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Management for optimum yield of open pollinated and hybrid canola

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Interim Report

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Forward

This interim report is a preliminary look at treatment effects on crop production and economic returns in a combined analyses across location and years and under different moisture conditions. Due to the scope of this research and the implications of its findings for the canola production industry more time for completion of the final report has been requested and granted by SCDC . A complete and detail final report will be submitted in March of 2003.

Introduction:

Newer O.P. and hybrid canola varieties provide higher yield potential but the management strategies necessary to achieve optimum yield are not well understood. To better understand the levels of inputs required to optimize yield and to enhance producers ability to optimize return on their investment field research trials were conducted over a three year period (1998-2001) at Melfort, Indian Head, and Scott with the following objective.

Objective: To evaluate the effect of seeding rate, fertilizer addition and fungicides on the optimum yield potential of hybrid and open pollinated canola in the Thick Black, Thin Black and Dark Brown soil zones.

In 2000 and 2001 a second N rate study was initiated at all locations to provide a broader range of N application rates with the following objective.

Objective: To determine if more N is required to maximize yield of hybrid than OP cultivars because of the higher yield potential of hybrids.

Materials and Methods:

The canola management study was established at Melfort (Thick Black), Indian Head (Thin Black) , and Scott (Dark Brown)in 1999, 2000, and 2001. The management study was lost at Melfort in 1999 as a result of damage to the growing point caused by leaching of Muster after a heavy rain. At Scott in 2000 suspected high levels of residual soil N were observed to run perpendicular across all 4 replicates of the management study resulting in abnormally high biomass and seed production. A combined analyses of results from the canola management study across years and locations was therefore confined to 2000-2001:Melfort, 1999&2001:Scott and 1999-2001:Indian Head for a total of 7 site-year locations. The inclusion of Melfort-2000 however did require adjustments for shatter loss caused by wind damage prior to threshing. An additional N rate study was conducted at each location in 2000 and 2001 to evaluate a broader range of N application rates. All 6 location years for the N rate study used in a combined analyses. Studies incorporated Quantum, representing high yielding open pollinated (OP) varieties and Invigor 2273 in 1999 and 2663 in 2000-2001 representing high yielding hybrid (HYB) varieties. Canola was direct seeded into wheat stubble using low disturbance hoe openers at Scott and knife openers at Melfort and Indian Head with on row packers. Row spacing was 8 inches at Scott, 9 inches at Melfort, and 12 inches at Indian Head. Background levels of nitrogen to 60 cm depth, phosphate to 15 cm, potassium to 15 cm and sulfur to 60 cm depth were measured each year to assist in establishing target N levels and to determine available N in the N rate study. Nitrogen was applied as urea at seeding by mid row banding at Scott and side banding at Indian Head and Melfort. A P-K-S blend was applied below the seed at Scott and beside the seed at Melfort in Indian Head. Weeds were controlled to minimize pest losses. Data collection included plant density, crop biomass and seed yield, growth staging (flowering initiation, end of flowering, 30% seed maturity) as well as percent green seed, % oil and protein (NIR). See table 11 for a more detailed summary of operations, inputs and data collection dates.

The canola management study experiment was designed as a 3 level factorial with a fungicide strip. Factors in the experiment in addition to OP and HYB cultivars included three fertility levels needed to supply 0.67, 1.0 and 1.33 X a target level and three seeding rates 2.7, 5.8 ,8.4 kg/ha. A blend of P-K-S was applied at rates that increased as N rate increased. Fertility levels were categorized as low, middle, and high with target levels specific to each location. Table 1 summarizes N (soil + fertilizer) levels on the experiment between 1999 and 2001. The fungicide strip received an application of Ronilan EG (vinclozolin) for control of sclerotinia with an added application of Quadris (azoxystrbin) at Melfort. Disease surveys were conducted prior to swathing.

Table 1. Combined soil and fertilizer nutrient levels (kg/ha) at each location for the canola management study.

	Scott				Indian Head				Melfort			
Year	1999	2000	2001	Mean	1999	2000	2001	Mean	1999	2000	2001	Mean
67 %	58	100	76	78	110	91	125	109	-	82	77	80
Target	84	111	113	103	144	127	169	147	-	121	117	119
133 %	110	123	150	128	184	163	212	186	-	161	157	159

The N rate study was designed as a factorial experiment with 6 rates of applied N; 0,30, 60, 90, 120 and 150 kg/ha. N was banded prior to seeding at Scott and side banded at Melfort and Indian Head at the time of seeding. Table 2 summarizes soil N levels prior to fertilizer N applications in 2000 and 2001. A single rate of a P-K-S blend was applied. Fungicides were applied when disease levels warranted. The target seed rate was 9 kg/ha.

Table 2. Soil N levels (kg/ha) prior to fertilizer application on the N rate study.

	Scott			Indian Head			Melfort		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Soil N (kg/ha)	74	22	48	45	30	29	68	61	65

Spring soil moisture conditions were near normal with the exception of below normal at Scott and above normal at Indian Head in 2001. Long term average May-July precipitation of 165 mm at Scott, 172 mm at Melfort and 186 mm at Indian Head yielded an overall average of 175 mm. May-July precipitation in 1999 ranged from 115% of normal at Scott to 144% of normal at Indian Head, in 2000 from 95%(Scott) to117%(Indian Head) of normal, and in 2001 39%(Indian Head) to 69%(Scott) of normal. For the seven location years used in the combined analyses of management study results overall precipitation averaged 151 mm or 86% of normal. For the 6 location years of the N rate study precipitation averaged 139 mm or 80% of normal. The growing season in 1999 and 2000 were characterized by cool temperatures with above normal temperatures recorded in 2001. The combination of near to above normal precipitation with cool temperatures in 1999 and 2000 generally resulted in lush crop canopies producing normal to above normal yields. Dry conditions in May of 2000 at Scott and Melfort and at all locations in 2001 reduced plant populations with additional plant loss occurring in the management study at Melfort in 2000 as a result of frost. Below normal precipitation and above normal temperatures in 2001 reduced biomass production that generated below normal yields.

Table 3. Monthly precipitation and mean monthly temperatures at Scott, Melfort and Indian Head.

Month	Precipitation (mm)				Temperature (Celsius)			
	1999	2000	2001	Long Term 1950-1997	1999	2000	2001	Long Term 1950-1997
Scott								
May	66	24	18	34	9.4	9.4	11	10.4
June	43	41	59	65	13.6	13.5	13.9	14.8
July	81	91	37	66	15.1	17.8	17.7	17.1
August	48	57	4	46	16.8	15.6	19	16.1
Melfort								
May	41	15	9	41	10.2	9.1	11.2	10.3
June	14	74	23	62	14	13	15.8	15.2
July	96	106	46	69	15.9	17.6	18.5	17.4
August	36	47	11	53	17	16.6	19.1	16.2
Indian Head								
May	67	68	2	50	10.4	10.1	11.4	10.8
June	116	105	29	74	14.5	13.1	14.4	15.9
July	84	46	41	62	16	18	18.1	18.5
August	88	63	13	53	16.6	16.4	18.9	17.5

Results and Discussion

1.0 Management Study Agronomic Results

Because the same weight of seed was sown for both cultivars, and the seed size for the Invigor Hybrid was greater than that of Quantum, the number of seeds sown was lower. This was the major factor affecting cultivar differences in plant density (Table 4). In general plant densities were lower for Invigor than Quantum, while the reverse occurred for percent establishment. Biomass and grain yield with the Invigor hybrid was similar or higher than Quantum at all location years, and averaged 12% higher for both. With above normal moisture during 1999, the grain yield differences between cultivars were relatively small. By contrast, 2001 was very dry at all locations, and grain yield differences between cultivars were quite large (Figure 1). This in itself may not be sufficient to conclude that hybrids (Invigor) are more drought tolerant than open pollinate (Quantum) cultivars. However it does provide strong evidence that they are at least equal and possibly more drought tolerant.

