overall but there was a significant year x phosphorus interaction. In 1996 and 1998 there was no response while in 1997, a small response was observed.

Based on these three years of field studies, we observed a positive response to nitrogen. The sensitivity of plant stands to side-banded urea was obvious at all rates used and caution is recommended when applying all the fertilizer N at seeding, as is the case with a one pass seeding and fertilizing system.

**Table 3.2.1. Nitrogen and Phosphorus Rate Study - Agronomic Information - Indian Head.**

	1996	1997	1998
Seeding Date	36293	36284	36291
Flowering	36345	36336	36323
Soil Fertility			
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	8.1	37.6	112.4
Phosphorus (kg/ha) PO <sub>4</sub> -P 0-6"	51.5	11.3	29.2
Harvest Date	Sept 12	Sept 3	Sept 1
Seeder Model and Row Spacing	Conserva-Pak 12"	Conserva-Pak 12"	Conserva-Pak 12"

Table 3.2.2. Anova for all variables measured at Indian Head (1996-1998).

Source	Plants m <sup>-2</sup>	Plant Height (cm)	Grain Yield		Oil Content (%)	Oil Composition (%)				
			kg/ha	bus/ac		Palmitic	Stearic	Oleic	Linoleic	Linolenic
Year (Y)	***	***	***	***	***	*,	***	***	*,	***
Nitrogen (N)	ns	ns	***	***	***	**	**	**	ns	***
Phosphorus (P)	ns	ns	*,	*,	**	ns	ns	ns	ns	ns
N x P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y x N	***	***	***	***	***	**	**	***	***	***
Y x P	ns	ns	**	**	ns	ns	*,	***	***	***
Y x N x P	*,	ns	ns	ns	ns	ns	ns	ns	ns	ns
N-Linear	***	**	*,	*,	*,	***	*,	***	ns	***
N-Quadratic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
N-Cubic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
P-Linear	ns	ns	ns	ns	*,	ns	ns	ns	ns	ns
P-Quadratic	ns	ns	ns	ns	*,	ns	ns	ns	ns	ns
P - Cubic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Values followed by \*\*\*, \*\*, \* and ns are significant at p<0.01, p<0.05, p<0.10 and not significant, respectively.

Table 3.2.3. Summary of results for all variables measured at Indian Head (1986-1998).

Variable	Plants m <sup>-2</sup>	Plant Height (cm)	Grain Yield		Oil Content (%)	Oil Composition (%)				
			kg/ha	bus/ac		Palmitic	Stearic	Oleic	Linoleic	Linolenic
<b>Year</b>										
1996	451a	54b	1693b	27.1b	44.1a	5.0b	2.4b	19.7a	13.6b	59.2a
1997	437a	50c	977c	15.6a	42.7b	5.0b	3.5a	22.5b	13.8a	55.3b
1998	389b	73a	2095a	33.5c	40.7c	5.1a	3.5a	25.2c	13.4c	52.9c
<b>Nitrogen (kg/ha)</b>										
0	494a	57c	1361a	21.0a	43.4a	5.1a	3.1b	21.5b	13.5a	56.8a
40	460ab	59ab	1574b	25.2b	42.6ab	5.0ab	3.1b	22.4a	13.6a	55.8a
80	391bc	60ab	1687b	27.0b	42.2ab	5.0b	3.2a	22.8a	13.7a	55.5a
120	360c	61a	1731b	27.7b	41.9b	5.0b	3.2a	23.3a	13.6a	55.0c
<b>Phosphorus P<sub>2</sub>O<sub>5</sub> (kg/ha)</b>										
0	415a	59a	1606a	25.7a	42.5ab	5.0a	3.1a	22.4a	13.6a	55.8a
15	421a	60a	1599a	25.6a	42.5ab	5.0a	3.1a	22.4a	13.6a	55.9a
30	440a	59a	1537a	24.6a	42.6a	5.0a	3.1a	22.5a	13.6a	55.8a
45	429a	59a	1612a	25.0a	42.3b	5.0a	3.1a	22.6a	13.7a	55.7a
<b>Year x Nitrogen</b>										
96-0N	527	50	1073	17.2	45.8	5.1	2.4	18.2	13.7	60.6
96-40N	478	53	1698	27.2	44.5	5	2.4	19.5	13.7	59.4
96-80N	414	55	1913	30.6	43.4	5	2.4	20.3	13.5	58.7
96-120N	383	57	2119	33.9	42.6	4.9	2.5	21.1	13.5	58
97-0N	562	49	924	14.8	43	5	3.4	21.8	13.6	56.2
97-40N	474	48	974	15.6	42.5	5	3.5	22.7	13.8	55.1

