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By

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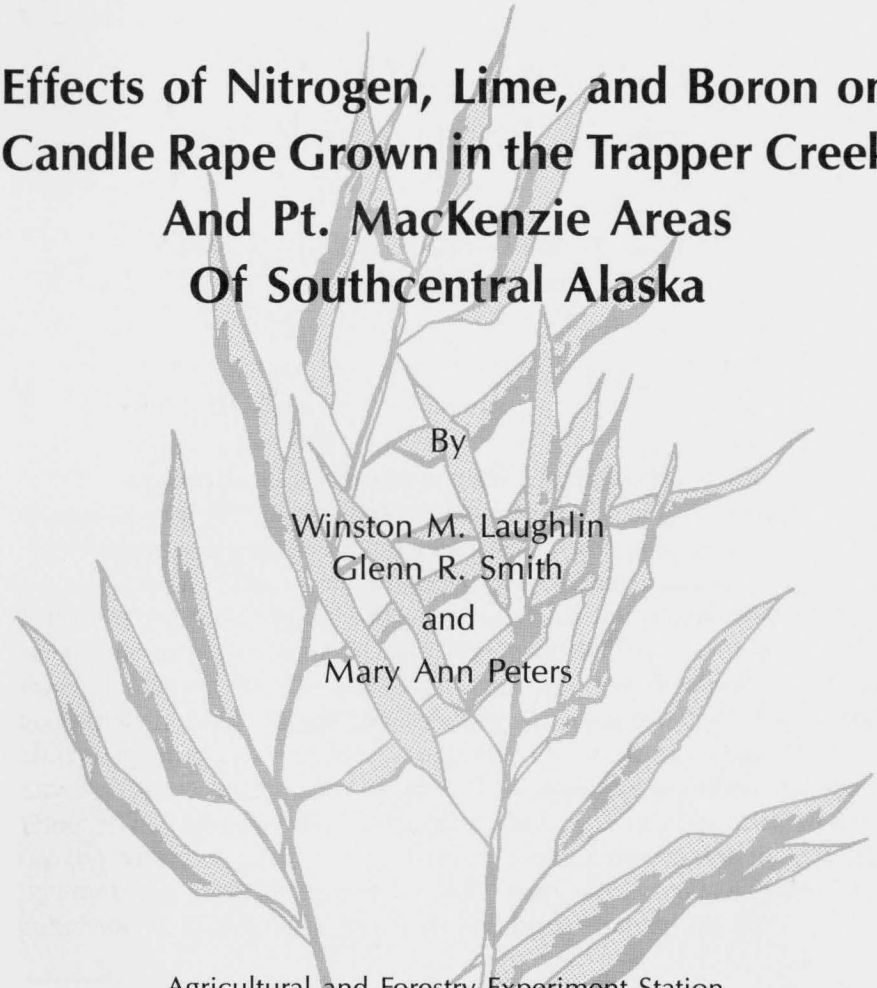

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Introduction

When growers in the Susitna Valley and later in the Pt. MacKenzie area of southcentral Alaska inquired as to the feasibility of growing rapeseed, we decided to determine the crops suitability and performance by conducting a field experiment. Bolton (1980) had attempted to predict the feasibility of producing rapeseed in Alaska's interior, but no research had been done in southcentral Alaska. We conducted one study from 1979 through 1981 on Rabideux silt loam (pH 5.1) near Trapper Creek and another from 1982 through 1984 on Kashwitna silt loam (pH 5.4) on the University of Alaska's research tract in the Pt. MacKenzie area. The first area had been cleared prior to 1978. This area was rototilled and roots removed in September 1978. The second area was on a tract cleared during the winter of 1981. After clearing, rotary plowing was done twice on the area. During the summer of 1981, roots were removed, and a field cultivator was used twice to loosen and bring roots to the surface.

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Experimental Procedure

A 3^2 factorial experiment was laid out in a randomized block with six replications involving three lime rates (0, 2, and 4 tons per acre) and three nitrogen (N) rates (0, 60, and 120 lb per acre) at the Trapper Creek study. In addition, one treatment replicated six times received no boron (B) and 120 lb N per acre; three of these plots received 4 tons lime per acre, and three received no lime. Lime was applied September 27, 1978, after rototilling the area, and then the lime was mixed into the surface 6 inches of soil with a second rototilling. At Pt. MacKenzie, a 2^3 factorial experiment with two N rates (60 and 120 lb per acre), two lime rates (2 and 4 tons per acre), and the presence and absence of B (1 lb per acre as borax), plus two other treatments without B (no N with 4 ton lime, and 120 lb N with no lime) was established. The lime treatments were applied September 25, 1981, and rototilled into the surface 6 inches of soil.

Individual plot size at both locations was 6 × 15 ft. Fertilizer treatments were broadcast annually on the surface of each plot near the middle of May and rototilled in lightly. Nitrogen was supplied as ammonium nitrate, P as treblesuperphosphate, and potassium (K) as sulfate of potash. All plots received annual applications of 100 lb P_2O_5 and 200 lb K_2O supplying 44 lb phosphorus (P) and 166 lb K per acre, respectively. Each year six rows of Candle rape *(Brassica campestris)* were planted with a Planet Jr. garden seeder using seedplate hole No. 2. After emergence, four 8-ft sections of the center rows of each plot were staked off for later harvest. During the latter part of August or early in September, plants in these measured sections were cut with pruning shears at ground level, rolled up in wrapping paper, placed in cloth sacks, and hung in a greenhouse to dry. The temperature in the greenhouse did not fall below 70 °F in any year except in 1984 when only solar heat was used. Just prior to threshing, the total weight of harvested air-dried plants was determined. After threshing, the seed was cleaned with a fanning mill, and the seed weight obtained. At threshing time, a straw sample was taken from each plot except in 1980. Straw and seed samples from each plot were ground separately to pass a 20-mesh stainless steel screen. Prior to grinding, the seed was kept below freezing, which made possible grinding without interferences from oil being released at higher temperatures.

