

Nitrogen, Phosphorus and Sulphur Fertility of Hybrids vs. Conventional Canola

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Introduction

The importance of N and S nutrition of canola is well recognized (Janzen and Bettany 1984; Bailey 1986; Grant and Bailey 1993; Jackson 2000; Malhi and Leach 2002). Agronomists today are recommending that a N:S ratio of between 5:1 and 7:1 is adhered to when fertilizer N and S are applied. This is also reflected in the provincial recommendations. Thus, Manitoba Agriculture and Food (2001) suggests that application of fertilizer in a N:S ratio of 8:1 to 5:1 will usually supply adequate sulphur; Saskatchewan Agriculture, Food and Rural Revitalization (2001) suggests that canola requires an available N to S ratio of about 5 to 7 to optimize yield; and, Alberta Agriculture, Food and Rural Development (2001) also point out that canola requires an N:S ratio of 7:1. However, work on the N:S ratio of applied fertilizers to canola is very limited. Derivation of optimum ratios has been coincidental to concurrent application of N and S to achieve proper crop balance on severely S deficient soils, but it has not been ascertained whether an “optimum” N:S ratio is required even on soils that are sufficient in either or both of these two major nutrients.

The introduction of high yielding hybrid canola cultivars has necessitated re-visiting management practices to obtain optimum canola yields. Hybrid canola results in higher yields compared to conventional or open pollinated canola cultivars (Brandt et al. 2002; Karamanos and Flore 2002). The same authors also concluded that optimum yield of hybrid canola may be obtained at fertility at or above current recommendations.

The objectives of this study were to assess:

1. Nitrogen, sulphur and phosphorus requirements of hybrid compared to conventional canola cultivars;
2. Interaction of nitrogen and sulphur (N:S) in both conventional and hybrid canola ;
3. Interaction of nitrogen and phosphorus (N:P) in both conventional and hybrid canola.

Materials and Methods

Effect of N Rates on Canola Yield

Irricana 1999: Twelve rates of nitrogen (0 to 200 lbN/acre) were side-banded as urea (46-0-0). Blanket applications of 27 lb P₂O₅/acre as 0-45-0, 45 lb K₂O/acre and 15 lb S/acre¹ as K₂SO₄ (0-0-50) were side-banded and broadcast and incorporated, respectively. Six-row plots with 9-inch spacing and 30-foot length were seeded with Invigor 2273 and 2153 and Innovator canola with an airseeder at a rate of 7 lb/acre on June 10 and were harvested on September 24.

Irricana 2000: Twelve rates of nitrogen (0 to 200 lbN/acre) as urea (46-0-0) and three rates of P₂O₅ (0, 18 and 36 lb/acre) were side-banded. A blanket application of 92 lb K₂O/acre and 30 lb S/acre as K₂SO₄ (0-0-50) was broadcast and incorporated. Six-row plots with 9-inch spacing and 30-foot length were seeded on April 30 with an airseeder at a rate of 7 lb/acre, for Invigor 2153, Hyola 401, SW Rider and Nexera 500, respectively and were harvested on September 13.

Effect of N and P rates on Canola Yield

Red Deer and Ellerslie 2001: Twelve rates of nitrogen (0 to 200 lbN/acre) as urea (46-0-0) and three rates of P₂O₅ (0,18 and 36 lb/acre) were side-banded. Blanket application of 45 lb K₂O/acre and 15 lb S/acre as K₂SO₄ (0-0-50) were broadcast and incorporated. Four-row plots with 9-inch spacing and 30-foot length were seeded with SW Rider or Q2 canola on May 4 at red Deer and May 16 at Ellerslie with a hoeddrill at a rate of 6 lb/acre. The plots were harvested on September 17 at Red Deer and 25 at Ellerslie.

Effect of N and S rates on Canola Yield

Red Deer and Wetaskiwin 2001: Twelve rates of nitrogen 0 to 200 lbN/acre) as urea (46-0-0) and three rates of S (0,18 and 36 lb/acre) were side-banded. Blanket applications of 27 lb P₂O₅/acre as 0-45-0, and 200 lb K₂O/acre as 0-0-62 were side-banded and broadcast and incorporated, respectively. Four-row plots with 9-inch spacing and 30-foot length were seeded with SW Rider or Q2 canola on May 4 with a hoeddrill at a rate of 6 lb/acre at Red Deer and on May 16 with a double disk drill at a rate of 6 lb/acre. The plots were harvested on September 17 at Red Deer and 26 at Wetaskiwin.

