# 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 ($/ha)<br>Including chemicals, machinery operating, custom work and hired labour, crop insurance premiums, utilities and miscellaneous expenses, and interest on variable expenses, but excludes seed and fertilizer costs that varied across treatments. | 129.40 |
| Other expenses ($/ha)<br>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%.

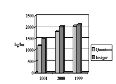
In the N rate trial, the interaction of cultivar with location-year and N rate was significant. The general trend for HYB to yield as much or more than OP at all N rates and for yield to increase with N rate up to an optimal rate held for almost all location years, except where yield for OP was greater 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.

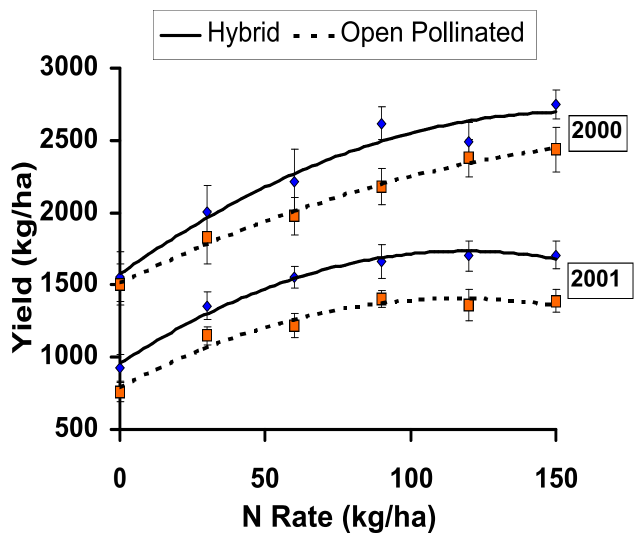



Figure 2. Yield (kg/ha) as a function of applied nitrogen under normal to above normal moisture conditions in 2000 and below normal moisture conditions in 2001.

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.

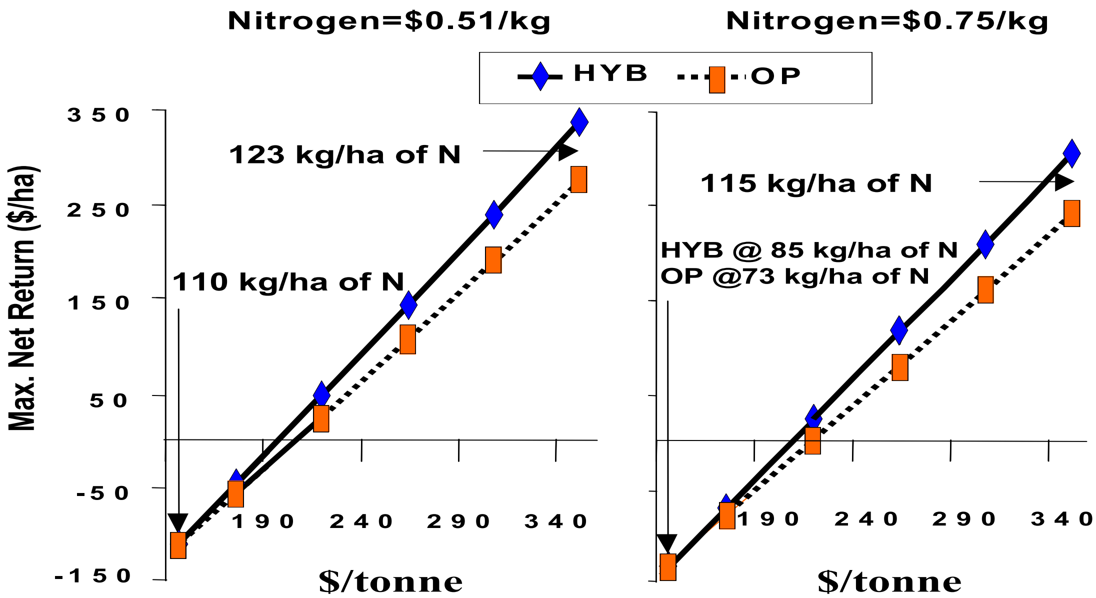



Figure 3. Maximum net returns for applied N when canola was priced from $147-352/tonne and N cost $0.51 and $0.75/kg

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.

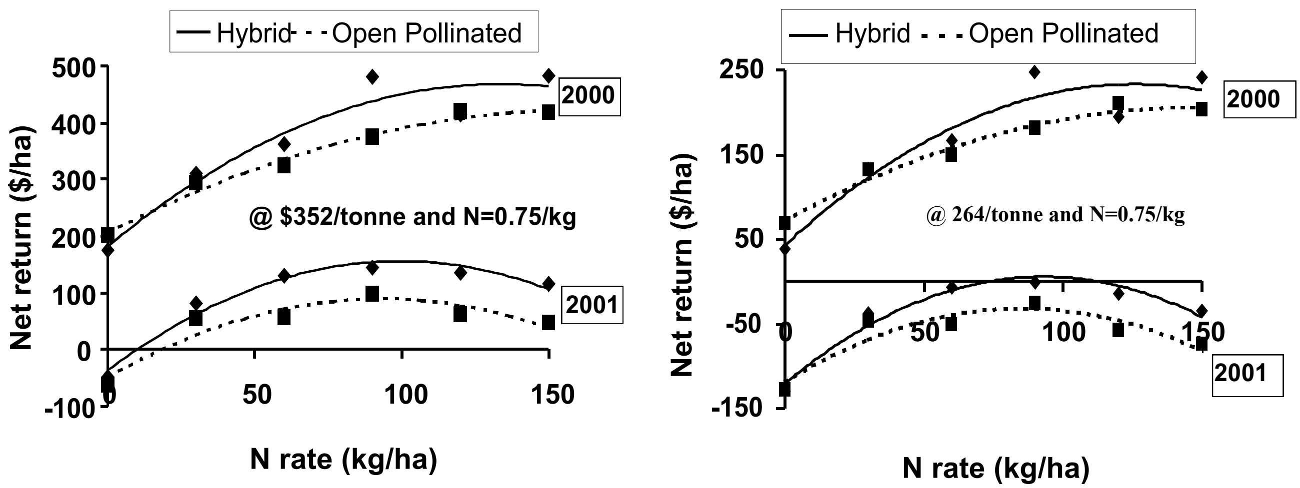



Figure 4. Impact of near normal moisture conditions in 2000 and below normal moisture in 2001 on net return ($/ac) of hybrid and open pollinated canola at $264-$352/tonne and N=0.7/kg.

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