Chemical analyses were made as follows: nitrate N was determined with a nitrate electrode (Smith 1975); total N and P were determined colorimetrically with a Technicon autoanalyzer (TIS 1976); K, calcium (Ca),

and magnesium (Mg) were determined with an atomic absorption spectrophotometer following a sulfuric-selenous acid digestion and using lanthanum to control interferences (Perkin-Elmer 1973); and total sulfur (S) was determined with an automatic S analyzer (Smith 1980).

The data for each of the two experiments were subjected to a split-plot type of analysis of variance for a repeated measures experiment. The main plots of the experiments were a 3 × 3 or a 2 × 2 × 2 randomized complete block with six blocks. Each experimental plot was measured over three years. In the analysis of variance, the whole plot effects were N and lime at Trapper Creek and N, lime, and B at Pt. MacKenzie, and all interactions among these factors. The subplot on repeated measures effects were year and all interactions involving years. In the significance tests for the year and year interaction effects, conservative tests using minimum degrees of freedom for the required F values for significance allowing for autocorrelations among years were utilized. Data derived from the additional treatments were omitted from the statistical analysis and are presented in the tables for comparison.

In 1979, Dale Saunders, a farmer about two miles from the Trapper Creek experiment, secured enough of our Candle rapeseed to plant about an acre in order to evaluate harvest with a combine. At harvest time, he put half of the crop in a swath and a week later combined the remainder of the standing crop.

Results and Discussion

Yield

The influences of N rates on rape yield for each year are shown in Table 1. Seed yields at Pt. MacKenzie were similar in each of the three years and are presented in Table 2. Nitrogen application increased both straw and seed yields each year at both locations. Each increasing N rate increased total plant yields in 1979 and 1980 at Trapper Creek. Each higher N rate increased total plant yields all three years at Pt. MacKenzie. Anderson and Kusch (1968) reported increases in rape seed yields at three sites in the Peace River area of Alberta when N fertilizer was used in combination with P or with P, K, and S. When only N was applied, no yield response

Table 1. Effect of N on rape yield at Trapper Creek, 1979-81 and at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]									Pt. MacKenzie[2]					
	Straw			Seed			Total Plant			Straw			Total Plant		
Lb N/A	1979	1980	1981	1979	1980	1981	1979	1980	1981	1982	1983	1984	1982	1983	1984
	(T/A)														
0	0.60c[3]	0.74c	0.70b	0.36c	0.27b	0.24b	0.96c	1.01c	0.94b	0.70c[4]	0.80c[4]	4.90c[4]	1.00c[4]	1.08c[4]	5.24c[4]
60	1.48b	1.96b	1.63a	0.69b	0.48a	0.36a	2.17b	2.44b	1.99a	2.15b	1.38b	10.08b	2.83b	1.86b	10.82b
120	1.77a	2.28a	1.52a	0.75a	0.48a	0.30a	2.52a	2.76a	1.82a	2.77a	1.67a	11.04a	3.68a	2.30a	11.97a

[1]Means of 18 measurements. [2]Means of 24 measurements. [3]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [4]Means of 6 measurements.

Table 2. Effect of N on P, K, and Ca concentration in rape straw and Mg concentration in rapeseed at Trapper Creek, 1979-81 and on seed yield, P concentration in rape straw, N, K, and Mg concentration in rapeseed, and N and P uptake at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]				Pt. MacKenzie[3]						
	Straw			Seed	Seed	Straw	Seed			Total Plant Uptake	
Lb N/A	P	K	Ca	Mg	Yield	P	N	K	Mg	N	P
	(%)				(T/A)	(%)				(lb/A)	
0	.162a[2]	2.54a	1.43b	.416a	.29c[4]	.18a[4]	3.78a[4]	.97a[4]	.378a[4]	39c[4]	14.9b[4]
60	.166a	2.16b	1.42b	.407ab	.63b	.14b	3.32b	.93b	.356b	97b	25.8a
120	.166a	1.99c	1.52a	.392b	.83a	.12c	2.86c	.87c	.340c	160a	27.9a

[1]Means of 54 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [3]Means of 72 measurements. [4]Means of 18 measurements.

was obtained. In New Zealand, Stoker and Carter (1984) reported a substantial yield increase to N fertilization when oilseed rape followed a cereal crop.

Table 3 shows the influence of liming rates on rape yields for each year. Lime application increased the straw and total plant yields in each of the three years at Trapper Creek. Lime increased straw yields in 1982 and 1984 and total plant yields in 1983 and 1984 at Pt. MacKenzie. Total plant and straw yields in 1984 were greater with 2 than with 4 ton lime per acre at Pt. MacKenzie. There the 1983 straw and 1982 seed yields were not influenced significantly by lime application, but 1983 seed yields were depressed by lime; 2 ton lime in 1984 produced more seed than did 4 ton in 1984. Seed yields at Trapper Creek were increased by lime application (table 4). The increases with lime application are similar to those reported in Alberta on soils of pH 5.0 to 5.5 (Alberta Ag. 1985, Hennig 1977). Hoyt (1981) improved the tilth of acid soils in the Peace River area, thereby increasing the emergence of the rape.