Comparison of N Requirements by Parent-Daughter Pairs

Four parent-daughter pairs were grown under twelve rates of nitrogen (0 to 150 lb/acre) and blanket rates of 30 lb P₂O₅/acre as 0-45-0, 55 lb K₂O/acre and 18 lb S/acre as K₂SO₄ (0-0-51-17) that were side-banded and broadcast and incorporated, respectively. All canola cultivars were obtained from Agriprogress Inc., Morden, Manitoba and were seeded length on May 25 in four-row plots with 9-inch spacing and 30-foot length with a hoeddrill at a rate of 6 lb/acre and were harvested on September 3.

Soil Characteristics of the Experimental sites

The main soil characteristics of the sites where the 1999 to 2001 experiments were carried are shown in Table 1. The 2002 sites were sampled in grids and the average N and S levels along with some basic statistics are shown in Table 2. Nitrogen and S levels in the soils of all sites were extremely variable (Figures 1 to 3), however, at this time only the average values for each site were utilized for interpretation of the data.

Table 1. Soil characteristics of the experimental sites where trials were conducted during 1999-2001.

Year	Location	OM (%)	Texture	pH	EC (mS/cm)	NO ₃ - N	P (lb/acre)	K	SO ₄ - S
1999	Irricana, AB	3.6	Loam	6.2	0.2	23	20	566	15
			Loam	6.7	0.2	20			13
2000	Irricana, AB	4.0	Loam	6.0	0.2	12	28	600+	16
			Clay Loam	7.3	0.4	6			12
2001	Red Deer	6.5	Clay	7.5	0.40	25	8	512	19
			Clay	7.9	0.40	15			13
	Wetaskiwin	1.7	Loam	6.3	0.2	6	45	166	3
			Loam	6.5	0.2	5			4
Ellerslie	8.2	8.2	Clay loam	7.5	0.20	34	36	347	31
			Loam	8.1	0.20	20			27

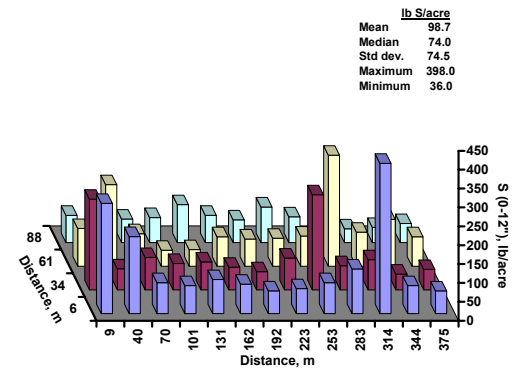
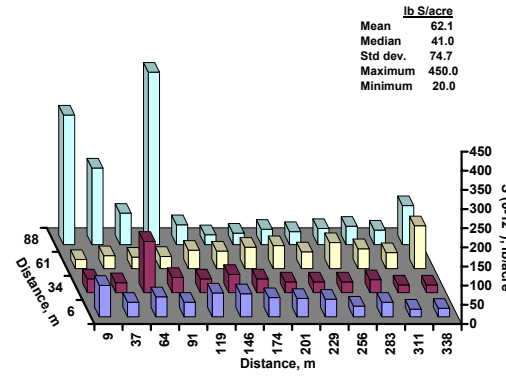
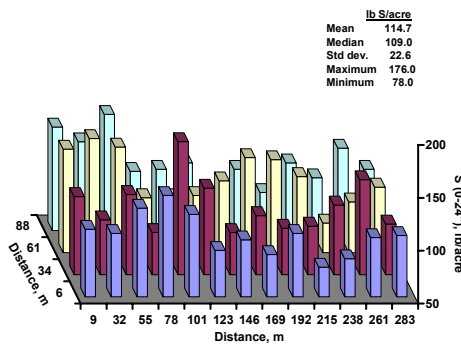
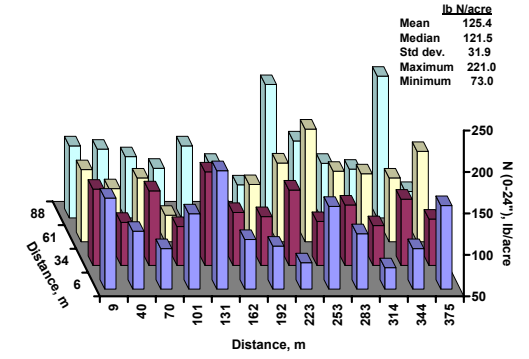
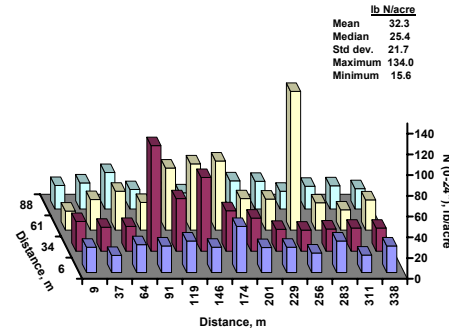
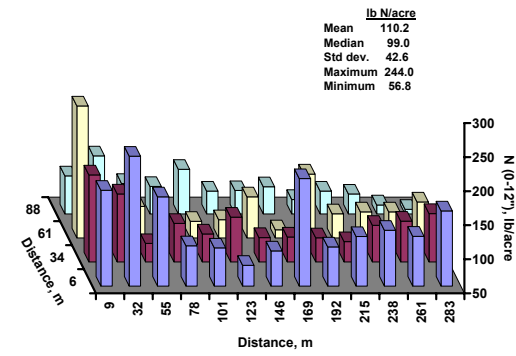