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Table 4. Plant densities, plant establishment, biomass production and grain yield of Invigor and Quantum canola at Scott, Melfort and Indian Head during 1999-2001. (Data is the mean of 3 seed rates and 3 fertility levels).

	Plant Density (#/M^2)		Percent Establishment		Biomass (t/ha)		Grain Yield (kg/ha)	
Location Year	Invigor	Quantum	Invigor	Quantum	Invigor	Quantum	Invigor	Quantum
Scott 1999	81b	139a	68	82	6.69a	5.77b	2470a	2360b
Indian Head 1999	56b	64a	45	38	11.02a	9.84b	1750	1790
Scott 2000	75a	66b	55	38	5.97	5.47	1690a	1460b
Indian Head 2000	112	107	82	61	9.45a	8.49b	2040a	1790b
Melfort 2000	19b	27a	14	15	7.27a	6.47b	2030a	1870b
Scott 2001	108b	144a	89	87	5.82a	5.37b	1350a	1200b
Indian Head 2001	41	40	34	24	6.40a	5.59	1300a	850b
Melfort 2001	45	46	37	28	6.41a	5.47b	1870a	1580b
8 Loc Yr Mean	**67b**	**79a**	**53**	**47**	**7.38a**	**6.56b**	**1810a**	**1610b**

Values followed by a different letter are significantly different at P=0.05.

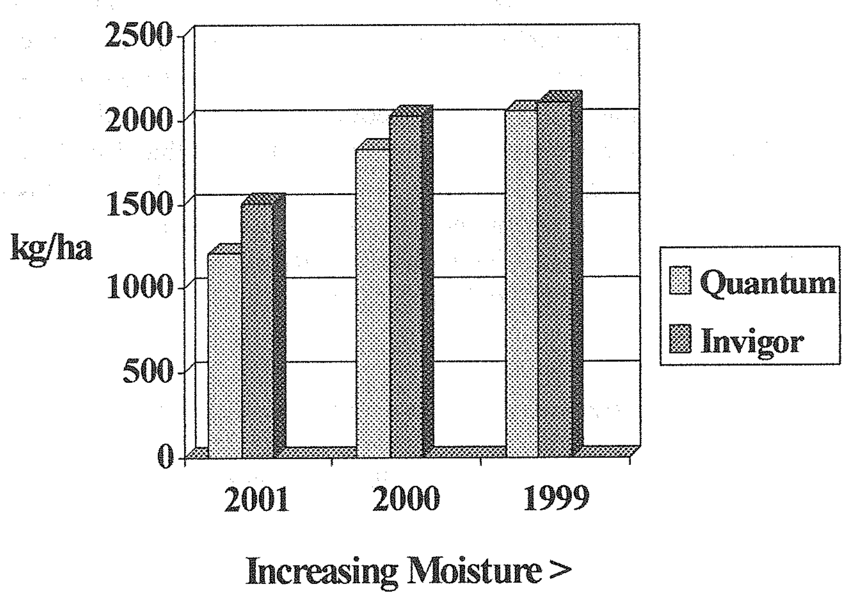

Figure 1. Impact of moisture on average yields of Quantum and Invigor (2273 in 1999 and 2663 in 2000-2001) at Scott, Melfort, and Indian Head.

There were small (generally 1-2 day) cultivar differences in time to start flowering and time to maturity, but the differences were not consistent across location years (data not shown). Disease incidence tended to be quite low for most location years, with one exception. At Melfort in 2000, sclerotinia incidence and sclerotinia induced seed loss (estimated) were higher for Invigor than for Quantum, although values for both cultivars were relatively low.

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A combined analyses of yields revealed a consistent response among the 2 cultivars to seed rate, nutrient level, and fungicide despite the HYB producing on average 865 kg/ha more biomass and 194 kg/ha more seed than OP. Fungicide treatment alone generally failed to invoke a yield response as levels of sclerotinia were low. The interaction of fungicide with fertility level was significant at P=0.05, and there was a tendency for the seed rate x fungicide interaction to be significant (P=0.055) when analysed across location years. At the low fertility level, yield was unaffected by fungicide (Table 5), while at the mid and high fertility levels, a small yield increase was noted where fungicides were applied. This suggests that enhanced growth with higher fertility likely created an environment more conducive to sclerotinia infection and development. At Scott in 1999, and at Indian Head in 2000, sclerotinia incidence and yield loss ratings did increase with increased fertility (data not shown).

Fungicide application only increased yield at the lowest seed rate (Table 6). This would suggest that the longer flowering period associated with reduced seed rates may have allowed more time for sclerotinia to affect the crop. However, sclerotinia incidence and severity ratings were similar for all seed rates (data not shown).

Increasing seed rate and increasing fertility level generally increased yield (Table 7). Higher seeding rates however did not increase biomass indicating later emerging branches created at low plant densities were less effective at converting biomass to yield than earlier emerging branches at high seeding rates. Fertility level x seed rate interactions showed yields increased as inputs increased. At the low fertility level, yield increased when seed rate was increased from 2.8 to 5.6 kg/ha, but was not increased further when seed rate increased to 8.4 kg/ha; higher fertility was required to induce a yield response to higher seed rate. Similarly, at the 2.8 kg/ha seed rate, yield was higher for the mid than low fertility but further increases in yield were not noted for the high fertility rate; responses to high fertility only occurred at the 5.6 and 8.4 kg/ha seed rates. This provided a strong indication that higher plant densities are required to take advantage of higher fertility, and vice versa. The lack of an interaction of cultivar with seed rate or fertility level provided a good indication that both cultivars require similar seed rates and fertility to optimize yield.

Table 5. Yield (kg/ha) response to fungicide treatment and increasing fertility averaged across 7 location years. (Values are means for 2 cultivars and 3 seed rates).

	Fertility Level		
Fungicide Treatment	Low	Mid	High
None	1619d	1723c	1807b
Treated	1593d	1782b	1856a
LSD (P=0.05)		39	

Values followed by a different letter are significantly different at P=0.05.

Table 6. Yield (kg/ha) response to fungicide treatment and increasing seed rate averaged across 7 location years. (Values are means for 2 cultivars and 3 fertility levels).

	Seed Rate (kg/ha)		
Fungicide Treatment	2.8	5.6	8.4
None	1558	1751c	1839a
Treated	1618d	1794c	1819ab
LSD (P=0.05)		51	

Values followed by a different letter are significantly different at P=0.05.

Table 7. Yield (kg/ha) response to increasing fertility and increasing seed rate averaged across 7 location years. (Values are means for 2 cultivars and 2 fungicide treatments).

	Seed Rate (kg/ha)		
Fertility Level	2.8	5.6	8.4
Low	1489	1673d	1654d
Mid	1616d	1773c	1868b
High	1659d	1870b	1964a
LSD (P=0.05)		51	

Values followed by a different letter are significantly different at P=0.05.

Because percent emergence varied considerably across location years, an attempt was made to identify the plant densities required to achieve adequate responses to higher fertility. In general, where plant densities were less than 45 plants/m^2 yield responses to higher fertility were 0-6% compared with the low fertility level. Where plant densities exceeded 65/m^2 yield responses to higher fertility averaged 12-18%.