The responses of B application at Pt. MacKenzie for each year is shown in Table 5. Boron application increased straw yield significantly in 1984, seed yields each year, and total plant yields in 1983 and 1984. At Trapper Creek, the means of 15 measurements indicate that B increased seed yields 1.6 times, but had no apparent effect on straw yields. Similar increases in rapeseed yields to B also were reported by Wooding (1985) in the Delta Junction area of interior Alaska. Plants at both locations that received no B also produced many pods which failed to set seed; these plants also continued to flower until harvest.

At Trapper Creek, Dale Saunders had considerable difficulty getting the swathed crop dry enough to thresh. Cool fall temperatures and frequent showers tend to discourage swathing. Better results were secured with direct combining, but timely harvest of a very large acreage by direct combining would be difficult. Bolton (1980) believes swathing of the crop as done in Canada will reduce shattering and speed up harvesting.

N Concentration and Uptake

Table 6 shows the response of N concentration and uptake each year to N rate. At Trapper Creek, each increasing N rate increased the N concentrations in both straw and seed in 1979 and 1981. The N concentration in the seed was increased by the highest N rate (120 lb N/per acre) in 1980. Uptake of N by the total plant was increased by N applica-

Table 3. Effect of lime on rape yield at Trapper Creek, 1979-81 and at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]						Pt. MacKenzie[2]								
	Straw			Total Plant			Straw			Seed			Total Plant		
T lime/A	1979	1980	1981	1979	1980	1981	1982	1983	1984	1982	1983	1984	1982	1983	1984
	(T/A)														
0	1.02b[3]	1.19b	0.84b	1.57b	1.51b	1.05b	2.16b[4]	1.47a[4]	9.91c[4]	.79a[4]	.66a[4]	.79b[4]	2.95b[4]	2.13b[4]	10.70c[4]
2	1.36a	1.97a	1.55a	1.97a	2.42a	1.90a	2.41a	1.47a	10.73a	.80a	.57b	.94a	3.21ab	2.04a	11.67a
4	1.47a	1.82a	1.46a	2.11a	2.27a	1.80a	2.52a	1.58a	10.39b	.79a	.55b	.73b	3.31a	2.13a	11.12b

[1]Means of 18 measurements. [2]Means of 24 measurements. [3]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [4]Means of 6 measurements.

Table 4. Effect of lime on seed yield; N, P, and S concentration in rape straw; and N, P, and Mg concentration in rapeseed at Trapper Creek, 1979-81; and on N, P, K, and Mg concentration in rapeseed and N, P, S, Ca, and Mg uptake at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]							Pt. MacKenzie[3]								
	Seed	Straw				Seed		Total Plant Uptake	Seed				Total Plant Uptake				
T lime/A	Yield	N	P	S	Ca	N	Mg	P	N	P	K	Mg	N	P	S	Ca	Mg
	-(T/A)-	(%)						-- (lb/A) --	(%)				(lb/A)				
0	.36b[2]	.97a	.14b	.56a	1.24c	3.51a	.41a	8.4b	3.75a[4]	.68c[4]	.81c[4]	.342b[4]	147a[4]	21.0c[4]	30.0c[4]	92c[4]	20.4a[4]
2	.47a	.97a	.17a	.46b	1.50b	3.50a	.42a	15.3a	3.57b	.84b	.88b	.348a	125b	25.2b	36.8b	120b	19.6a
4	.47a	.99a	.18a	.46b	1.62a	3.49a	.38b	15.2a	3.52b	.86a	.92a	.348a	132b	28.5a	40.3a	129a	19.4a

[1]Means of 54 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [3]Means of 72 measurements. [4]Means of 6 measurements.

Table 5. Effect of B on Candle rape yield; N, P, S, and Mg concentration in the straw; and N and P concentration in seed. Pt. MacKenzie, 1982-84.[1]

	Straw			Seed			Total Plant		
Lb B/A	1982	1983	1984	1982	1983	1984	1982	1983	1984
	----------	----------	----------	Yield (T/A)	----------	----------	----------	----------	----------
0	2.47a[2]	1.50a	10.33b	0.67b	0.41b	0.59b	3.14a	1.91b	10.92b
1	2.46a	1.55a	10.79a	0.91a	0.71a	1.08a	3.37a	2.26a	11.87a

	Straw								
	N			P			S		
Lb B/A	1982	1983	1984	1982	1983	1984	1982	1983	1984
	----------	----------	----------	Concentration (%)	----------	----------	----------	----------	----------
0	0.68a	0.78a	0.79a	0.14a	0.12a	0.22a	0.44a	0.29a	0.34a
1	0.60a	0.51b	0.70a	0.10b	0.06b	0.12b	0.45a	0.23b	0.34a

	Straw			Seed					
	Mg			N			P		
Lb B/A	1982	1983	1984	1982	1983	1984	1982	1983	1984
	----------	----------	----------	Concentration (%)	----------	----------	----------	----------	----------
0	.156a	.158a	.171a	3.17a	3.79a	4.01a	0.97a	0.79a	0.88a
1	.140b	.118b	.130b	3.12a	3.54b	3.66b	0.92b	0.67b	0.86b