Figure 1. Soil N and S levels at the Ft. Saskatchewan site (2002).

Figure 2. Soil N and S levels at the Sylvania site (2002).

Figure 3. Soil N and S levels at the Rosebank site (2002).

Table 2. Nitrogen and S levels in the soils of the 2002 trials.

	Ft. Saskatchewan			Sylvania			Rosebank			Miami		
	N	S	N:S	N	S	N:S	N	S	N:S	N	S	N:S
Mean	110.2	114.7	1.0	32.3	62.1	0.8	125.4	98.7	1.9	81.5	159.4	1.0
Std dev.	42.6	22.6	0.4	21.7	74.7	0.5	31.9	74.5	1.2	23.4	150.2	0.6
Median	99.0	109.0	0.9	25.4	41.0	0.7	121.5	74.0	1.7	85.5	76.0	1.0
Max	244.0	176.0	2.3	134.0	450.0	2.6	221.0	398.0	6.2	139.0	480.0	2.4
Min	56.8	78.0	0.4	15.6	20.0	0.0	73.0	36.0	0.0	26.0	38.0	0.1

Effect of N:S and N:P ratios on Canola Yield

Ft. Saskatchewan, Sylvania, Miami and Rosebank 2002: Sulphur as ammonium sulphate (20.5-0-0-24) was applied in three N:S ratios (1.5:1, 6:1 and 12:1) in conjunction with six rates of N fertilizer (0, 36, 72, 108, 144, and 180 lb N/acre) applied as urea (46-0-0) in a split-split-plot design with canola cultivars (conventional, liberty link system, roundup ready system) as main plots, N:S ratios as sub-plots and N rates as sub-sub-plots. All treatments were replicated four times. Plots at Sylvania were seeded on May 18, at Miami May 25, Ft. Saskatchewan on May 28 and at Rosebank on June 1, 2002. Growing conditions in Manitoba were less than ideal with hot temperatures during canola flowering that resulted in pod abortion. The Ft. Saskatchewan and Sylvania sites were dry to begin with, but timely rains resulted in improved growing conditions.

Five rates (0, 18, 36, 54, and 72 lb P₂O₅/acre) of P as monoammonium phosphate (12-51-0) were applied in all combinations with five rates (0, 45, 90, 135, 180 lb N/acre) of N fertilizer (46-0-0) in a split-split-plot design with canola cultivars (conventional, liberty link system, roundup ready system) as main plots, P₂O₅ rates as sub-plots and N rates as sub-sub-plots with four replications. Plots at Sylvania were seeded on May 19, at Miami and Ft. Saskatchewan on May 27 and at Rosebank on June 2, 2002.

The plots were harvested on September 18 at Miami, September 20 at Rosebank, October 3 at Sylvania, October 7 at Ft. Saskatchewan using a Wintersteiger Nurserymaster Elite experimental combine and the grain samples were dried at 60 °C by forced air and weighed to determine grain yield.

The results from all tests were subject to ANOVA and regression analysis using SYSTAT 8.0 (SPSS Inc. 1998).

Results and Discussion

Nitrogen and Sulphur

Combining the results of all seventeen-site years over all treatments of either S or P₂O₅ per experiment resulted in an overall yield advantage of hybrids over conventional canola cultivars of 12 % for the same fertility regime. This increase can presumably be attributed to hybrid yield superiority due to genetics (Figure 4). Fertilizer practices, in particular application of N, doubled that advantage to 24%.