97-80N	380	51	1008	16.1	42.6	4.9	3.5	22.7	13.9	55
97-120N	333	53	1001	16	42.7	4.9	3.4	22.8	13.8	55
98-0N	391	72	2088	33.4	41.4	5.1	3.4	24.4	13.3	53.8
98-40N	427	74	2055	32.9	40.6	5	3.5	25	13.3	53.2
98-80N	374	74	2150	34.4	40.6	5.1	3.5	25.4	13.5	52.6
98-120N	364	73	2087	33.4	40.4	5	3.5	26	13.5	52

## Lemberg

The summary of the analysis of variance is given in Table 3.3.1 and the summary of the results in Table 3.3.2. A significant N effect was observed for all variables measured. As N increased, plant populations decreased, plant height and grain yield increased, oil content decreased and oil composition changed. The change in oil composition is small in absolute terms. A linear response was observed for all factors as indicated by the significant linear contrast. Increasing the rate of P improved plant populations and grain yield with a slight reduction in oil content and small changes in oil composition. A NxP interaction was only observed for oil content and composition of linoleic fatty acid (18:2).

Based on the results for this location, responses to N & P were observed and the sensitivity of flax stands to urea, as with the other locations was evident. Caution is recommended when applying all the fertilizer in a side-banding operation as is the case in a one-pass seeding and fertilizing system.

Table 3.3.1. Nitrogen and Phosphorus Rate Study - Agronomic Information - Lemberg

	1996	1997
Seeding Date	36292	36287
Soil Fertility		
Nitrogen (kg/ha) NO <sub>3</sub> -N 0-24"	20.4	10.5
Phosphorus (kg/ha) PO <sub>4</sub> -P 0-6"	30.4	15.3
Harvest Date	36443	Sept 11
Seeder Model and Row Spacing	Conserva-Pak 12"	Conserva-Pak 12"

Table 3.3.2. Analysis of variance for all variables measured at Lemberg (1996-1997).

Source	Plants m <sup>-2</sup>	Plant Height (cm)	Grain Yield		Oil Content (%)	Oil Composition (%)				
			kg/ha	bus/acre		Palmitic	Stearic	Oleic	Linoleic	Linolenic
Year (Y)	***	**	**	**	ns	**	***	**	***	***
Nitrogen (N)	***	***	***	***	***	***	***	***	***	***
Phosphorus (P)	**	ns	**	**	**	ns	ns	***	ns	***
N x P	ns	ns	ns	ns	**	ns	ns	ns	**	ns
Y x N	**	ns	***	***	***	ns	***	***	***	***
Y x P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y x N x P	ns	ns	ns	ns	**	ns	ns	ns	ns	ns
<hr/>										
N-Linear	**	**	**	**	**	***	ns	**	ns	**
N-Quadratic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
N-Cubic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
P-Linear	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
P-Quadratic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
P - Cubic	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Values followed by \*\*\*, \*\*, \* and ns are significant at p<0.01, p<0.05, p<0.10 and not significant, respectively.

Table 3.3.4. Summary of results for all variables measured at Lemberg (1996-1997).