[1]Means of 24 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 6. Effect of N on the N concentration and N and P uptake at Trapper Creek, 1979-81 and on N, P, and S concentration in rapeseed at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]								
	Straw		Seed			Total Plant Uptake			
	N		N			N		P	
Lb N/A	1979	1981	1979	1980	1981	1979	1981	1979	1981
	Concentration (%)					(lb/A)			
0	0.73c[2]	0.73c	3.59c	3.16b	3.25c	36c	26b	10.4c	6.4c
60	1.03b	0.90b	3.76b	3.27b	3.38b	82b	54a	19.5b	11.1a
120	1.39a	1.08a	4.14a	3.41a	3.54a	110a	54a	21.0a	9.3b

	Pt. MacKenzie[3]								
	N			P			S		
Lb N/A	1982	1983	1984	1982	1983	1984	1982	1983	1984
	Concentration (%)								
0[4]	0.41b	0.38b	0.56c	1.10a	1.06a	0.88a	0.26c	0.30b	0.30c
60	0.48b	0.60a	0.66b	1.03b	0.79b	0.89a	0.29b	0.36a	0.33b
120	0.80a	0.68a	1.03a	0.86c	0.67c	0.86b	0.35a	0.35a	0.38a

[1]Means of 18 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [3]Means of 24 measurements. [4]Means of 6 measurements.

tion in both 1979 and 1981. In 1981, each increasing N rate increased the 1979 N uptake.

At Pt. MacKenzie, N concentration in the straw was increased by N in 1983 and 1984. Each increasing N rate increased the straw N concentration in 1984, but only the highest N rate increased it in 1982. At Pt. MacKenzie, each increasing N rate decreased N concentration in the rapeseed but increased N uptake by the total plant (table 2).

Lime application at Pt. MacKenzie reduced N concentration in the rapeseed and N uptake by the entire plant, but had no significant effect on N concentration in the rape straw at Trapper Creek (table 4). The variation in N concentration and uptake for each year is shown in Table 7. Lime application at Trapper Creek increased N uptake by the total plant both years. At Pt. MacKenzie, lime applications decreased the N in the straw in 1982 but had no significant effect in 1983. Nitrogen concentration in straw decreased irregularly from lime treatments in 1984 as follows: 0 > 4 > 2 ton lime per acre.

Table 5 shows the response to B application in N concentration in both straw and seed at Pt. MacKenzie varied from year to year. Boron application reduced N concentration in straw 1983 but did not influence it significantly in 1982 and 1984. Boron reduced the N concentration in seed in 1983 and 1984 but did not influence it significantly in 1982. Boron application reduced the N uptake at Pt. MacKenzie only in 1984 (table 8). The extremely high uptake values for 1984 result from the combination of increased straw production that year and a greater air-dry weight resulting from the lack of heat during drying in the greenhouse. At Trapper Creek, B application had no apparent effect on N concentration in the seed, but reduced it in the straw. Means of six measurements from plots receiving no B at Trapper Creek show N uptake of 80 and 3 lb per acre with and without lime, respectively.

Phosphorus Concentration and Uptake

At Trapper Creek, N application had no significant effect on the phosphorus (P) concentration in the rape straw, but at Pt. MacKenzie, each increasing N rate depressed P concentration in the straw, and P uptake by the total plant was increased by N application (table 2). The P concentration in the seed at each of the three lime rates at Trapper Creek

Table 7. Effect of lime on the N and K uptake by rape and the K concentration on rape straw and seed at Trapper Creek, 1979-81 and on the N, P, and K concentrations in rape straw at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]									Pt. MacKenzie[2]								
	Total Plant Uptake				Straw		Seed			Straw								
	N		K		K		K			N			P			K		
T lime/A	1979	1981	1979	1981	1979	1981	1979	1980	1981	1982	1983	1984	1982	1983	1984	1982	1983	1984
	(lb/A)									(%)								
0	67b[3]	29b	68a	38b	2.88a	2.00a	1.14b	0.91a	0.90b	0.80a[4]	0.59a[4]	1.12a[4]	.09c[4]	.05c[4]	.14b[4]	2.15a[4]	1.77a[4]	2.32a[4]
2	78a	54a	76a	67a	2.39b	2.01a	1.18a	0.91a	1.01a	0.63b	0.63a	0.76c	.11b	.08b	.14b	1.82b	1.69ab	1.83b
4	83a	50a	79a	60a	2.24c	1.86b	1.19a	0.90a	1.01a	0.65b	0.65a	0.93b	.13a	.10a	.20a	1.79b	1.64b	1.63c

[1]Means of 18 measurements. [2]Means of 24 measurements. [3]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [4]Means of 6 measurements.

Table 8. Effect of B on N, P, Ca, and Mg uptake by the total rape plant at Pt. MacKenzie, 1982-84.[1]

	N			P			Ca			Mg		
Lb B/A	1982	1983	1984	1982	1983	1984	1982	1983	1984	1982	1983	1984
	(lb/A)											
0	78a[2]	54a	253a	19.6a	9.9a	55.3a	75a	39a	242b	12.9a	7.3a	39.5a
1	88a	66a	231b	21.6a	11.2a	43.7b	78a	40a	275a	13.8a	7.8a	35.5b

[1]Means of 24 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

was significantly depressed by each increasing N rate (table 9). The yearly variations in P concentration in rapeseed at Pt. MacKenzie and total P uptake at Trapper Creek are shown in Table 6. Each increasing N rate in 1982 and 1983 depressed the P concentration in Pt. MacKenzie rapeseed, while the highest N rate (120 lb per acre) in 1984 depressed P concentration. Total P uptake at Trapper Creek increased with each increasing N rate; P uptake in 1981 decreased with N rates as follows: 60 > 120 > 0.