To derive a critical level of soil plus fertilizer N for optimum yield of canola, the yields from each trial were expressed as a percentage of the maximum yield obtained for the trial. They were then plotted against soil (0-12") plus applied N (Figure 5). The N and S levels in the 12-24" depth were not included as presence of gypsum in many soils caused the S levels to exceed what was set as the upper detection limit to be reported without dilution of sample extracts by the soil testing laboratories.

One striking difference between the two graphs is that maximum yield for hybrid canola was obtained with an additional 40 lb of applied N (Figure 4), but only with an additional 30 lb of soil + applied N per

acre (Figure 5). This would suggest that hybrids utilize soil N more efficiently and is in line with previous observations that hybrids are more efficient scavengers of soil nutrients (Karamanos and Flore 2002).

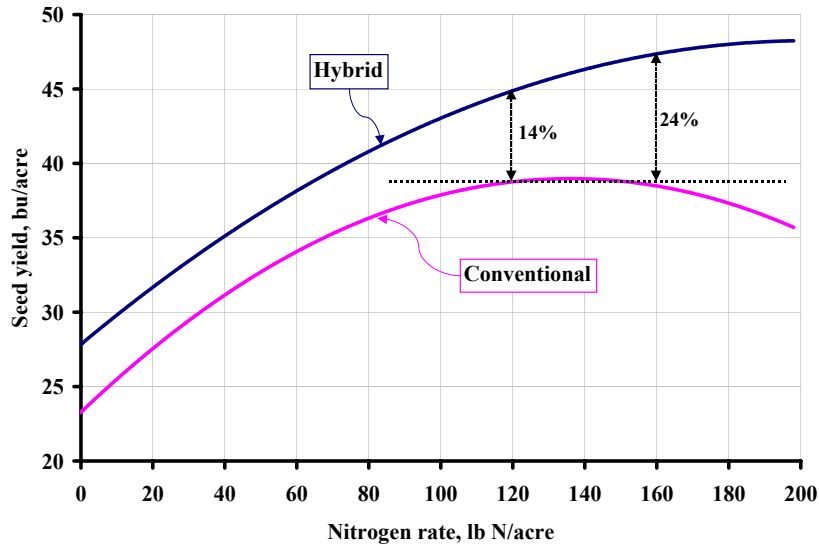


Figure 4. Comparison of overall yield obtained for canola hybrids to that of conventional canola cultivars based on applied N rates (Westco 17 site-years; 1999-2002).

Multiple regression analysis of all the data from the 1999 to 2001 trials that were set up as experiments with twelve rates of N and either one, two or three rates of S resulted in a significant effect of N only. However, dramatically different trends were obtained when multiple regressions were carried out using all the 1999 to 2001 trials by adding the soil N and S levels in the 0-12" depth to the corresponding levels of applied N and S, respectively.

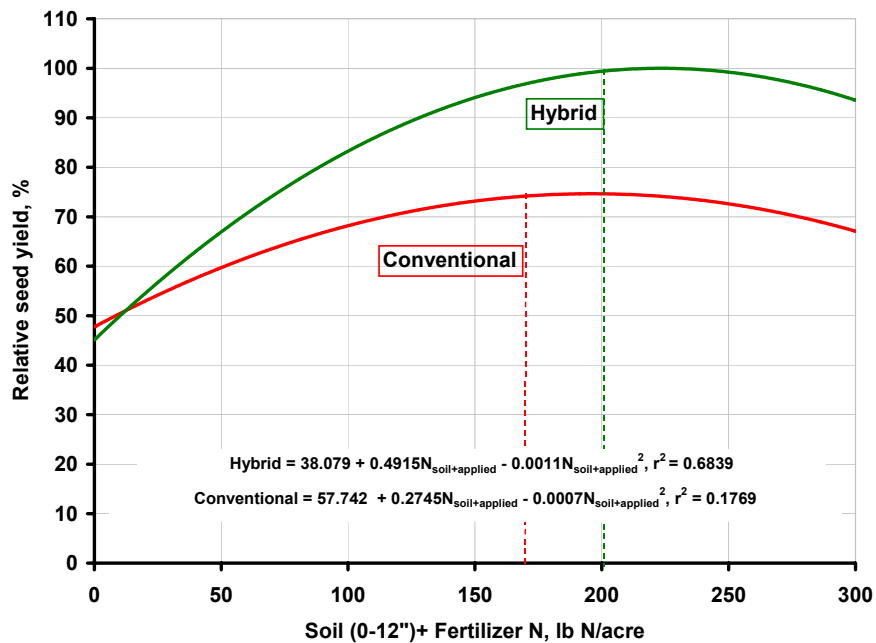


Figure 5. Comparison of relative yield of canola hybrids to that of conventional canola cultivars based on soil + applied N (Westco 17 site-years; 1999-2002).