1.1 N Rate Study Agronomic Results

Soil tests showed an average residual soil N to 60 cm of 53 kg/ha in 2000 and 41 kg/ha in 2001 on wheat stubble, of which 50% was assumed to be available. Harvest yields indicated 118 kg/ha of applied N was sufficient to maximize OP and HYB yields under the dry conditions of 2001 but failed to maximize yield under near normal moisture conditions in 2000 (Fig. 2). At the high N rate of 150 kg/ha of N in 2000 HYB yielded 2751 kg/ha versus 2439 kg/ha for OP. In 2001 the HYB reached a maximum yield of 1734 kg/ha compared to 1411 kg/ha for OP. Averaged over all location years yields of OP and HYB were maximized at between 136-149 kg/ha of applied N with the HYB yielding 15% more than OP(Figure 3). HYB yielded more at all levels of applied N indicating the HYB used N more efficiently to produce yield than OP. Seed production by HYB increased relative to OP as N supply increased yielding 10% more when no N was applied and 16.6 % more when 110 kg/ha of N was applied. However when averaged across years, both cultivars maximized yield at almost similar N levels with the HYB averaging 2198 kg/ha at 160 kg/ha of available N while OP averaged 1906 kg/ha at 170 kg/ha of N. The higher N use efficiency of the HYB increased yields by an average of 246 kg/ha over all N rates. These results indicate that HYB used N more efficiently and did not require higher N application rates.

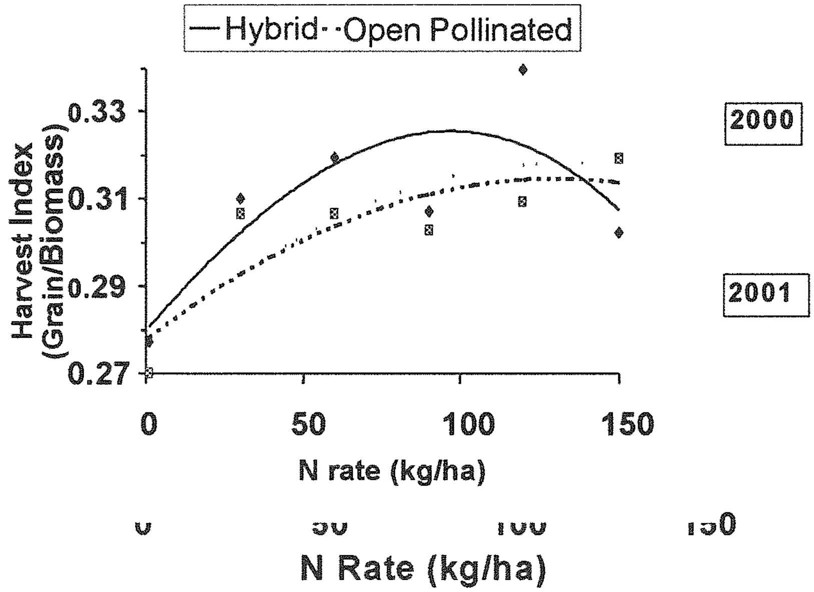
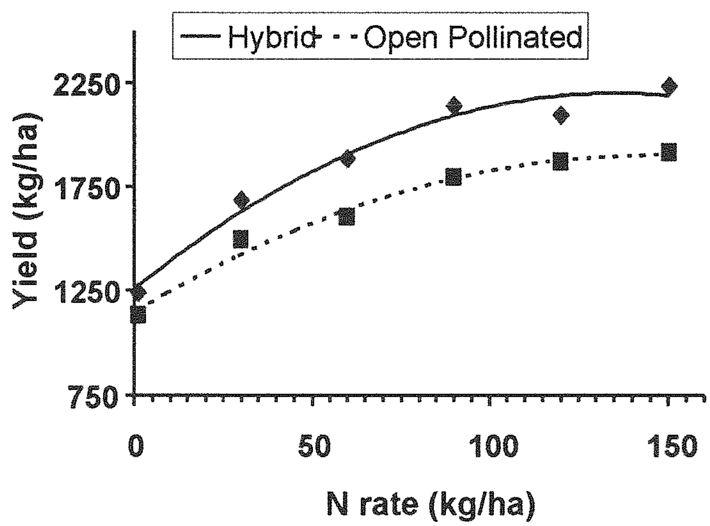


Figure 2. Yield (kg/ha) as a function of applied nitrogen under normal-above normal moisture



conditions in 2000 and below normal moisture conditions in 2001.

Figure 3. Yield (kg/ha) as a function of applied nitrogen.

Harvest index values plotted against increasing levels of applied N revealed consistently greater HYB plant growth may have resulted in the HYB consuming more soil water in May and June (Figure 4). Depleted soil water reserves when not replaced by rain reduced the water available for seed fill later in the growing season. This resulted in maximum harvest index being achieved at a lower applied N rate for the HYB than OP (94 kg/ha vs 129 kg/ha). Although this may have prevented the HYB from achieving its higher yield potential, the HYB still produced more grain per unit of biomass than the OP.

Figure 4. Harvest index as a function of applied nitrogen.

2.0 Management Study Economics / Marginal Returns

Economic analyses were performed on the data based on costs from the 2001 Crop Planner published by Saskatchewan Agriculture and Food (available on the Saskatchewan Agriculture and Food website). Table 8 outlines the actual expenses used in the analysis. Treatments were evaluated on the basis of profit probability as determined by canola price and N cost. Highest profit probability conditions existed at high canola price and low N costs ($352/tonne canola- N=$0.51/kg), intermediate at high canola price and high N cost or low canola price and low N cost ($352/tonne-N=$0.75/kg, $264/tonne-N=$0.51/kg) and low profit probability at low canola price and high N cost ($264/tonne-N=0.75/kg). Assumed seed costs for HYB were $9.35/kg for HYB and $4.40/kg for OP.

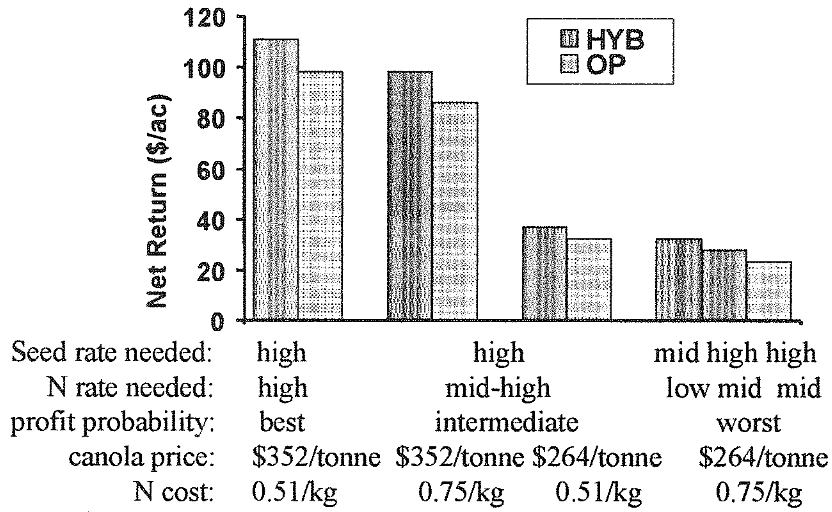
Table 8. Crop production costs ($/ha) used in economic analyses (based on 2001 Crop Planner published by Saskatchewan Agriculture and Food). [actual values are a weighted average for the Dark Brown and Black soil zones based on the number of location years of data for each soil zone].