Table 9. Effect of N on the P concentration in rapeseed at Trapper Creek, and the S concentration in rape straw and the Ca concentration in rapeseed at Pt. MacKenzie.

	Trapper Creek[1]			Pt. MacKenzie[2]					
	P (Seed)			S (Straw)			Ca (Seed)		
	(lime/A)								
Lb N/A	0	2	4	0	2	4	0	2	4
	(%)								
0	0.96a[3]	1.01a	0.99a			0.582			0.53[4]
60	0.79b	0.95b	0.93b		0.34a	0.39a		0.50a	0.51a
120	0.74c	0.87c	0.89c	0.27[2]	0.30b	0.35b	0.39[2]	0.45b	0.48b

[1]Means of 18 measurements. [2]Means of 36 measurements. [3]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [4]Means of 6 measurements.

Lime application increased P concentration in the rape straw and P uptake by the total plant at Trapper Creek; at Pt. MacKenzie each increasing lime rate increased the P concentration in the rapeseed and P uptake by the total plant (table 4). Lime application increased the P concentration in rapeseed at Trapper Creek when N was applied, but without added N, 2 ton lime produced a higher P concentration than did no lime (table 10). At Pt. MacKenzie, P concentration in the straw increased with each increasing lime rate in 1982 and 1983; however, in 1984, only the heaviest lime rate (4 ton per acre) increased P concentration in the straw significantly (table 7).

Table 5 indicates the P concentration in both the straw and seed was depressed by application of B in each of the three years at Point MacKenzie. In 1984, B application depressed P uptake by the total plant, but in 1982 and 1983, B application had no significant effect on P uptake (table 8). At Trapper Creek, means of six measurements show B doubled the P concentration in rape straw when no lime was applied, but halved it when lime was added. Phosphorus uptake was increased 48 times by B application when no lime was applied.

Table 10. Effect of lime on the P concentration in rapeseed and Ca uptake by the total plant at Trapper Creek and the S concentration in rape straw and the Ca concentration in rapeseed at Pt. MacKenzie.

	Trapper Creek[1]						Pt. MacKenzie[2]					
	P (Seed)			Total Plant Uptake (Ca)			S (Straw)			Ca (Seed)		
	(lb N/A)						(lb N/A)					
T lime/A	0	60	120	0	60	120	0	60	120	0	60	120
	Concentration (%)			(lb/a)			Concentration (%)					
0	0.96b[3]	0.79b	0.74b	14b	24b	32b			0.272			0.392
2	1.01a	0.95a	0.87a	34a	61a	63a		0.34b	0.30b		0.50a	0.45b
4	0.99ab	0.93a	0.89a	38a	67a	70a	0.58[4]	0.39a	0.35a	0.532	0.51a	0.48a

[1]Means of 18 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [3]Means of 36 measurements. [4]Means of 6 measurements.

K Concentration and Uptake

Each increasing N rate depressed K concentration in the rape straw at Trapper Creek and in the seed at Pt. MacKenzie (table 2). The variations from year to year in K concentration in the seed and K uptake by the entire plant at Trapper Creek is presented in Table 11. Potassium concentration in the seed was increased by 120 lb N in 1979 and by 60 lb in 1981, but was not influenced significantly by N rates in 1980. In both 1979 and 1981, total plant uptake of K was increased by N application. Table 12 shows that increasing the N rate from 60 to 120 lb per acre at Pt. MacKenzie increased the straw K concentration both with and without B. Table 13 shows that in increasing the N rate from 60 to 120 lb per acre, total plant K uptake was increased in 1982 and 1984 when no B was applied; however, in 1983 without B and with B in each of the three years, K uptake was not influenced significantly by B.

The yearly variations in K uptake at Pt. MacKenzie and in K concentration in straw and seed at both locations are presented in Table 7. The K concentration in the rape straw at Trapper Creek in 1979 and at Pt. MacKenzie in 1984 decreased with each increasing lime rate. However, in 1981 at Trapper Creek and in 1983 at Pt. MacKenzie this decrease occurred only with the heaviest lime application. At Pt. MacKenzie in 1982, lime application decreased the K concentration of the straw. Lime application at Trapper Creek increased the seed K concentration in 1979 and 1981 and the K uptake in 1981, but had no significant effect on K in the seed in 1980 or on K uptake in 1979 (table 7). Each increasing lime rate at Pt. MacKenzie increased K concentration in the seed when the three years were averaged together (table 4) and decreased the K uptake by the total plant in 1984 (table 14).

The K concentration in the rape straw at Pt. MacKenzie was depressed by application of B only at the highest N rate (120 lb per acre) (table 12). Rapeseed K concentration was depressed by B application (table 15). Only in 1984 did B application increase K uptake (table 13). At Trapper Creek, B use had no apparent effect on K concentration in the straw or seed, but B application increased the K uptake 24-fold when no lime was applied.