Variable	Plants m <sup>-2</sup>	Plant Height (cm)	Grain Yield		Oil Content (%)	Oil Composition (%)				
			kg/ha	bus/ha		Palmitic	Stearic	Oleic	Linoleic	Linolenic
Year										
1996	306a	51a	1157ba	18.4a	43.9a	5.1b	2.6b	20.0a	13.5b	58.9b
1997	507b	54b	1066a	17.1b	43.1b	5.2a	3.3a	22.3b	14.5a	54.8a
Nitrogen (kg/ha)										
0	477a	49b	744a	11.9a	45.2a	5.2a	2.9a	19.2b	13.7a	59.0a
40	438a	52a	1052b	16.8b	43.7ab	5.2a	2.9a	21.0a b	14.0a	57.0ab
80	383a	54a	1309c	20.9c	42.7b	5.1b	3.0a	21.9a	14.2a	55.9b
120	328b	54a	1328c	21.2c	42.3b	5.0b	3.0a	22.4a	14.1a	55.4b
Phosphorus P <sub>2</sub> O <sub>5</sub> (kg/ha)										
0	413a	52.1a	1055a	16.9b	43.5a	5.1a	2.9a	20.9a	14.0a	57.0a
15	381a	519a	1096a	17.5a	43.6a	5.1a	3.0a	21.2a	13.9a	56.8a
30	415a	52.3a	1111a	17.8a	43.5a	5.2a	2.9a	21.1a	14.0a	56.9a
45	417a	52.4a	1171a	18.7a	43.1a	5.1a	3.0a	21.3a	13.9a	56.6a
Year x Nitrogen										
96-0N	353	49	690	11	45.1	5.2	2.6	18.6	13.4	60.2
96-40N	303	50	968	15.5	44.7	5.1	2.5	19.3	13.6	59.5
96-80N	308	52	1418	22.8	43.2	5	2.6	20.4	13.6	58.4
96-120N	260	52	1527	24.4	42.3	5	2.7	21.5	13.4	57.4
97-0N	601	50	799	12.8	45.2	5.3	3.2	19.8	14	57.7
97-40N	573	53	1136	18.2	42.7	5.2	3.4	22.6	14.3	54.5
97-80N	458	55	1199	19.2	42.2	5.1	3.4	23.3	14.7	53.5
97-120N	397	56	1129	18.1	42.1	5.1	3.4	23.4	14.7	53.4

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

**Executive Summary:** The objective of this study was to determine the effects of nitrogen, phosphorus, potassium and sulfur on flax yields when added to the same fertilizer band (one rate of each only). This allowed us to determine the feasibility of using all these nutrients in a single band. The effects were measured on selected agronomic variables which also included oil content and composition.

### S 4.1 Melfort

The incremental response of flax to the nutrients N, P, K, and S was found to be minimal at the Melfort trial location. The application of 120 kg of urea N/ha alone provided as good a flax yield response as was recorded with the addition of the nutrients P, K and S (Table 4.1.2). The negative impact of side banded fertilizer appears to be largely due to the urea N, with little added impact with the addition of P, K or S. Harvest heights were increased with the addition of the fertilizer treatments, and grain yields were increased by 77 to 81%. As was observed in the N & P management and N x P rate studies, the addition of fertilizer reduced the % oil, iodine number and Linolenic acid %, while increasing the Oleic and Linoleic acid %. While soil test results recommended the application of P and S in most years to the flax crop, our yield values indicate that there was not a response to anything other than the N.

In summary, N appears to have the largest impact on final flax grain yield. At the test locations evaluated in this study there was little grain yield benefit recorded from the addition of P, K or S fertilizer with N on flax. These results indicate that soil testing for flax may prove to be a very useful tool in managing fertilizer inputs.

**Table 4.1.1. Nitrogen Phosphorus, Potassium and Sulfur Study - Agronomic Information - Melfort.**

	1996	1997	1998
<b>Seeding Date</b>	36309	36294	36281
<b>Harvest Date</b>	36436	Sept 11	Sept 1
<b>Seeder Model and Row Spacing</b>	Conserva-Pak 9"	Conserva-Pak 9"	Conserva-Pak 9"