Variable expenses ($/ha) Including chemicals, machinery operating, custom work and hired labour, crop insurance premiums, utilities and miscellaneous expenses, and interest on variable expenses, but excludes seed and fertilizer costs that varied across treatments.	129.40
Other expenses ($/ha) Including building repair, property taxes, insurance and licences, machinery depreciation, building investment, and land investment.	129.75

HYB averaged $24/ha more in net returns than OP at $264/tonne and $40/ha more at $352/tonne. Under best profit probability conditions net returns of OP and HYB were maximized at the high seed rate (8.4 kg/ha) and high fertility level ($242/ha for OP vs $272/ha for HYB). See figure 5. At intermediate profit probability levels high seed rates and moderate-high fertility levels maximized net returns from $79/ha for OP to $242/ha for HYB. Under low profit probability conditions the high seed rate in combination with moderate fertility level continued to maximize profits for OP ($58/ha) but reduced HYB net returns by $9/ha compared to mid seed rate (5.6 kg/ha) and low fertility ($79/ha). This suggests reducing inputs will lower net returns because yield is reduced. Even at the low canola price ($264/tonne) and high N cost (N=$0.75/kg) savings from reduced inputs for HYB appeared minimal compared to the potential loss should canola prices improve (Figure 5). These results, which occurred when growing season moisture averaged across location years was below normal, suggests that the full economic value of higher yielding canola cultivars can only be realized when fertilizer and seed rates are at or above the maximum recommended rate.

Figure 5. Net returns for variable seed and N rates when canola was priced from \$352-264/tonne and N costs ranged from \$0.51-0.75/kg.

Net returns were also calculated using an average canola price of \$310/tonne for each cultivar x seed rate x fertility level x fungicide treatment for each location year. In addition the returns per \$ invested and coefficients of variability of net returns for each treatment combination was determined. To



calculate an index of variability of net income, the coefficient of variability (CV)for one treatment (considered a check) was assigned a value of 1.00, and indexes for other treatments were calculated based on the magnitude of the corresponding CV relative to the check [example; if the CV for a treatment was 25% lager than for the check, the index would be 1.25].

Only selected economic data are reported here.

Not surprisingly, total costs were higher (reflecting seed costs) for the hybrid than the open pollinate variety, but the value of higher yield more than offset higher costs (Table 9), resulting in net returns that were \$34/ha higher. Net income was only 2/3 as variable for the Invigor hybrid than for Quantum (index of variability of 0.67 vs 1.00), and return per \$ invested was higher for Invigor. The reduced income variability reflected the relatively good yield performance of Invigor in 2001, the driest year at all locations. This is not surprising, and reflects that cultivars or other practices that perform well in dry years provide income stability. The effect of the hybrid in this study is somewhat unique in that many technologies that improve drought tolerance also restrict yield in years of favourable moisture. Technologies that restrict yield losses in dry years but perform well in wetter conditions are the most desirable of strategies to cope with drought and stabilize income.

Net returns were highest for the combination of high fertility and the highest seed rate (Table 10), and were generally low for the lowest seed rate, although it was low also for low fertility, high seed rate combination. Income variability was high and return per \$ invested low for the low seed rate across all fertility levels. Low seed rates increase the probability that plant populations are insufficient to make efficient use of moisture and inputs used to produce a crop. With high seed rates, it is important that fertility is adequate to ensure that the crop can optimize yield. Overall the mid to high fertility rates, combined with mid to high seed rates were favoured.

Table 9. Economic Comparison of Cultivars (means for 7 location years)[Canola @ $310/tonne].

	Invigor	**Quantum**
Total Cost ($/ha)	**400**	**373**
Gross Return ($/ha)	**563**	**502**
Net Return ($/ha)	**163**	**129**
Index of income variability*	**0.67**	**1**
Return per $ invested	**1.4**	**1.35**

***Index of income variability is a relative measure of the coefficient of variability of net income over location years where the 5.6 kg/ha seed rate with mid fertility has been assigned a value of 1.00.**

Table 10. Economic comparisons of seed and fertilizer rates.

Seed Rate (kg/ha)	**Net Returns ($/ha)**			**Index of Income Variability***			**Return per $ Invested**		
	Fertility level			Fertility level			Fertility level		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
2.8	120	132	118	1.2	1.4	1.92	1.35	1.36	1.3
5.6	154	158	161	0.96	1	1.2	1.42	1.41	1.39
8.4	130	168	172	0.98	0.95	1.05	1.39	1.42	1.4

*Index of income variability is a relative measure of the coefficient of variability of net income over location years where the 5.6 kg/ha seed rate with mid fertility has been assigned a value of 1.00.

2.2 N Rate Study Economic /Marginal Returns

An economic evaluation of the data was performed using production costs from the 2001 Saskatchewan Crop Planner published by Saskatchewan Agriculture and Food. Additional functions were added to account for assumed differences in seed costs of $9.35/kg for HYB and $4.40/kg for OP. In addition, several price scenarios for fertilizer N and for the value of canola were evaluated. When maximizing net returns, higher HYB yields translated into an additional $15.10/ha for every $50/tonne increase in the price of canola above $147/tonne (Figure 6). In general, the economic benefit of growing the HYB over OP was >Indian Head > Melfort > Scott. When adequately N fertilized, the HYB provided greater economic returns than OP at all sites. A combined analyses showed net returns were maximized for both cultivars near 112 kg/ha of applied N, when canola was priced between $220-352/tonne and N costs ranged from $0.51-0.75/kg. When results were separated on the basis of moisture availability the income advantage of the HYB was retained under below normal moisture conditions. N required to maximize returns for both cultivars however decreased as moisture decreased. At $264/tonne and N=0.75/kg, 126 kg/ha or more of applied N was required to optimize net returns in 2000 compared to 90 kg/ha under the drier conditions of 2001. These results indicate many producers are setting lower target N levels than are required to optimize returns for canola on wheat stubble even when moisture and canola prices fall short of expectations.

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These results indicate that target N levels for canola grown on wheat stubble in a moisture limited environment should be the same for a higher yielding hybrid as they are for a high yielding open pollinated variety. It also suggests that high yielding varieties should be receiving more fertilizer to maximize yield and optimize net economic return than is currently being applied by many producers.

Figure 6. Maximum net returns for applied N when canola was priced from $147-352/tonne and N cost $0.51 and $0.75/kg.
Figure 7. Impact of near normal moisture conditions in 2000 and below normal moisture in 2001 on net returns ($/ac) of hybrid and open pollinated canola at $264-352/tonne and N=0.75/kg

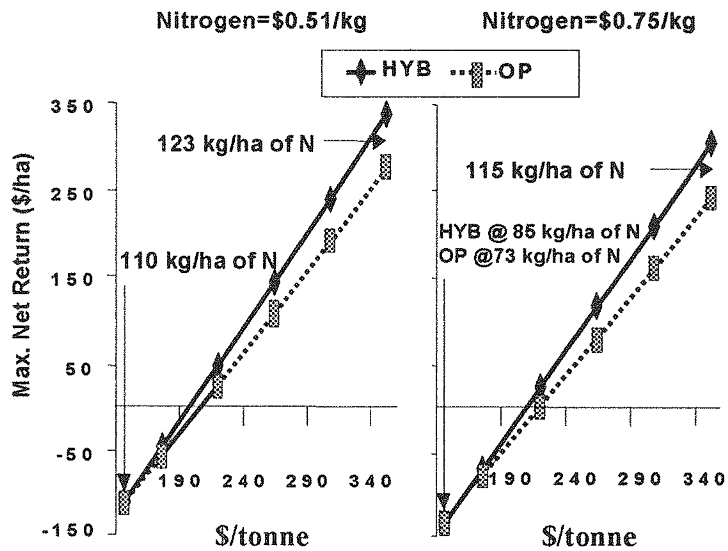
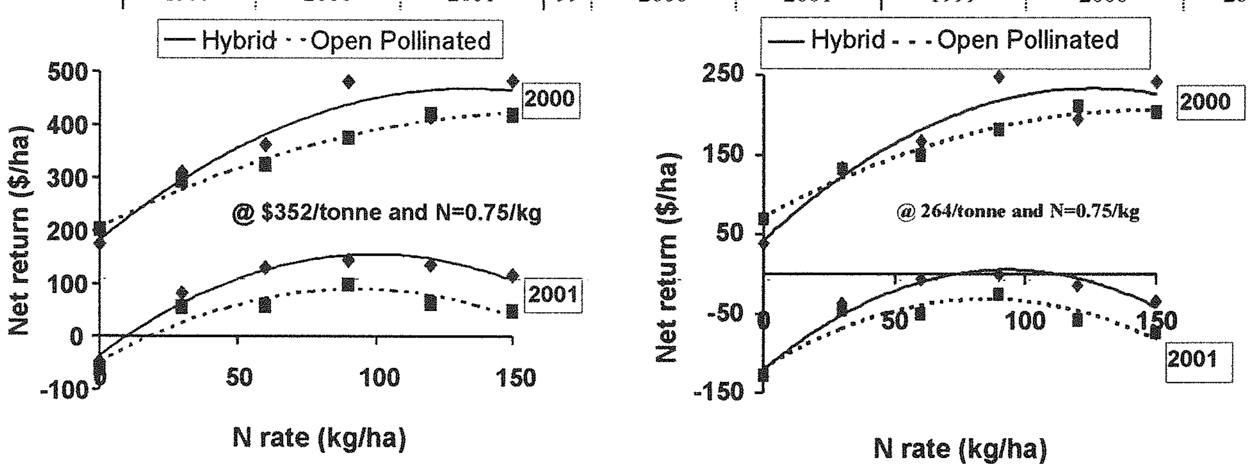