Table 11. Effect of N on the K and S concentrations in rapeseed, S concentrations in rape straw, and total plant K uptake at Trapper Creek, 1979-81 and straw Mg concentration and total plant S, Mg, and Ca uptake at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]									
	Seed			Straw		Seed			Total plant uptake	
	K			S		S			K	
Lb N/A	1979	1980	1981	1979	1981	1979	1980	1981	1979	1981
	(%)								(lb N/A)	
0	1.14b[2]	0.92a	0.96b	0.59a	0.53a	0.28c	0.33b	0.28c	42b	36b
60	1.17ab	0.89a	1.00a	0.47b	0.47b	0.30b	0.34b	0.32b	87a	70a
120	1.20a	0.91a	0.96b	0.44c	0.48b	0.34a	0.36a	0.35a	95a	60a

	Pt. MacKenzie[3]											
	Total Plant Uptake									Straw		
	S			Ca			Mg			Mg		
Lb N/A	1982	1983	1984	1982	1983	1984	1982	1983	1984	1982	1983	1984
	(lb N/A)									(%)		
0[4]	12.0c	9.8a	50.1b	26c	24b	132c	4.7c	4.5b	20.8c	.182a	.157a	.183a
60	24.1b	11.4a	78.8a	65b	37a	236b	11.2b	7.0a	35.7b	.141b	.145ab	.151b
120	29.8a	12.1a	74.9a	88a	43a	281a	15.5a	8.0a	39.4a	.155b	.131b	.149b

[1]Means of 18 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability. [3]Means of 24 measurements. [4]Means of 6 measurements.

Table 12. Effect of N and B on the K concentration in rape straw at Pt. MacKenzie, 1982-84.[1]

Lb N/A	(lb B/A) 0	(lb B/A) 1	Lb B/A	(lb N/A) 60	(lb N/A) 120
	(%)			(%)	
60	1.60b[2]	1.62b	0	1.60a	1.97a
120	1.97a	1.76a	1	1.62a	1.76b

[1]Means of 36 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 13. Effect of N and B on the K uptake by the total rape plant at Pt. MacKenzie, 1982-84.[1]

	(lb B/A) 0			(lb B/A) 1		
Lb N/A	1982	1983	1984	1982	1983	1984
	(lb/A)			(lb/A)		
60	84b[2]	48a	314b	100a	64a	427a
120	112a	56a	368a	120a	68a	417a
	(lb N/A) 60			(lb N/A) 120		
Lb B/A	1982	1983	1984	1982	1983	1984
	(lb/A)			(lb/A)		
0	84a	48a	314b	112a	56a	368b
1	100a	64a	427a	120a	68a	417a

[1]Means of 12 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 14. Effect of lime on the S and Ca concentration in rapeseed, Mg concentration in rape straw at Trapper Creek, 1979-81 and on the Mg concentration in rape straw and the K uptake by the total plant at Pt. MacKenzie, 1982-84.

	Trapper Creek[1]								Pt. MacKenzie[2]					
	Seed						Straw		Straw			Total Plant Uptake		
	S			Ca			Mg		Mg			K		
T lime/A	1979	1980	1981	1979	1980	1981	1979	1981	1982	1983	1984	1982	1983	1984
	(%)											(lb/A)		
0	.32a[3]	.36a	.33a	.64c	.57c	.58c	.32a	.11a	.20a	.15a	.16a	107a	62a	474a
2	.30b	.34b	.31b	.76b	.65b	.63b	.23b	.10a	.15b	.14a	.14a	103a	58a	411b
4	.31ab	.33b	.30b	.81a	.71a	.67a	.21b	.08b	.14b	.13a	.16a	105a	60a	352c

[1]Means of 18 mesurements. [2]Means of 24 measurements. [3]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 15. Effect of B application on the K, Ca, and Mg concentrations in rapeseed and the S uptake by the total plant at Pt. MacKenzie, 1982-84.[1]

Lb B/A	K	Ca	Mg	S
	(%)			(lb/A)
0	.96a[2]	.51a	.36a	.37a
1	.84b	.43b	.34b	.40a

[1]Means of 72 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Sulfur Concentration and Uptake

The variations in S concentration and uptake at Trapper Creek are shown in Table 11. The S concentration in the rape straw was reduced each year by N application and in 1979 S concentration was reduced by each increasing N rate. The S concentration in the seed was increased in 1979 and 1981 by each increasing N rate and increased in 1980 by N. Table 16 presents the effects of both N and lime rates on S uptake at Trapper Creek for each of the two years. Only in 1979, when no lime was applied, did each increasing N rate increase the S uptake; at other lime rates each year and without lime in 1981, N application increased the S uptake. At Pt. MacKenzie S concentration in the straw was reduced by increasing the N rate from 60 to 120 lb per acre. The high S concentration when no N was applied probably results from increased concentration because of reduced growth (table 9). The S concentration in the seed increased with each increasing N rate in 1982 and 1984 and with N application in 1983 (table 6). Sulfur uptake by the entire plant was increased by each increasing N rate in 1982, was not influenced by N in 1983, and was increased equally by both N rates in 1984 (table 11).