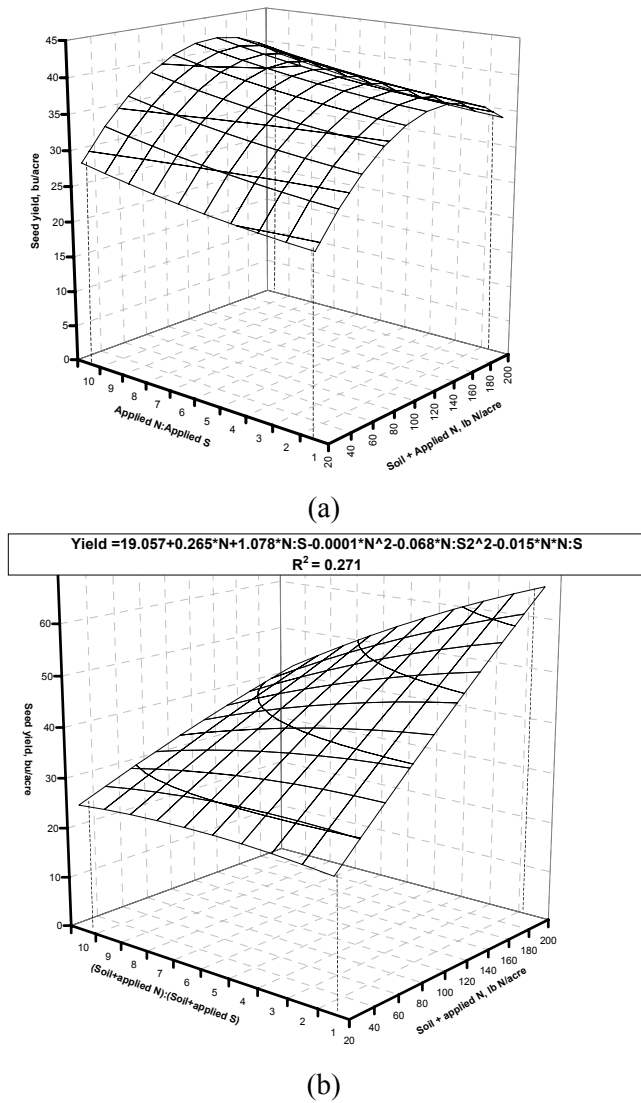


Figure 6. Seed yields of conventional canola cultivars as influenced by the rate of N and the N:S ratio of (a) applied and (b) soil + applied N and S (Westco 10 site-years; 1999-2001).

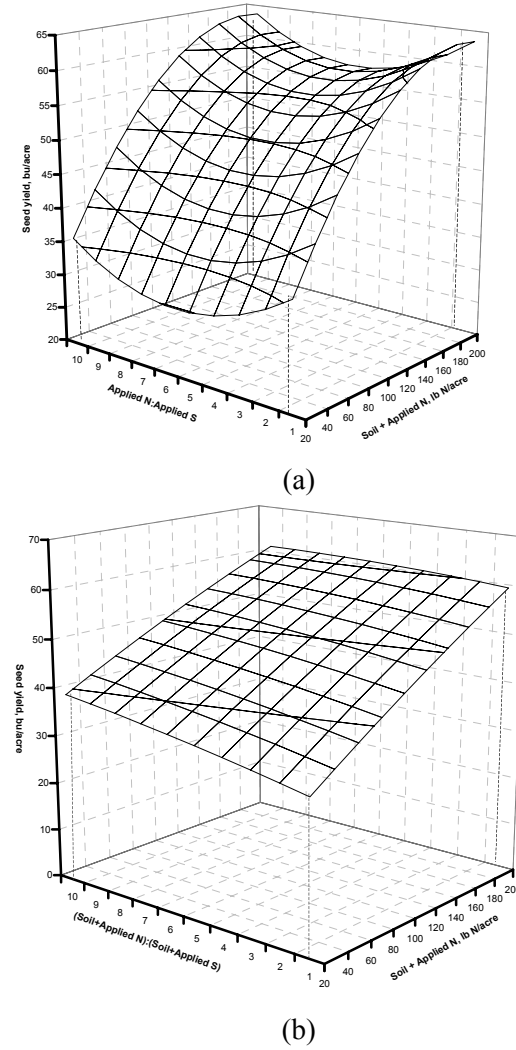


Figure 7. Seed yields of hybrid canola cultivars as influenced by the rate of N and the N:S ratio of (a) applied and (b) soil + applied N and S (Westco 13 site-years; 1999-2001).

