Management for Optimum Yield of Open Pollinated and Hybrid Canola

S. Brandt, D. Ulrich, G. Lafond[*] ,S. Mahli** and A.M. Johnston[†]

Scott Research Farm, P.O. Box 10, Highway 374 Scott, SK S0K 4A0
*Indian Head Research Farm, Box 760, Indian Head, SK S0G 2K0
** Melfort Research Farm, Highway 6 South Melfort, SK S0E 1A0
[†] Potash and Phosphate Institute of Canada, Suite 704, CN Tower, Midtown Plaza
Saskatoon, SK S7K 1J5

Introduction

Newer open pollinated (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 a three year study was conducted at Melfort, Indian Head, and Scott during 1999, 2000 and 2001 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.

Materials and Methods

Field experiments were established at Melfort (thick Black), Indian Head (thin Black), and Scott (Dark Brown) in 1999, 2000, and 2001. The experiment at Melfort was lost in 1999 as a result of damage to the growing point caused by leaching of Muster after a heavy rain. The weed control strategy at all sites was too optimize yield production and as a result was similar. 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), although the crop quality data is not reported here. See Table 1 for a more detailed summary of operations, inputs and data collection dates.

The experiment was designed as a 3 level factorial with fungicide treatment as a split plot. Factors in the experiment included 2 canola cultivars (Invigor hybrid and Quantum open pollinated variety) three fertility levels of 67%, 100% and 133% of a target fertility level and three seeding rates of 2.8, 5.6 ,8.4 kg/ha. Fertility rates were categorized as low, middle and high. At Scott nitrogen as urea (46-0-0) was mid row banded using a Versatile hoe drill with a 8" row spacing. At Indian Head and Melfort urea was side banded with row spacings of 12" and 9" respectively. At all three locations a blend of P-K-S was applied; below the seed at Scott and beside the seed at Melfort and Indian Head at three different rates that increased as N rate increased (Table 2). Additional details are provided in Table 1.

The fungicide strip received an application of Ronilan EG (vinclozolin) for control of sclerotinia. A disease survey was conducted prior to swathing.

At Scott suspected high levels of residual soil N in 2000 were observed to run perpendicular across all 4 replicates of the experiment resulting in high biomass and seed production. To ensure only treatment effects were contained in the data set, results from affected plots were deleted. To facilitate a combined site-year-location analysis, the results from Scott in 2000 were not used.

Despite below normal spring precipitation at Scott and Melfort in 2000 and at all locations in 2001, soil moisture reserves or timely rains ensured adequate crop stands for all site-year-locations. At Melfort in 2000 plant stands were reduced substantially due to frost. The 1999 and 2000 growing seasons were characterized by cool temperatures with normal to above normal precipitation (Table 3) resulting in lush crop canopies and normal to above normal yields. In contrast, 2001 was characterized by above normal temperatures and below normal precipitation resulting in below normal yields.

Table 1. Field operation, inputs, and data collection dates for canola management study.

	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
Soil Test Results (kg/ha)									
NO_3-N 0-60cm	34.7	17	40	-	39	28	38	74	22
PO_4-P 0-15cm	11.2	16	27	-	21	19	42	55	4
K 0-15cm	571	557	571	-	570	540	>600	>600	-
SO_4-S 0-60cm	95	17	55	-	71	52	112	172	-
Fertilizer Nutrient application rates (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
Seeding Rates (kg/ha) Seed size(g/1000) 1999: Inv2273=4.7 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
Herbicides									
#1 product	edge	Edge	Edge	-	Roundup	Roundup	Liberty	Roundup	Roundup
#1 rate:g ai/ha	1130	1350	1413	-	659	440	500	440	1758
#1 date	Apr26	Nov22/99	Oct 17/00	-	May 7	May 10	Jun 8	May 14	May 8
#2 product	Roundup	Roundup	Roundup	-	Poast Ultra	Poast Ultra	Poast Ultra	Poast Ultra	Poast Ultra
#2 rate:g ai/ha	890	879	900	-	222	222	211	211	145
#2 date	May 7	May 4	May 8	-	Jun 5	Jun 12	Jun 12	Jun 13	Jun 12
#3 product	Muster		Lontrel	-	Poast U	Muster	Muster	Lontrel	Muster
#3 rate:g ai/ha	15		153	-	222	15	22	151	15
#3 date	Jun 22		Jun 11	-	Jun 19	Jun 12	Jun 12	Jun 13	Jun 12
#4 product	Assure	Poast Ultra		-	Muster	Lontrel			Lontrel
#4 rate:g ai/ha	102	361		-	22	151			151
#4 date	Jun 22	Jun 7		-	Jun 19	Jun 12			Jun 12
#5 product		Lontrel		-		Decis			Decis
#5 rate:g ai/ha		150		-		74			62
#5 date		Jun 7		-		Jul 16			Jul 20
Fungicides									
#1 product	Ronilan 750	Ronilan 750	Ronilan	-			Ronilan	Ronilan	Ronilan
#1 rate:g ai/ha	1000	1000	400	-			500	500	500
#1 date	Jul 22	Jul 22	Jul 13	-			Jun 29	Jul 7	Jul 5
#2 product				-	Ronilan	Ronilan			
#2 rate:g ai/ha				-	494	494			
#2 date				-	7Jul 14	7Jul 3			
Seeder	Conserva-Pak - 12" row spacing			Conserva-Pak - 9" row spacing			Versatile hoe drill - 8" row spacing		

(Note:deleted quadris as was a non issue. Qudris was not included in economic analyses)

Table 2. Combined soil and fertilizer nutrient levels at each location for the canola management study(kg/ha).

	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

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	46a	41	62	16	18	18.1	18.5
August	88	63	13	53	16.6	16.4	18.9	17.5

Results and Discussion

Agronomic Responses

Because the same weight of seed was sown for both cultivars, the number of seeds sown was lower due to larger seed size for the Invigor Hybrid than for Quantum. 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 differences for percent establishment were inconsistent. Biomass and grain yield with the Invigor hybrid was similar or higher than Quantum at all location years, and averaged 12% higher for both biomass and seed yield. 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. 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.

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 between cultivars are significantly different at P=0.05.

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.

Fungicide treatment alone did not affect yield, but 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), and there was a significant interaction of seed rate with fertility level. 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	1558e	1751c	1839a
Treated	1618d	1794bc	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	1489e	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%.

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. Because seed costs and fertilizer costs varied between treatments, the actual costs associated with each treatment were used, based on seed costs of $ 9.35/kg for Invigor seed and $4.40/kg for Quantum seed, $0.51 /kg for N, $0.57/kg for P205, $0.18 /kg for K and $0.44/kg for S. Several canola prices were investigated, and the analysis reported here is based on a canola price of $310/tonne.

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

Net returns were calculated 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.

Conclusions

Invigor hybrids increased yield and net income over the open pollinated cultivar Quantum. In addition, yield and net income were stabilized, and return on investment was increased.

Ensuring adequate plant populations is an important component of optimizing inputs, and reducing variability of yield and income. To achieve this, seed rates should be at or slightly above current recommendations.

Where plant populations are adequate, fertility should be at or above current recommendations.