Evaluating the Agronomic and Economic Value of High Quality Canola Seed

Final Report

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Saskatchewan Canola Development Commission

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Executive Summary

The effect of seeding date and swathing time on the canola seed vigour was investigated at 5 locations (Scott, Saskatoon, Loon Lake, Melfort, and Indian Head) over two years (2003-04). Two separate field experiments were conducted. In the 2004 experiment, different seedlots of LG3455 canola were produced at Scott in 2003 by seeding at three seeding dates (May 6, May 20, June 3) and swathing at 4 different times or straight combining. The seed produced from these treatments were then evaluated by a standard germination test as well as other germination and vigour tests (accelerated aging, controlled deterioration, and electrical conductivity) developed at the Saskatoon Research Center. The performance of the seedlots was also evaluated in field studies conducted at the five locations (nine site-years). In the 2003 study, canola seedlots of Ebony were produced in Melfort in 2000-01 at different seeding dates and swathing times. The seedlots were subjected to the same germination tests and field evaluations (six site-years) as the 2004 study. The objective of this study was two-fold: to evaluate the effect of seed production practices on canola seed performance, and to assess the ability of germination and vigour tests to predict the field performance of canola seedlots.

In the 2004 study, both seeding date and swathing time had an effect on canola seedlot performance. Seedlots that were seeded prior to May 20 resulted in higher seedling establishment, canola biomass, and seed yield compared to seedlots that were seeded on June 3. Also, seedlots that were swathed with less than 20% seed moisture content resulted in higher seedling establishment and seed yield as well.

In the 2003 study, swathing time had the largest impact on seedlot performance with swathing at moisture contents greater than 35 to 45% having a negative effect, particularly in growing seasons when environmental conditions were stressful. Seedlots that were produced in 2000 performed better than seedlots produced in 2001, where mean air temperatures were above average, and precipitation was below average.

Germination / vigour test results were highly correlated with field performance, indicating that tests developed at the Saskatoon Research Center are a good indicator of relative performance of canola seedlots. Measuring seedling weight in the lab provided the highest correlations; however, most seed laboratories do not want to grow seedlings and measure weight due to labour requirements. Therefore, a relatively simple seed vigour index was developed (germination percentage after 7 days/100 X thousand seed weight (g) which was highly correlated with seedlot performance in the field.

Seed growers should try to seed their canola in early to mid-May to produce high vigour seed. Delaying swathing somewhat later than commercially grown canola also results in higher vigour seed.

Objectives:

The objectives of this study were:

1) to evaluate the effect of seed production practices (seeding date, swathing time) on canola seed performance;
2) to assess the ability of laboratory seed germination and vigour tests to predict the field performance of canola seedlots.

2004 Study
Materials and Methods

Seedlots of canola (*cv.* LG3455) were produced at the Scott Research Farm in 2003 by seeding at three seeding dates (May 6, May 20, and June 3) and swathing at 5 different stages (Table 1). The growing season in which the seedlots were grown were characterized by above-normal air temperatures in August and below-normal precipitation in May and June (Table 2).

The seedlots were characterized by thousand kernel weight and green seed content (Table 1). The seedlots were subjected to three laboratory tests: the standard germination test, the accelerated aging test, and the controlled deterioration test. The seed was also subjected to an electrical conductivity test.

The seedlots were seeded in a randomized complete block design at eight sites in Saskatchewan in 2004. The sites were Scott (dark brown soil zone), Loon Lake (grey soil zone), Saskatoon (conventional till seeded early) (dark brown soil zone), Saskatoon (conventional till seeded late) (dark brown soil zone), Saskatoon (minimum till seeded early) (dark brown soil zone), Saskatoon (minimum till seeded late) (dark brown soil zone), Melfort (thick black soil zone) and Indian Head (thin black soil zone). The Scott and Loon Lake sites were seeded on tilled fallow, the Melfort site on tilled stubble and Indian Head was direct seeded into standing cereal stubble. Four tests were conducted at Saskatoon; two were conducted under conventional till (seeded early and late); the other two were under minimum till (seeded early and late).

The plots were seeded at a rate of 200 seeds per 6 meters of row (33 seeds/ m row). Seed was treated with Helix Extra prior to seeding. Plot size varied by site. Fertilizer nutrients were applied according to soil test recommendations.

Seeding dates at the sites were:

Loon Lake – May 13, 2004
Scott – June 2, 2004
Melfort – May 27, 2004
Indian Head – May 14, 2004
Saskatoon (Minimum Till early) – May 11, 2004
Saskatoon (Minimum Till late) – May 26, 2004
Saskatoon (Conventional Till early) – May 12, 2004
Saskatoon (Conventional Till late) – May 27, 2004

Weed control was accomplished with glyphosate applied at recommended rates and timing.