**Table 4.1.2. Flax (cv. Norlin) agronomic response to N, P, K and S management at Melfort, 1996 to 1998.**

	Crop Stand (plants m <sup>-2</sup> )	Harvest Height (cm)	Grain Yield (kg ha)	Oil (%)	Iodine Value	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)
<b>Year</b>										
1996	423 a	67 a	2165 a	42.9	194.4 a	5.1 b	2.4 c	20.1 b	13.7 b	58.6 a
1997	320 b	56 b	1425 b	43.2	189.0 b	5.0 c	3.0 b	21.7 a	15.3 a	55.0 c
1998	263 c	66 a	1370 b	43.0	189.1 b	5.3 a	3.2 a	21.7 a	13.8 b	56.0 b
<b>Treatment</b>										
N only (urea)	326	65 a	1806 a	42.6 b	189.6 b	5.1	2.9	21.8 a	14.4 a	55.7 b
N (urea) + P (MAP)	324	63 b	1767 a	42.3 b	189.6 b	5.1	2.9	21.9 a	14.4 a	55.8 b
N (urea) + P (MAP) + K	339	64 ab	1766 a	42.3 b	190.0 b	5.2	2.9	21.6 a	14.2 ab	56.1 b
N (urea) + P (MAP) + S (AS)	339	64 ab	1783 a	42.1 b	189.9 b	5.1	2.9	21.8 a	14.3 ab	56.0 b
N (urea) + P (MAP) + K + S (AS)	310	65 a	1802 a	42.1 b	189.7 b	5.2	2.9	21.9 a	14.1 b	56.0 b
Check	375	57 c	996 b	46.4 a	196.3 a	5.3	2.8	18.2 b	14.1 b	59.7 a
<b>Study Mean</b>	<b>335</b>	<b>63</b>	<b>1653</b>	<b>43.0</b>	<b>190.8</b>	<b>5.2</b>	<b>2.9</b>	<b>21.2</b>	<b>14.2</b>	<b>56.6</b>
<b>Pr &gt; F</b>										
Year	0.0001	0.0006	0.0001	0.6640	0.0001	0.0001	0.0001	0.0014	0.0001	0.0001
Treatment	0.3387	0.0001	0.0001	0.0001	0.0001	0.0779	0.0729	0.0001	0.0392	0.0001
Year x Treatment	0.0322	0.9826	0.0857	0.0030	0.0307	0.0005	0.2655	0.0058	0.2229	0.0190
C.V.	14	4	8	1	1	1	3	3	1	1

## S 4.2 Indian Head

Some of the pertinent agronomic information is presented in Table 4.2.1. Plant populations were affected by various combinations of nutrients with the check showing the highest plant populations. Where only nitrogen was used, the plant populations were lower than where other nutrients like P, K and S were added to the fertilizer band (Table 4.2.2). The treatments with N&P had lower plant populations then when N, P, K and S were present. In the case of grain yield, adding nutrients improved grain yields and adding various combinations of P, K, and S was better than adding N only. It was difficult to determine how much of an effect adding K and S had. Oil content was about 1.5% higher where no fertilizer was used but adding various combinations of N, P, K or S did not affect oil content. The effects on oil composition were very stable. The differences reported are very small in absolute terms and have no effect on the overall quality of the oil.

**Table 4.2.1. Nitrogen Phosphorus, Potassium and Sulfur Study - Agronomic Information - Indian Head.**

	1996	1997	1998
Seeding Date	36293	36284	36291
Harvest Date	Sept 12	Sept 3	Sept 1
Seeder Model and Row Spacing	Conserva-Pak 12"	Conserva-Pak 12"	Conserva-Pak 12"

Table 4.2.2. The effects of different combinations of N, P, K and S on selected variables in flax (1996-1998) at Indian Head.

Treatment	Plants/m <sup>2</sup>	Plant height (cm)	Grain Yield kg/ha	Oil content (%)	Oil Composition			
					Palmitic	Stearic	Oleic	Linoleic
N only	372	59	1537	24.6	5.1	3.1	22.7	13.9
N & P	389	59	1624	26	42.4	5.1	3	22.5
N & P & K	411	62	1618	25.9	42.5	5	3.1	22.3
N & P & S	416	58	1643	26.3	42.3	5.1	3.1	22.7
N & P & K & S	455	61	1647	26.4	42.3	5	3.1	22.4
Check	506	56	1207	19.3	43.9	5.1	3	20.9
cv	17.7	5.8	7.8	7.8	1	1.5	2.2	1.2
S.e.	18	0.8	28.4	0.5	0.1	0.02	0.1	0
S.E. of difference between treatments								
Contrasts								
Check vs rest	**	**	**	***	*,**	*,**	***	***
N vs rest (no check)	*,*	ns	**,ns	ns	ns	ns	ns	***
N vs N+P	ns	ns	*,ns	ns	ns	ns	*,ns	ns
N vs NPKS	***	ns	**,ns	ns	ns	ns	ns	***
N+P vs rest (no check)	ns	ns	ns	ns	ns	ns	ns	ns
N+P vs N+P+K	ns	*,ns	ns	ns	ns	ns	ns	*,ns
N+P vs N+P+S	ns	ns	ns	ns	ns	ns	*,ns	ns
N+P vs NPKS (only)	**	ns	ns	ns	*,ns	ns	ns	ns
Check vs NPKS	ns	***	***	*,**	*,**	***	ns	*,**

<sup>1</sup> Values indicated by \*\*\*, \*\*, \* and ns are significant at p<0.01, p<0.05, p<0.10 and not significant, respectively.