Table 11. Management and N Rate study operation, inputs, and data collection dates.



	Indian Head			Melfort			Scott		
	1999	2000	2001	99	2000	2001	1999	2000	2001
Seeding Date	May 25	May 3	May 7-8	-	May 7- 8	May 7	May 7	May 12	May 5
Swathing Date	Aug 31	Aug 15	Aug 20	-	Sept 6	Aug 15-22	Aug 20-25	Aug 18-31	Aug 9
Harvest Date	Sept 16	Aug 29	Aug 28	-	Oct 2	Sept-4	Aug 27-Se 4	Sept 13	Aug 18
Plant Counts	Jun 29	May 30		-	Jun 16	Jun 4	Jun 2	Jun 8	May 29
Biomass	Aug 25	Aug 14		-	Aug 31	Aug 15	Aug 19-20	Aug 22-24	Aug 7
Dis. Survey	Aug 24	Aug 10	Aug 15	-		Aug 17	Aug 19-23	Aug 22	Aug 7

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Canola	Quantum Invig 2473	Quantum Invig 2473	Quantum Invig 2663	-	Quantum Invigor 2663		Quantum Invigor 2273	Quantum Invigor 2663	
Soil Test Results on Management and/or N Rate study(kg/ha)									
NO_3-N 0-60cm	34.7	17/45	40/30	-	39 / 68	28/61	38	74	22
PO_4-P 0-15cm	11.2	16/22	27/36	-	21/ 60	19/54	42	55	4
K 0-15cm	571	557/571	571/571	-	570 / 605	540/456	>600	>600	-
SO_4-S 0-60cm	95	17/112	55/71	-	71 / 72	52/64	112	172	-
Fertilizer Management Study (kg/ha)									
N Placement	side band				side band		mid row band		
N target %	66 100 133	66 100 133	66 100 133		66 100 133	66 100 133	66 100 133	66 100 133	66 100 133
N	75 109 149	74 110 146	85 129 172	-	43 82 122	49 89 129	20 46 72	26 37 49	54 91 128
P_2O_5	23 34 45	22 34 45	17 25 33	-	6 19 32	6 19 32	17	11 17 23	17 23 29
K	11 17 23	11 17 23	8 13 17	-	6 19 32	6 19 32	0	11 17 23	17 23 29
S	11 17 23	11 17 23	8 13 17	-	2 6 11	2 6 11	0	4 6 8	6 8 10
Fertlizer N Rate study (kg/ha)									
N	-	0, 30, 60, 90, 120, 150		-	0, 30, 60, 90, 120, 150		-	0, 30, 60, 90, 120, 150	
P K S	-	26 13 13		-	33 33 11	33 33 11	-	33 33 11	23 23 8
Seeding Rates (kg/ha) Seed size(g/1000) 1999: Inv2273=4.5 Qtm=3.3 2000: Inv2663=4.1 Qtm=3.2 2001:Inv2663=4.6 Qtm=3.4									
Management		2.8 5.6 8.4			2.8 5.6 8.4		2.3 4.5 9	2.7 6.5 9.4	3.1 6.3 9.4
N Rate	-	9	9	-	9	9	-	9	9.4
Herbicides (Management and N Rate study) N Rate study only*									
product	edge	Edge	Edge	-	Roundup	Roundup	Liberty	Roundup	Roundup
rate:g ai/ha	1130	1350	1413	-	659	440	500	440	1758
date	Apr26	Nov22/99	Oct 17/00	-	May 7	May 10	Jun 8	May 14	May 8
product	Roundup	Roundup	Roundup	-	Poast Ultra	Poast Ultra	Poast Ultra	Poast Ultra	Poast Ultra
rate:g ai/ha	890	879	900	-	222	222	211	211	145
date	May7	May 4	May 8	-	Jun 5	Jun 12	Jun 12	Jun 13	Jun 12
product	Muster	Select*	Lontrel	-	Poast U	Muster	Muster	Lontrel	Muster
rate:g ai/ha	15	35.6*	153	-	222	15	22	151	15
date	Jun 22	May 25*	Jun 11	-	Jun 19	Jun 12	Jun 12	Jun 13	Jun 12
product	Assure	Poast Ultra		-	Muster	Lontrel			Lontrel
rate:g ai/ha	102	361		-	22	151			151
date	Jun 22	Jun 7		-	Jun 19	Jun 12			Jun 12
product		Lontrel		-		Decis			Decis
rate:g ai/ha		150		-		74			62
date		Jun 7		-		Jul 16			Jul 20
Fungicides (Management Study)									
product	Ronilan 750	Ronilan 750	Ronilan	-	Quadris	Quadris	Ronilan	Ronilan	Ronilan
rate:g ai/ha	1000	1000	400	-	125	125	500	500	500
date	Jul 22	Jul 22	Jul 13	-	Jun 28	Jun 11	Jun 29	Jul 7	Jul 5
product						-	Ronilan	Ronilan	
rate:g ai/ha						-	494	494	
date						-	Jul 14	Jul 3	
Seeder	Conserva-Pak - 12" row spacing							Conserva-Pak - 9" row spacing	