Table 4 shows a decrease in Trapper Creek rape straw S concentration with lime application. At Pt. MacKenzie there was an increase in S uptake by the entire plant with each increasing lime rate. The S concentration in the rapeseed was decreased by lime application in 1980 and 1981 and tended to be depressed by lime in 1979 (table 14). At Trapper Creek in 1979, without N application, each increasing lime rate produced an increase in S uptake by the total plant; whereas, in 1981, without applied N and at both the 60 and 120 lb N rates in both years, lime application increased S uptake (table 16). Increasing lime rates at Pt. MacKenzie increased S concentration in the straw (table 10). This increase in the straw S concentration is difficult to relate to the decrease at Trapper Creek. At Pt. MacKenzie, increasing the lime rate from 2 to 4 ton per acre increased S concentration in the seed only in 1983 and where no B had been applied (table 17).

The S concentration in Pt. MacKenzie rape straw was depressed by B application in 1983, but was not influenced significantly the other two years (table 5). At both lime rates in 1983 and 1984, B depressed S concentration in the seed; in 1982, no effect of B was apparent (table 17). The S uptake by the entire plant was not influenced significantly by B (table 15).

Table 16. Effect of N and lime on the S and Mg uptake by the total rape plant at Trapper Creek, 1979 and 1981 (means of 6 measurements).

Sulfur

	(T lime/A)							(lb N/A)					
	0		2		4			0		60		120	
	1979	1981	1979	1981	1979	1981		1979	1981	1979	1981	1979	1981
Lb N/A							T Lime/A						
	(lb/A)							(lb/A)					
0	5.8c[1]	6.0b	9.3b	9.5b	12.7b	10.9b	0	5.8c	6.0b	14.6b	11.0c	18.7b	10.7b
60	14.6b	11.0a	24.0a	22.7a	21.1a	19.1a	2	9.3b	9.5a	24.0a	22.7a	21.5a	20.5a
120	18.7a	10.7a	21.5a	20.5a	20.7a	18.5a	4	12.7a	10.9a	21.1a	19.1b	20.7ab	18.5a

Magnesium

	(T lime/A)							(lb N/A)					
	0		2		4			0		60		120	
	1979	1981	1979	1981	1979	1981		1979	1981	1979	1981	1979	1981
Lb N/A							T Lime/A						
	(lb/A)							(lb/A)					
0	5.7b	2.8a	6.6c	3.0b	7.3b	3.4b	0	5.7a	2.8a	15.1a	4.1b	16.7b	3.2b
60	15.1a	4.1a	13.7b	7.4a	14.3a	5.4a	2	6.6a	3.0a	13.7a	7.4a	19.1a	6.2a
120	16.7a	3.2a	19.1a	6.2a	16.1a	4.9ab	4	7.3a	3.4a	14.3a	5.4b	16.1b	4.9ab

[1]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 17. Effect of lime and B on the S concentration in rapeseed at Pt. MacKenzie, 1982-84.[1]

	(lb B/A)					
	0			1		
T lime/A	1982	1983	1984	1982	1983	1984
	(%)					
2	.33a[2]	.37b	.37a	.31a	.33a	.34a
4	.32a	.41a	.38a	.31a	.33a	.34a
	(T lime/A)					
	2			4		
Lb B/A	1982	1983	1984	1982	1983	1984
	(%)					
0	.33a	.37a	.37a	.32a	.41a	.38a
1	.31a	.33b	.34b	.31a	.33b	.34b

[1]Means of 12 measurements. [2]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

At Trapper Creek, B application had no significant effect on either the straw or seed, but increased the S uptake 20-fold.

Calcium Concentration and Uptake

The heaviest N rate (120 lb per acre) increased Ca concentration in the Trapper Creek rape straw (table 2). The Ca concentration in the seed was reduced by the heaviest N rate in 1979, and also by 60 lb N in 1980; N rates did not influence Ca concentration in the seed significantly in 1981 (table 18). Total plant Ca uptake was increased by each increasing N rate in 1979 and by N application in 1981 (table 18).

Table 18. Effect of N on the Mg concentration in rape straw, the Ca concentration in rapeseed, and the total plant Ca uptake at Trapper Creek, 1979-81 (means of 18 measurements).

	Mg (Straw)		Ca (Seed)			Total Plant Uptake (Ca)	
Lb N/A	1979	1981	1979	1980	1981	1979	1981
	----------(%)----------					------(lb/A)------	
0	.237b[1]	.102a	.77a	.66a	.65a	25c	22b
60	.250b	.097a	.75a	.62b	.62a	56b	50a
120	.276a	.092a	.69b	.65ab	.62a	68a	49a

[1]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 19 presents the variations in Ca concentration in rape straw at Pt. MacKenzie resulting from N, lime, and B applications in each of the three years. The Ca concentration in the straw was increased by increasing the N rate from 60 to 120 lb per acre when 2 ton lime per acre were used without B in 1982 and 1984, and in 1982 when 4 tons of lime were used with B. Table 9 indicates that Ca concentration in the Pt. MacKenzie seed was depressed by increasing the N rate from 60 to 120 lb per acre. The Ca uptake was increased by each increasing N rate in 1982 and 1984 and by N application in 1983 (table 11).

The Ca concentration in rape straw (table 4) and seed Ca at Trapper Creek concentration (table 14) were increased each year by each increasing lime rate. Furthermore, Ca uptake was increased by lime application (table 10). Increasing the lime rate at Pt. MacKenzie from 2 to 4 ton per

Table 19. Effect of N, lime, and B on the Ca concentration in rape straw at Pt. MacKenzie, 1982-84 (means of 6 measurements).