#### S4.3 Lemberg

Some of the pertinent agronomic information is presented in Table 4.3.1. The various fertilizer combinations of N, P, K and S did not have an effect on plant populations. Plant height was lowest for the check with the other fertilizer treatments being the same. With respect to yield, the check was the lowest. Where P was added, a yield benefit was observed relative to N only. Oil content was higher for the check which corresponded with the lower yields. Some differences in fatty acid profiles were observed but the differences were small in absolute terms (Table 4.3.2).

The overall conclusion that can be made is that including all the macro-nutrients in a single band, on 12" spacing did not have a negative effect on plant populations, oil content and composition. Some improvements in yield were observed with certain combinations of nutrients.

**Table 4.3.1. Nitrogen Phosphorus, Potassium and Sulfur Study - Agronomic Information - Lemberg.**

	1996	1997
<b>Seeding Date</b>	36292	36287
<b>Harvest Date</b>	Sept 12	Sept 5
<b>Seeder Model and Row Spacing</b>	Conserva-Pak 12"	Conserva-Pak 12"

Table 4.3.2: The effects of different combinations of N, P, K and S on selected variables in flax (1996-1997) at Lemberg.

Treatment	Plants/m <sup>2</sup>	Plant height (cm)	kg/ha	Grain Yield bus/ac	Oil content (%)	Oil Composition				
						Palmitic	Stearic	Oleic	Linoleic	Linolenic
N only	379	53	1049	16.7	42.2	5.1	3	21.5	14.3	56.1
N & P	365	54	1164	18.6	42.3	5.1	3	22.3	14.2	55.4
N & P & K	403	53	1051	16.8	42.3	5.1	3	22.2	14.2	55.5
N & P & S	411	53	1091	17.5	42.5	5.1	3	22.3	14.1	55.4
N & P & K & S	392	56	1220	19.5	42.5	5.2	3	21.8	14.2	55.8
Check	419	49	651	10.4	44.9	5.3	2.9	19.2	13.8	58.8
cV	16.6	6	12.9	12.9	1.2	1.5	1.9	2.5	2	0.9
s.e.	18.9	0.9	38.9	0.6	0.1	0.02	0.02	0.2	0.1	0.2
Contrasts										
Check vs rest	ns <sup>1</sup>	**	***	***	***	***	***	***	***	
N vs rest (no check)	ns	ns	**	**	ns	ns	ns	ns	ns	
N vs N+P	ns	ns	**	**	ns	ns	ns	ns	ns	
N vs NPKS	ns	ns	***	***	ns	ns	ns	ns	ns	
N+P vs rest (no check)	ns	ns	ns	ns	ns	ns	ns	ns	ns	
N+P vs N+P+K	ns	ns	ns	ns	ns	ns	ns	ns	ns	
N+P vs N+P+S	ns	ns	ns	ns	ns	ns	ns	ns	ns	
N+P vs NP KS (only)	ns	ns	ns	ns	**	ns	ns	ns	ns	
Check vs NP KS	ns	***	***	***	***	***	***	***	***	

<sup>1</sup> Values indicated by \*\*\*, \*\*, \* and ns are significant at p<0.01, p<0.05, p<0.10 and not significant, respectively.