SK-24

MANAGEMENT OF HIGH YIELDING CANOLA CULTIVARS

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ABSTRACT

Yield potential of new canola varieties is much higher than older ones, raising questions about whether current management recommendations are adequate to ensure optimum yield. One question that arises is whether such varieties require greater inputs of fertilizer nutrients, particularly nitrogen (N), to realize optimum economic returns. We initiated a three level factorial experiment to investigate the impact of 3 seeding rates, 3 target fertility levels and a fungicide application at 3 locations over 3 years on productivity of high yielding open pollinated [OP] and hybrid [HYB]canola cultivars. We initiated a second experiment to evaluate whether the same 2 cultivars differed in their response to fertilizer N, and conducted it at the same locations during 2000 and 2001. A combined analysis of yields from the seed rate x fertility x fungicide study revealed a consistent response among the 2 cultivars to seed rate, nutrient level, and fungicide despite the HYB producing on average 200 kg ha^{-1} greater grain yield than the OP cultivar. The HYB yield advantage tended to be greater as moisture declined. Fungicide generally failed to increase yield. Yields generally increased with increasing fertility level and increased seed rate. However yield responses to high fertility occurred only with high seed rates, and vice versa [significant seed rate x fertility rate interaction]. This suggests that the full benefit of higher fertility was only realized when adequate plant populations were present. Net returns based on costs from the 2001 Saskatchewan Crop Planner (Sask. Ag. and Food) were evaluated. HYB averaged \$27 ha^{-1} more than OP at \$310 $tonne^{-1}$ and was higher at all canola prices above \$150 $tonne^{-1}$. In the N rate study where residual soil N to 60 cm depth averaged 47 kg ha^{-1}, yields were maximized at between 135 and 148 kg ha^{-1} of applied N. HYB yielded 10% more than OP with zero fertilizer N, increasing with N rate to 17% higher with 100 or more kg ha^{-1} of applied N. These results indicate that HYB used N more efficiently and did not require higher N application rates to optimize yield. Net returns were maximized for both cultivars near 115 kg ha^{-1} of applied N when canola was priced between \$220 and 350 $tonne^{-1}$ and N at \$0.50- 0.75 $tonne^{-1}$. When adequately N fertilized, greater N use efficiency of the HYB provided greater yields and greater economic returns than OP at all sites despite a higher seed cost. These results indicate that target N levels for canola grown on wheat stubble in moisture limited environments should be the same for a higher yielding hybrid as they are for a high yielding open pollinated variety. It also suggests that high yielding varieties should be receiving more fertilizer to maximize yield and optimize net economic return than is currently being applied by many producers. These results, which occurred when growing season moisture averaged across location years was below normal, suggest that the full economic value of higher yielding canola cultivars can only be realized when fertilizer and seed rates are at or above the maximum recommended rates.

INTRODUCTION

Newer open pollinated and hybrid canola varieties provide higher yield potential but management strategies necessary to achieve optimum yield are not well understood. Nutrients, particularly nitrogen [N] frequently restrict yield of canola [Nuttall et al 1987], and it is reasonable to expect that higher fertilizer application rates would be required to support higher yields possible with such cultivars. However, this has not been tested to date, thus little is known about how higher yields may impact optimum fertilizer rates. Seed of new varieties is several times more expensive than older ones, so seed rates are seen as a possible area for cutting costs. Optimum plant populations for canola vary from 40-200 plants M^{-2}, and percent emergence can be quite variable (Thomas 2002). It is possible that the characteristics that lead to higher yield may also give these cultivars greater capacity to compensate for low plant densities. However, experience with corn hybrids suggests that greater rather than lower plant populations are needed to optimize production with high yield hybrid cultivars [Metcalf and Elkins 1980]. To better understand the levels of inputs required to optimize yield and to enhance producers ability to optimize return on their investment, field research trials were conducted over a three-year period (1998-2001) at Melfort, Indian Head, and Scott representing areas with typically the most to least favorable growing conditions in the traditional canola production area of Saskatchewan. Objectives of the studies were to evaluate whether combinations of fungicides, seed rates and fertility levels needed to be altered, and whether increased rates of fertilizer N would be required to optimize yield of newer higher yielding varieties.

MATERIALS AND METHODS

Studies were conducted at Melfort (clay), Indian Head (heavy clay), and Scott (loam). Background levels of nitrogen, phosphate, potassium and sulfur depth were measured each year to establish residual soil fertility. Canola was direct seeded into wheat stubble using low disturbance openers with on row packers. Nitrogen was applied as urea at seeding by mid row banding at Scott and side banding at Indian Head and Melfort. A P-K-S blend was applied below the seed at Scott and beside the seed at Melfort and Indian Head. Weeds were controlled to minimize pest losses. Data collection included plant density, crop biomass and seed yield, growth staging (flowering initiation, end of flowering, 30% seed maturity) as well as percent green seed, % oil and protein.

The canola management study was designed as a 3 level factorial with a fungicide strip. Factors in the experiment were 2 cultivars, 3 N fertility levels to supply 0.67, 1.0 and 1.33 X a target level of fertility and 3 seeding rates of 2.7, 5.8, 8.4 kg ha^{-1}. Quantum was selected to represent a high yielding open pollinated (OP) cultivar, and Invigor 2273 in 1999 and Invigor 2663 in 2000-2001 representing high yielding hybrid (HYB) cultivars. A blend of P-K-S was applied at rates that increased as N rate increased. The fungicide strip received an application of Ronilan EG (vinclozolin) for control of *sclerotinia* with an added application of Quadris (azoxystobin) at Melfort. Background levels of nitrogen to 60 cm depth, phosphate to 15 cm, potassium to 15 cm and sulfur to 60 cm depth were measured each year to establish residual soil fertility. Residual soil N varied from 20 to 60 kg ha^{-1} depending on location and year. The management study was lost at Melfort in 1999 and at Scott in 2000.

The N rate study was designed as a factorial experiment with 6 rates of applied N; 0, 30, 60, 90, 120 and 150 kg ha^{-1} as urea and the same OP and HYB cultivars. Residual soil N varied from 25 to 75 kg ha^{-1}. A single rate of P-K-S blend was applied, and the seed rate was 7 kg/ha.

Spring soil moisture conditions were near normal except at Scott [below] and Indian Head [above] in 2001. Long term average May-July precipitation of 165 mm at Scott, 172 mm at Melfort and 186 mm at Indian Head yielded an overall average of 175 mm. May-July precipitation in 1999 ranged from 115% of normal at Scott to 144% of normal at Indian Head, in 2000 from 95%(Scott) to117%(Indian Head) of normal, and in 2001 39%(Indian Head) to 69%(Scott) of normal. For the seven location years used in the combined analyses of management study results overall precipitation averaged 151 mm or 86% of normal. For the 6 location years of the N rate study precipitation averaged 139 mm or 80% of normal.

Economic analyses were performed on the data based on costs from the 2001 Crop Planner published by Saskatchewan Agriculture and Food (available on the Saskatchewan Agriculture and Food website). Variable expenses excluding seed and fertilizer costs and fixed costs were roughly equal at $129 ha^{-1} [Table 3]. Seed costs for HYB were $9.35 kg^{-1} for HYB and $4.40 kg^{-1} for OP. Net returns were calculated using an average canola price of $310/tonne for each cultivar x seed rate x fertility level x fungicide treatment for each location year. In addition the returns per $ invested and coefficients of variability of net returns for each treatment combination was determined. To calculate an index of variability of net income, the coefficient of variability (CV) for one treatment (considered a check) was assigned a value of 1.00, and indexes for other treatments were calculated based on the magnitude of the corresponding CV relative to the check [example; if the CV for a treatment was 25% larger than for the check, the index would be 1.25]. Only selected economic data are reported here.

Table 1. Crop production costs ($/ha) used in economic analyses (based on 2001 Crop Planner published by Saskatchewan Agriculture and Food).

Variable expenses ($/ha) Including chemicals, machinery operating, custom work and hired labour, crop insurance premiums, utilities and miscellaneous expenses, and interest on variable expenses, but excludes seed and fertilizer costs that varied across treatments.	129.40
Other expenses ($/ha) Including building repair, property taxes, insurance and licences, machinery depreciation, building investment, and land investment.	129.75

RESULTS AND DISCUSSION

The 2 cultivars responded consistently to seed rate, nutrient level, and fungicide across all location years, despite the HYB producing greater seed yield than OP. Because the same weight of seed was sown for both cultivars, and the seed size for the HYB was greater than that of OP [by an average 40%], the number of seeds sown was lower. This was the major factor affecting cultivar differences in plant density (Table 2), with generally lower densities for HYB than OP, while the reverse occurred for percent establishment. Biomass and grain yield with the HYB was similar or higher than OP at all location years, and averaged 12% higher for both. With above normal moisture during 1999, grain yield differences between cultivars were relatively small. By contrast, 2001 was very dry at all locations, and grain yield differences between cultivars were quite large (Figure 1). This in itself may not be sufficient to conclude that hybrids (Invigor) are more drought tolerant than open pollinated (Quantum) cultivars. However, it does provide good evidence that they do not require more available moisture to express a yield advantage, and possibly are more drought tolerant.