Seed yield of the conventional canola cultivars as a function of soil + applied N and applied N:S ratio showed and increase with the rate of soil + applied N to approximately 140 lb N/acre independently of the N:S ratio of applied N and S (Figure 6a). However, when the N and S from the top 12 inches of the soil were added to the applied fertilizer N and S, it resulted in a dramatic impact of the N:S ratio on the yield of conventional canola (Figure 6b). This demonstrates the extreme importance of soil N and S in determining canola nutrient requirements. Seed yield of hybrid canola as a function of soil + applied N and either applied N:S or soil + applied N:S ratios indicated that maximum hybrid canola yields are obtained at a higher N rate than that for conventional canola cultivars. There was no significant impact of the N:S ratios on the seed yield unless the soil was severely S deficient in (Figure 7).

These trends were derived from trials where there was no attempt to adjust the N:S ratio based either on N or S application rates. Rather, different N and S rates were applied in various combinations. All researchers, who have demonstrated that a balance of N and S is required in order to obtain N optimum canola yield, have used this form of experimentation. Deduction of the optimum N:S ratio has mainly been based on N and S uptake (Janzen and Bettany 1984) rather than seed yields. Experiments with a combination of varying rates of N and S demonstrate the need for balanced N and S nutrition (Jackson 2000; Malhi and Leach 2002). However, inference of an optimum N:S ratio of either applied or soil + applied N and S is rather difficult, as it will heavily depend on the soil N and S levels. The experiments in 2002 were designed to address the N:S ratio issue of applied and (by inference) soil + applied N and S as N rates were kept constant, but S rates were varied to achieve a desired N:S ratio (1.5:1, 6:1 or 12:1).

The effect of fertilizer N rate was significant ($P < 0.001$) in all experiments. Hybrid yielded significantly higher ($P < 0.05$) than conventional canola cultivars in all experiments; therefore, they were all combined into one graph (Figure 8). There were no significant differences in the yields obtained for hybrid canola at various N:S ratios, however, conventional canola yields were restricted at the high and low N:S ratios when N rate exceeded 108 lb N/acre.

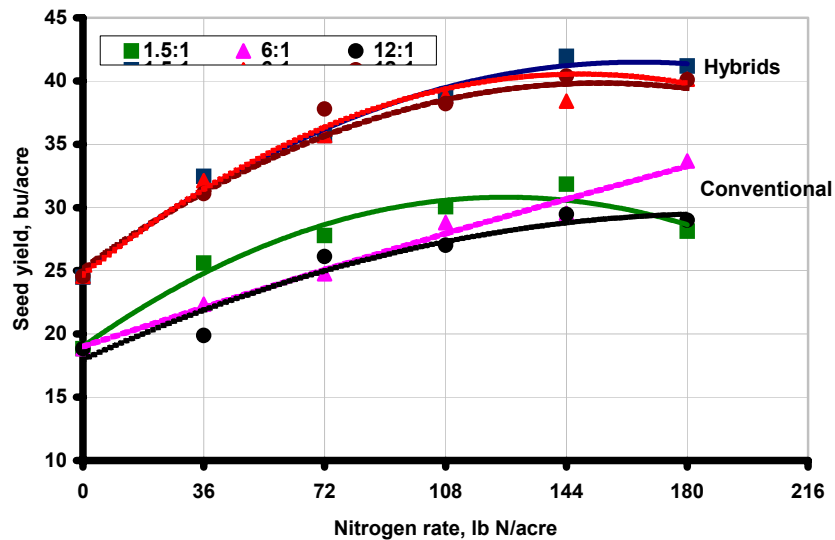


Figure 8. Comparison of overall yield obtained for canola hybrids to that of conventional canola cultivars based on applied N rates (Westco 4 site-years; 2002).

All soils in these experiments contained S levels that are considered to be adequate, hence, application of fertilizer N and S in three distinct ratios (1.5:1, 6:1 and 12:1) had virtually no impact on the yield of hybrid canola.

Phosphorus

In 2001, twelve N rates were applied in combination with three rates of P_2O_5 . The hybrid canola variety behaved differently from the traditional canola variety, however, responses were very much dependent on the P status of the soil.