## **Study #5. Nitrogen Management**

### **Executive Summary**

The objective of this study was to compare fall banding, spring banding and early spring broadcast of urea, ammonium nitrate and urea treated with Agrotain™, on grain yield and quality and other agronomic measurements of interest. Some of the pertinent agronomic information for the study is given in Table 5.1.1. This study was conducted for two consecutive years at Indian Head, 1996 and 1997 and was established to complement the nitrogen and phosphorus management study discussed previously by providing more treatments with regards to nitrogen management for flax production. In both years, nitrogen management had no effect on plant stand. In both years, plant height was less for the check treatment and the fall banded treatments produced shorter plants than the other nitrogen placement treatments (Table 5.1.2). The 1997 growing season was very dry and no differences among nitrogen management treatments were observed for plant stand, plant height and grain yield. Some differences were observed on oil quality or composition but the differences were small in absolute terms (Table 5.1.3). A higher oil content was observed for some treatments in 1996 but they were associated, in all cases, with lower yields. Some differences were observed for oil composition but these differences were small in absolute terms. Based on the results from this study, it would appear that applying nitrogen at seeding time, in a side-banding operation is a feasible alternative for grain yield, oil content and oil composition. The sensitivity of flax to fertilizer, although not apparent in this study, needs to be considered when applying all fertilizer requirements at seeding time.

**Table 5.1.1. Nitrogen Management Study - Agronomic Information 1996-97 - Indian Head.**

	1996	1997
Seeding Date	May 14	May 5/97
Flowering	July 5	June 26/97
Fall Banding Date	Oct 24/95	Oct. 18/96
Spring Broadcast	36292	May 6/97

**Table 5.1.2. Nitrogen Management at Indian Head - 1996.**

Treatments	Plants/m <sup>2</sup>	Plant height (cm)	Yield kg/ha	Oil %	Iodine #	Palmitic acid %	Stearic acid %	Oleic acid %	Linoleic acid %	Linolenic acid %
Check	463	52	1130	45.1	194	4.8	2.4	20.7	13.7	58.4
UR-FB	488	52	1815	43.3	194	4.9	2.5	20.6	13.5	58.6
AN-FB	494	52	1855	43.2	194	4.9	2.5	20.6	13.6	58.7
UR-Side BD	489	55	2086	42.9	194	4.8	20.5	20.8	13.7	58.2
AN-Side BD	435	53	1961	42.6	197	4.9	2.5	19.3	13.6	59.8
UR-Broadcast	485	53	2060	42.8	194	4.8	2.5	20.9	13.5	58.3
AN-Broadcast	479	53	2025	42.6	195	4.9	2.5	20.2	13.6	58.9
Contrast <sup>1</sup>	33	1.2	75	0.2	0.6	0.05	0.03	0.4	0.1	0.3
Check vs rest	ns	ns	***	***	ns	ns	ns	ns	ns	ns
Banding vs Broadcast	ns	ns	*	*	ns	ns	ns	ns	ns	ns
Fall Banding vs Side Banding	ns	*	**	**	ns	ns	ns	ns	ns	ns
Urea vs Ammonium Nitrate	ns	ns	ns	ns	*	ns	ns	*	ns	*

<sup>1</sup> Values followed by \*\*\*, \*\*, \* or ns are significant at the 1%, 5% and 10% level and no significant, respectively.

**Table 5.1.3. Nitrogen Management at Indian Head - 1997.**

Treatments	Plants/m <sup>2</sup>	Plant height (cm)	Yield kg/ha	Oil %	Iodine #	Palmitic acid %	Stearic acid %	Oleic acid %	Linoleic acid %	Linolenic acid %
Check	503	42	621	42.2	188.1	5.1	3.5	22.1	13.9	55.4
UR-FB	648	45	624	41.9	187.7	5.1	3.5	22.3	14	55.1
AN-FB	561	43	631	41.9	186.9	5.1	3.5	22.7	14.1	54.6
UR-Side BD	511	47	617	42.3	186.9	5.1	3.5	22.6	14.4	54.5
AN-Side BD	558	45	698	41.9	186.3	5.1	3.5	22.7	14.1	54.7
UR-Broadcast	350	49	729	42	185.9	5.1	3.5	22.9	14.3	54.2
AN-Broadcast	481	47	787	42.2	188.1	5.1	3.5	23	14.5	53.9
Contrast <sup>1</sup>										
Check vs rest	ns	0.054*	0.08*	ns	* *	ns	ns	* *	* *	**
Banding vs Broadcast	ns	ns	ns	ns	**	ns	ns	**	**	**
Fall Banding vs Side Banding	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Urea vs Ammonium Nitrate	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

<sup>1</sup> Values followed by \*\*\*, \*\*, \*, or ns are significant at the 1%, 5% and 10% level and no significant, respectively.