The response to fungicide was very small but did increase as fertility level increased, and tended also to be greater where low seed rates were used [data not shown]. This would suggest that the longer flowering period associated with higher fertility and/or reduced seed rates may have allowed more time for *sclerotinia* to affect the crop.

Increasing seed rate and increasing fertility level generally increased yield (Table 3). However, at the low fertility level, yield increased when seed rate was increased from 2.8 to 5.6 kg ha^{-1}, with no further increase at 8.4 kg ha^{-1}. Higher fertility was required to increase yield at the highest seed rate. Similarly, at 2.8 kg ha^{-1} seed rate, yield was higher for the mid than low fertility but further increases in yield were not noted for the high fertility rate; responses to high fertility only occurred at the 5.6 and 8.4 kg ha^{-1} seed rates. This provides a strong indication that higher plant densities are required to take advantage of higher fertility, and vice versa. The lack of an interaction of cultivar with seed rate or fertility level suggests that both cultivars require similar seed rates and fertility to optimize yield.

Because percent emergence was variable across location years, we attempted to identify plant densities required to achieve adequate responses to higher fertility. In general, where plant densities were less than 45 plants m^{-2} yields with high fertility was 0-6% greater than with low fertility. Where plant densities exceeded $65m^{-2}$ yield responses to higher fertility averaged 12-18%.

In the N rate trial, the interaction of cultivar with location-year and N rate was significant. The general trend for HYB to yield as much or more than OP at all N rates and for yield to increase with N rate up to an optimal rate held for almost all location years, except where yield for OP was greater than HYB at the 60 kg ha^{-1} N rate at Indian Head in 2000. Under dry conditions in 2001, yield of both cultivars was maximized with 118 kg/ha of applied N (Figure 2), but was not maximized even with the highest N rate under near normal moisture conditions in 2000. Averaged over all location and years, yield of the HYB was maximized at 2198 kg/ha with134 kg/ha of fertilizer N. The yield of the OP variety was maximized 1906 kg/ha with 149 kg/ha of fertilizer N. HYB yielded more at all levels of applied N indicating that it used N more efficiently than the OP variety. The relative difference in yield between the 2 cultivars increased as N supply increased, yielding 10% more when no N was applied and 16.6 % more when 110 kg/ha of N was applied.

Table 2. Plant densities, plant establishment, biomass production and grain yield of Invigor and Quantum canola at Scott, Melfort and Indian Head during 1999-2001. (Data is the mean of 3 seed rates and 3 fertility levels).

	Plant density (#/M^2)		Percent establishment		Biomass (t/ha)		Grain yield (kg/ha)	
Location (year)	Invigor	Quantum	Invigor	Quantum	Invigor	Quantum	Invigor	Quantum
Scott (1999)	81b	139a	68	82	6.69a	5.77b	2470a	2360b
Indian He (1999)	56b	64a	45	38	11.02a	9.84b	1750	1790
Scott (2000)	75a	66b	55	38	5.97	5.47	1690a	1460b
Indian Head (2000)	112	107	82	61	9.45a	8.49b	2040a	1790b
Melfort (2000)	19b	27a	14	15	7.27a	6.47b	2030a	1870b
Scott (2001)	108b	144a	89	87	5.82a	5.37b	1350a	1200b
Indian Head (2001)	41	40	34	24	6.40a	5.59	1300a	850b
Melfort (2001)	45	46	37	28	6.41a	5.47b	1870a	1580b
8 Loc Yr Mean	**67b**	**79a**	**53**	**47**	**7.38a**	**6.56b**	**1810a**	**1610b**

Values followed by a different letter are significantly different at P=0.5.

Table 3 Yield with 3 fertility and 3 seed rates
Averaged across 7 location years.
(Means for 2 cultivars and 2 fungicide treatments)

Fertility level	Seed rate (kg ha^{-1})		
	2.8	5.6	8.4
Low	1489e	1673d	1654d
Mid	1616d	1773c	1868b
High	1659d	1870b	1964a

Values followed by a different letter are significantly different at P=0.05.

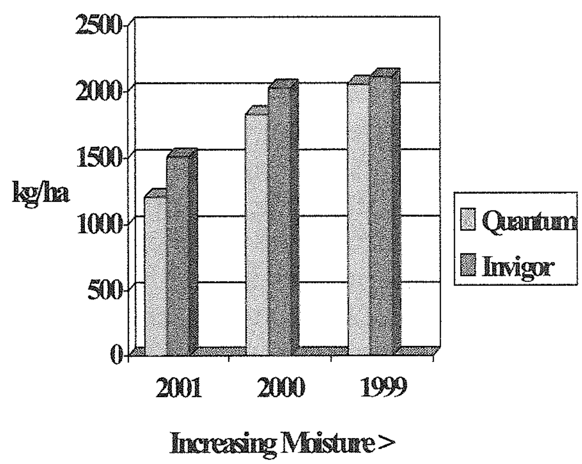

Figure 1. Impact of moisture on yields of Quantum and Invigor canola averaged for Scott, Melfort, and Indian Head SK.

Oil concentration averaged 47.9% for Invigor 2663, and 46.3% for Quantum, and protein concentration was slightly higher for Invigor 2663 than Quantum [24.4 vs 24.1%], but the trend was less consistent than for oil. However, because Invigor 2663 was consistently higher yielding, protein yield was consistently higher. Increasing the N application rate consistently increased protein concentration protein yield and oil yield while decreasing oil percentage (data not shown). At N rates above 90 kg ha^{-1}, oil yield showed very little added response, but protein yield continued to increase. There was a clear trend green seed to increase with N rate [from 0.25% at the lowest rate to 1.10 % at the highest N rate]. This could increase the risk of downgrading, but the threshold for the top grade is 2% greens.

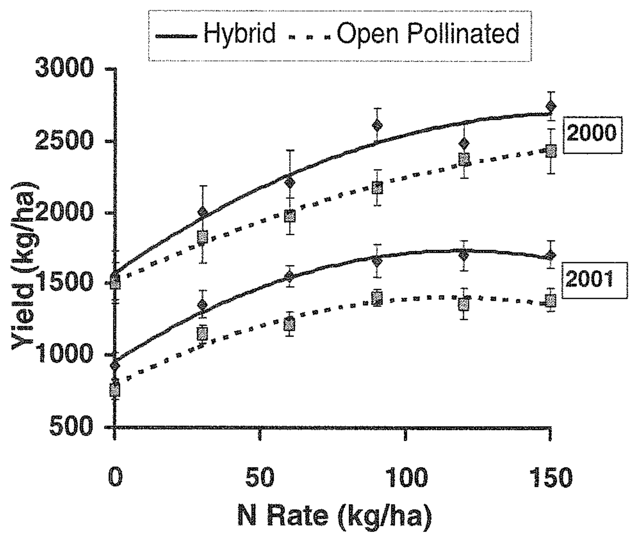

Figure 2. Yield (kg/ha) as a function of applied nitrogen under normal to above normal moisture conditions in 2000 and below normal moisture conditions in 2001.

Not surprisingly, total costs were higher (reflecting higher seed costs) for the HYB than the OP variety, but were more than offset by the value of greater yield (Table 4). Net income was only 2/3 as variable for Invigor than for Quantum, and return per $ invested was higher for Invigor. The reduced income variability reflected the relatively good yield performance of Invigor in 2001, the driest year, and reflects that cultivars or other practices that perform well in dry years provide income stability. Technologies that restrict yield losses in dry years but perform well in wetter conditions are the most desirable of strategies to cope with drought and stabilize income.

Table 4. Economic Comparison of Cultivars (means for 7 location years)[Canola @ $310/tonne].