The Red Deer site can be considered highly deficient, as the phosphorus soil test level was 8 lb P/acre of Modified Kelowna (MK) extractable-P (Qian et al. 1994); hence it was responsive to application of P_2O_5 (Figure 9).

On average, 18 lb P_2O_5 /acre resulted in 10 and 36 lb P_2O_5 /acre resulted in 15 percent yield difference for SW Rider canola (Figure 9b). However, the differences between the 36 lb P_2O_5 /acre and the control treatment grew from an average of 10 percent at lower than 125 lb N/acre rates to an average of 25 percent at N rates greater than 125 lb/acre. Maximum yield of Q2 canola, on the other hand, was obtained between 90 and 100 lb N/acre and was thereafter declined without any evidence of P_2O_5 interfering with nitrogen fertility, other than maximum yield for all N rates was obtained with 18 lb P_2O_5 /acre.

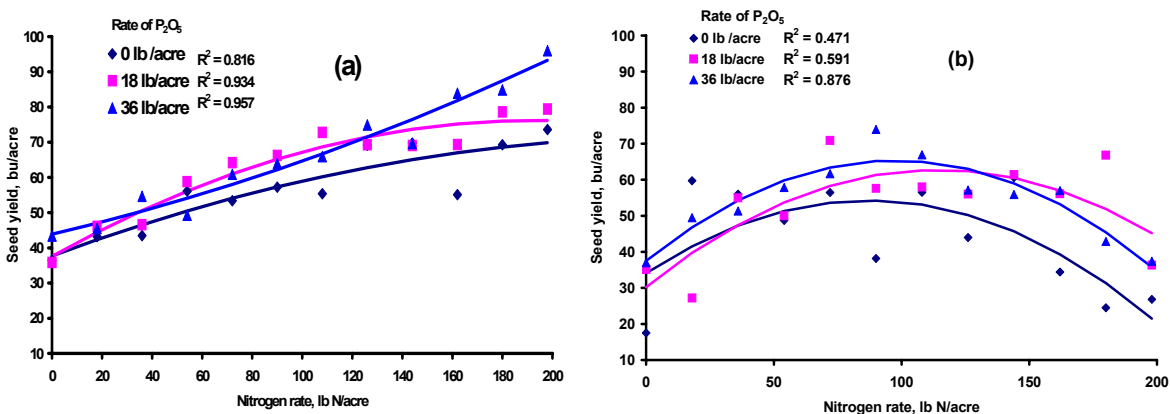


Figure 9. Effect of N and P on SW Rider (a) and Q2 (b) canola yield at Red Deer in 2001.

Phosphorus soil test levels at the Eilerslie site were considerably higher (36 lb MK-extractable P/acre) and are considered marginal to sufficient. Although application of P_2O_5 did not appear to benefit SW Rider (Figure 10a) at this site, Q2 required the addition of 18 lb P_2O_5 /acre in order to obtain maximum yield at all levels of nitrogen application (Figure 10b).

In 2002, significant response to P application was obtained only at Sylvania. This site contained 13.8 lb of MK-extractable P/acre compared to 37.3, 26.4 and 36.6 for the Ft. Saskatchewan, Rosebank and Miami sites, respectively. The orthogonal contrasts for the N and P effects at this site are shown in Table 3. There was a significant difference between the cultivars and responses both to N and P (Figure 11) were highly significant ($P < 0.01$). However, none of the interactions were significant, thus suggesting that all canola cultivars at this site responded to both N and P independently of each other's rate of application.

Conclusions

Hybrid canola cultivars yield, on average, as much as 25 % higher than conventional canola cultivars. Decisions concerning the nitrogen, phosphorus and sulphur requirements of both hybrid and conventional canola cultivars should be based on soil test levels for the corresponding nutrients.