	1982				1983				1984			
	(T lime/A)											
	2		4		2		4		2		4	
	(lb B/A)											
Lb N/A	0	1	0	1	0	1	0	1	0	1	0	1
	Concentration (%)											
60	1.26b[1]	1.36a	1.38a	1.36b	1.21a	1.14a	1.14a	1.21a	1.01b	1.10a	1.18a	1.25a
120	1.50a	1.31a	1.38a	1.60a	1.16a	1.01a	1.16a	1.12a	1.20a	1.18a	1.18a	1.36a
	(lb N/A)											
	60		120		60		120		60		120	
	(lb B/A)											
T lime/A	0	1	0	1	0	1	0	1	0	1	0	1
	Concentration (%)											
2	1.26a	1.36a	1.50a	1.31b	1.21a	1.14a	1.16a	1.01a	1.01b	1.10b	1.20a	1.18b
4	1.38a	1.36a	1.38a	1.60a	1.14a	1.21a	1.16a	1.12a	1.18a	1.25a	1.18a	1.36a
	(lb N/A)											
	60		120		60		120		60		120	
	(T lime/A)											
Lb B/A	2	4	2	4	2	4	2	4	2	4	2	4
	Concentration (%)											
0	1.26a	1.38a	1.50a	1.38b	1.21a	1.14a	1.16a	1.16a	1.01a	1.18a	1.20a	1.18b
2	1.36a	1.36a	1.31b	1.60a	1.14a	1.21a	1.01a	1.12a	1.10a	1.25a	1.18a	1.36a

[1]Means within a column followed by the same letter are not significantly different at the 5% level of probability.

acre increased Ca concentration in rape straw significantly in 1982 and 1984 when 120 lb N per acre was applied with B, and in 1984 when 60 lb was used with or without B (table 19). The Ca concentration in the rapeseed at Pt. MacKenzie was increased by each increasing lime rate when N was applied at 120 lb per acre (table 10). Total plant Ca uptake was increased by each increasing lime rate (table 4).

The Ca concentration in the rape straw from Pt. MacKenzie was increased by B when 120 lb N and 4 ton of lime per acre was used in 1982 and 1984, but was decreased in 1982 when 120 lb N and 2 ton lime were applied. Boron application reduced the Ca concentration in the seed (table 15). The Ca uptake was increased by applied B only in 1984 (table 8).

Magnesium Concentration and Uptake

The Mg concentration in rape straw at Trapper Creek was increased by the highest N rate in 1979 and not influenced significantly by N in 1981 (table 18). The Mg concentration in the seed was reduced by the 120 lb N per acre rate (table 2). Nitrogen application at Trapper Creek increased the Mg uptake at all lime rates in 1979 and 1981 except in 1981 when no lime was applied; with 2 ton lime per acre in 1979, each increasing N rate increased the Mg uptake. The Mg concentration in rape straw at Pt. MacKenzie was reduced each year by N application, although the decrease from no N to 60 lb per acre in 1983 was not large enough to be significant (table 11). Each increasing N rate reduced the Mg concentration in the rapeseed (table 2). The Mg uptake by the total plant was increased by each increasing N increment in 1982 and 1984 and by application of N in 1983 (table 11).

The Mg concentration in rape straw at Trapper Creek was reduced by all rates of lime in 1979 and by 4 ton of lime per acre in 1981 (table 14). This same high lime rate reduced the Mg concentration in the seed (table 4). Table 16 shows an increase in Mg uptake when 2 ton lime was used with the 60 lb N rate in 1981 and with 4 ton lime and 120 lb N in 1979 and 1981. The Mg concentration in straw at Pt. MacKenzie was reduced by lime application in 1982 but was not influenced by lime in 1983 or 1984 (table 14). The Mg concentration in rapeseed at Pt. MacKenzie was increased by lime application but the total Mg uptake was not influenced significantly (table 4).

At Pt. MacKenzie, B application reduced the Mg concentration in the straw each year (table 5). Table 15 shows a reduction in the Mg concentration in the seed with B application. The Mg uptake was reduced by B only in 1984 (table 8).

Summary

Candle rape was planted three years in the Trapper Creek area and three years at Pt. MacKenzie. Three N and lime rates with and without B were used. Straw and seed yields were obtained all six years; chemical analyses were made of the seed each year and of the straw for five years.

The analyses of variance show numerous variations in the response to N by year, to lime by year, and to B by year and other interactions. These are discussed in detail and the following generalities may be drawn.

Each increasing N rate (60 and 120 lb per acre compared with none) increased straw yield five years and seed yield four years out of six. Yield of both straw and seed was always increased by N application. Each increasing N rate increased or tended to increase the N concentration in the rape straw, and the N, P, S, Ca, and Mg uptake at both locations. Each increasing N rate decreased or tended to decrease the P and K concentration in straw and seed at both locations, the S concentration in straw at Trapper Creek, and the Ca and Mg concentrations in both straw and seed at Pt. MacKenzie.

Each increasing lime rate increased or tended to increase the straw and total yield and P concentration at both locations and the Ca uptake at Trapper Creek.

Boron application increased seed yields at both locations, and straw and total yields, P, S, and Mg concentrations in straw and seed, K and S concentrations in the seed, and P, Ca, and Mg uptake at Pt. MacKenzie.

We believe excellent rapeseed crops can be grown in both the Trapper Creek area and at Pt. MacKenzie when properly fertilized with N, P, K, and B. Lime may be required on the more acidic soils. The cool, damp weather conditions prevalent at harvest time, however, tend to impair ideal seed recovery.

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