	Invigor	Quantum
Total cost ($/ha)	400	373
Gross return ($/ha)	563	502
Net return ($/ha)	163	129
Index of income variability*	0.67	1.00
Return per $ invested	1.40	1.35

*Index of income variability is a relative measure of the coefficient of variability of net income over location years where Quantum has been assigned a value of 1.00.

Net returns were highest for the combination of high fertility and the highest seed rate (Table 5), and were generally quite low for the lowest seed rate, or for the low fertility- high seed rate combination. Income variability was high and return per $ invested low for the low seed rate across all fertility levels. Low seed rates increase the probability that plant populations are insufficient to make efficient use of moisture and inputs used to produce a crop. With high seed rates, it is important that fertility is adequate to ensure that the crop can optimize yield. Overall the mid to high fertility rates, combined with mid to high seed rates were favoured.

Table 5. Economic comparisons of seed and fertilizer rates.

Seed rate (kg/ha)	Net returns ($/ha)			Index of income variability*			Return per $ Invested		
	Fertility level			Fertility level			Fertility level		
	Low	Mid	High	Low	Mid	High	Low	Mid	H
2.8	120	132	118	1.20	1.40	1.92	1.35	1.36	1
5.6	154	158	161	0.96	1.00	1.20	1.42	1.41	1
8.4	130	168	172	0.98	0.95	1.05	1.39	1.42	1

*Index of income variability is a relative measure of the coefficient of variability of net income over location years where the 5.6 kg/ha seed rate with mid fertility has been assigned a value of 1.00

When maximizing net returns, higher HYB yields translated into an additional $15.10/ha for every $50/tonne increase in the price of canola above $147/ tonne (Figure 3). In general, the economic benefit of growing the HYB over OP was >Indian Head > Melfort > Scott. When adequately N fertilized, the HYB provided greater economic returns than OP at all sites. A combined analysis showed net returns were maximized for both cultivars near 112 kg ha^{-1} of applied N, when canola was priced between $220-352/tonne and N costs ranged from $0.51-0.75/kg.

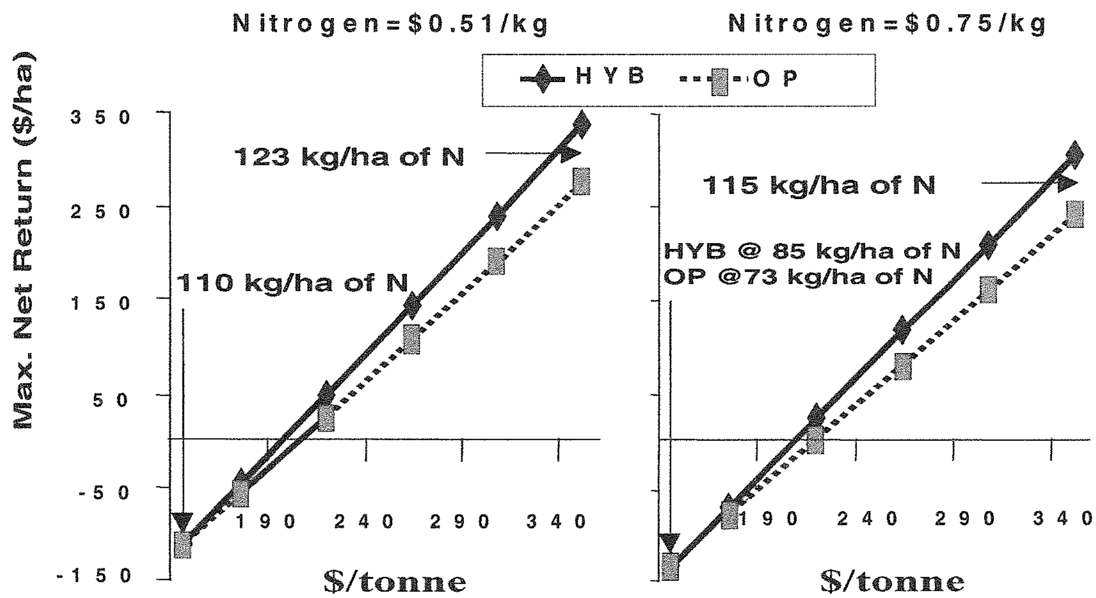

Figure 3. Maximum net returns for applied N when canola was priced from $147-352/tonne and N cost $0.51 and $0.75/kg

When results were separated on the basis of moisture availability (Figure 4) the income advantage of the HYB was retained under below normal moisture conditions. For both cultivars N required to maximize returns decreased as moisture decreased. At $264/tonne for canola and N=0.75/kg, 126 kg/ha or more of applied N was required to optimize net returns in 2000 compared to 90 kg ha^{-1} under the drier conditions of 2001. However, conventional soil test recommendations suggested that the optimum N rate for these sites with normal moisture in 2000 should be 73 kg ha^{-1} for conventional OP canola, and 93 for a high yielding HYB. For 2001 the respective recommended N rates for below normal moisture conditions were 37 and 53 kg ha^{-1} for OP and HYB canola. These results suggest that current recommendations for N may be too low to optimize returns with this crop. Results also suggest that N rates should be similar for both OP and HYB canola varieties.

The result is that many producers may be setting target N levels that are lower than required to optimize returns for canola even when canola prices are low and conditions are dry. While this data raises questions about current recommendations, rates need to be evaluated over a broader range of conditions to provide a basis for revisions to the recommendations. Any studies undertaken to address the issue should involve higher N rates used in this study, since we were unable to maximize yield in all situations with the rates used.

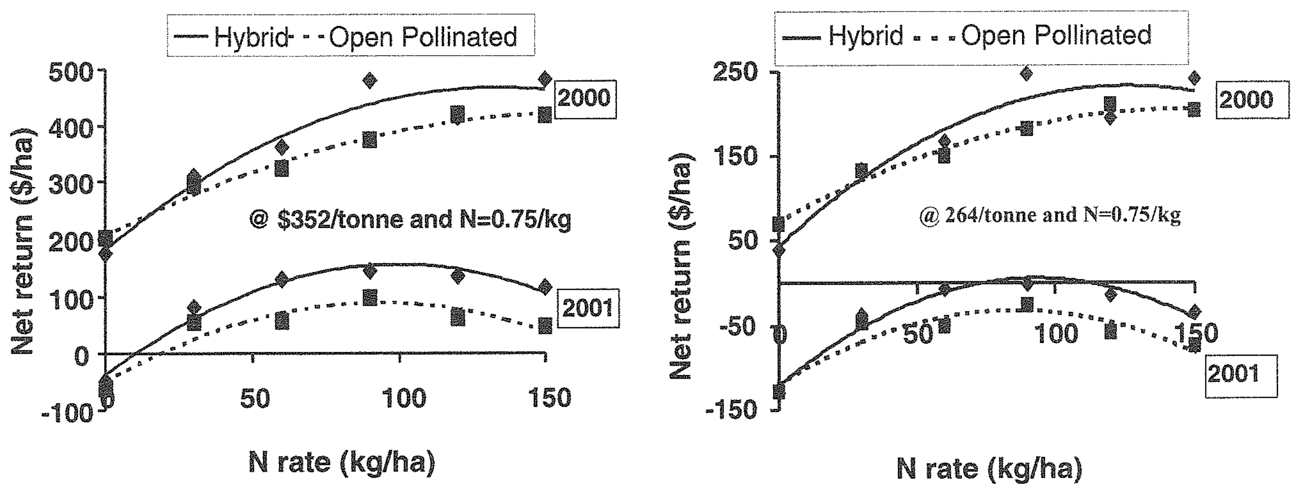

Figure 4. Impact of near normal moisture conditions in 2000 and below normal moisture in 2001 on net return ($/ac) of hybrid and open pollinated canola at $264-$352/tonne and N=0.7/kg.

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