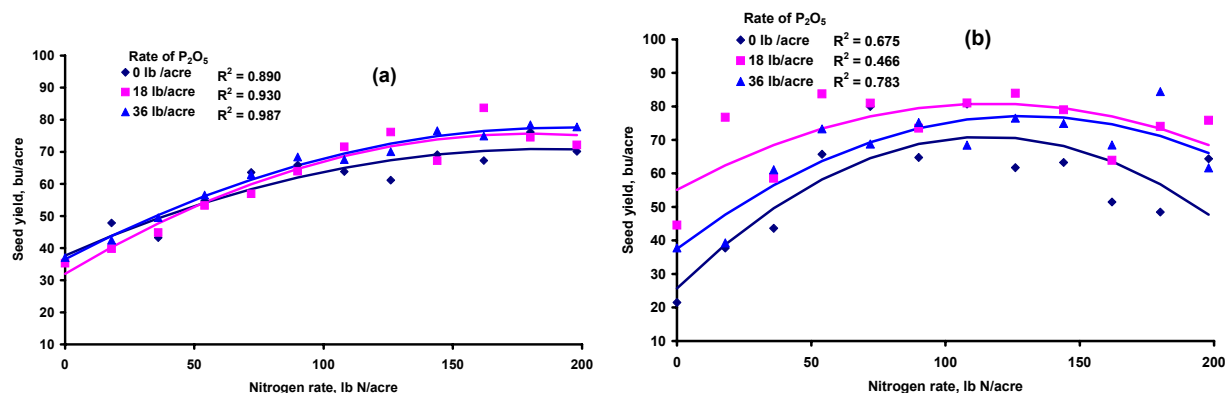


Figure 10. Effect of N and P on SW Rider (a) and Q2 (b) canola yield at Ellerslie in 2001.

Table 3. Portion of the analysis of variance of the N:P experiment in Sylvania pertaining to cultivar differences and responses to N and P.

	df	MSN	MSD	MS	F	Required F		
						0.10	0.05	0.01
Hybrid cultivar vs Conventional cultivar	1	970282	504	1925.16	20.22	3.78	5.99	13.75
Hybrid cultivar 1 vs Hybrid cultivar 2	1	289731	168	1724.59	18.12			
Response to N fertilizer	1	131470155	45360	2898.37	122.09	2.74	3.90	6.81 ^z
Linear response to P	1	1159209	480	2415.02	101.73			
Quadratic response to P	1	148654	672	221.21	9.32			
Cubic response to P	1	49310	480	102.73	4.33			
Residual response to P	1	11358	3360	3.38	0.14			
MPE	6	95.2						
SPE	180	23.74						

^z for df=150.

Canola yield is highly dependent on N fertility. Optimum yields of canola are derived so long as individual N, P and S requirements are fulfilled. Most of S deficiencies seem to be corrected with approximately 20 lb S/acre, although more severe S deficiencies may require levels of S application closer to 30-35 lb S/acre. Spatial variability of S may necessitate a blanket application of 10 lb S/acre even on soils that test sufficient in S. Nitrogen requirements to obtain optimum yield of hybrid canola cultivars are higher than that of conventional canola cultivars. Once an N or S deficiency is corrected, there appears to be little need for balancing N and S application rates at any particular ratio, especially with canola hybrids. Similarly, there is no evidence of an NXP interaction; once, a P deficiency is corrected (rates of 15 to 35 lb P₂O₅/acre), optimum yields are obtained with no need of additional P.

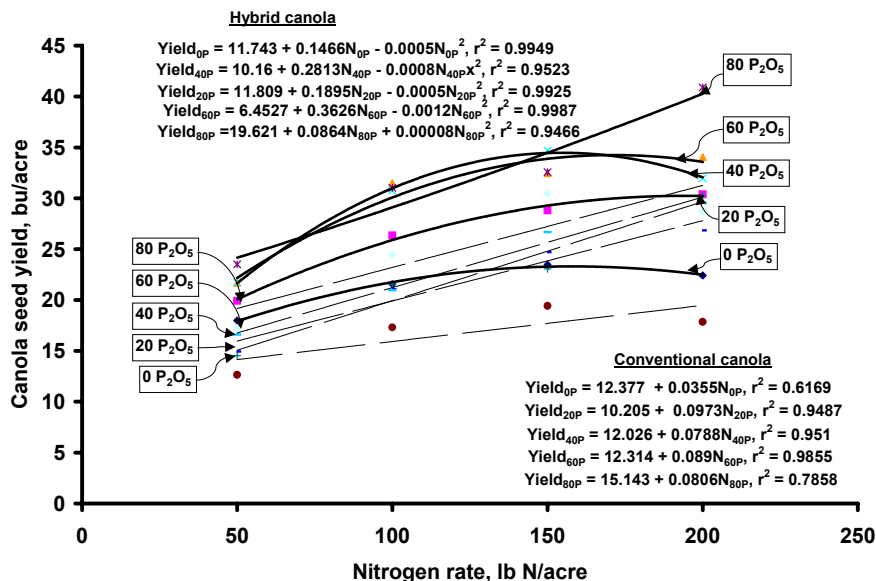


Figure 11. Comparison of overall yield obtained for canola hybrids to that of conventional canola cultivars based on applied N rates at different P₂O₅ levels (Sylvania, 2002).

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