Data collection included seedling emergence counts at 14, 21, and 28 days after seeding, canola seedling fresh weight at 14, 21, and 28 days after seeding, and canola seed yield. Canola seedling fresh weight was determined by randomly collecting 10 canola plants per plot and weighing immediately.

Both laboratory and field results were subjected to analysis of variance using PROC GLM in SAS. Sites were considered a random effect for the field data and only a combined analysis is presented.

Results and Discussion

Laboratory results

The ANOVA for the standard germination test, the accelerated aging test, and the controlled deterioration test are shown in Table 3, while means are presented in Table 4. ANOVA indicated that both seeding date and swathing time had a significant effect on % germination and seedling weight. The first two seeding dates produced seed with 6-7% higher germination than late seeded canola in all three germination tests (Table 4). The earliest swathing dates resulted in seed with 3 to 6% lower germination, depending on the type of germination test (Table 4).

There were two seedlots that would not meet the No. 1 certified seed standards of 90% germination within 7 days (Table 4). Both of these seedlots were produced from the latest seeding date.

Seeding date and swathing time also had a significant effect on the weight of seedlings produced by the three tests. Although there was seeding date X swathing time interactions, generally there was a relationship between seedling weight and thousand kernel weight (Fig. 1). The weight of the seedlings produced in the accelerated aging test showed a very strong relationship with thousand kernel weight (Figure 1).

Field results

<u>Seedling emergence</u>

Seeding date and swathing time had a significant effect on canola seedling emergence at 14, 21, and 28 days after seeding (Table 5). At all evaluation timings, the seed derived from the latest seeding date resulted in approximately 15 % lower seedling numbers than the seed derived from the early seeding dates (Table 6). The seed derived from the earliest swathing times resulted in approximately 30% lower seedling numbers than the later swathing dates or the straight combined canola (Table 6). This was consistent for all evaluation timings.

There was a seeding date X swathing time interaction for canola seedlings when evaluated at 14 and 21 days after seeding (Table 5). All swathing dates resulted in statistically lower canola seedlings than the straight combined canola at the May 20 seeding date (Fig. 2). At the May 6 and June 3 seeding date, only the first swathing date resulted in statistically lower canola seedlings. The seed derived from the combination of early swathing and late seeding resulted in the lowest number of canola seedlings (Fig. 2).

<u>Seedling fresh weight (g/plant) and total canola biomass (g/m row)</u>

Seedling date had a significant effect on canola seedling fresh weight (g/plant) 14 days after seeding, but not at 21 and 28 DAS (Table 5). The canola seed derived from the latest seeding date resulted in a 10% reduction in seedling fresh weight compared to the first two seeding dates (data not shown). The seed derived from the earliest swathing dates resulted in the lowest canola seedling fresh weight at all evaluation timings (Table 7)

Total canola biomass was calculated by multiplying fresh weight per seedling by seedling emergence. Both seeding date and swathing time had an effect on total canola biomass (g/m row) production (Table 5). Seed derived from late seeding resulted in the lowest total canola biomass produced at 14, 21, and 28 DAS (Table 8). As well, seed derived from the earliest swathing dates resulted in the lowest total biomass at all evaluation dates (Table 8). At the 14 and 21 DAS evaluation timing, canola seed derived from the SW2 timing also produced statistically lower total canola biomass than did the straight combining treatment.

Canola seed yield

Seed derived from the May 6 seeding date resulted in 5% higher yields than seed derived from the June 3 seeding date (Table 8). Seed derived from the earliest swathing yielded 12% lower than seed derived from later swathing dates (Table 8). There was a seeding date by swathing time interaction (Table 5), but its significance is of little consequence. Seed derived from SW2 at the May 20 seeding date was statistically lower than seed derived from the SW4 swathing time (Fig. 2). Seed derived from the SW2 swathing time was not statistically lower yielding at the other seeding dates (Fig. 2).

There was a strong relationship between thousand kernel weight and canola seed yield. A second-order polynomial equation was used to fit the relationship (Figure 4). Ninety-one percent of the variability in canola seed yield could be explained by thousand kernel weight.

Correlation between germination / vigour tests and field performance

The controlled deterioration and the accelerated aging germination tests were slightly higher correlated with seedling emergence, seedling fresh weight, total biomass, and canola yield than the standard germination test (Table 9). Seedling weights obtained from the three tests were more highly correlated with seedling emergence, seedling fresh weight, total biomass and canola yield than was % germination. Therefore, measuring canola seedling weight in addition to germination percentage appears to be beneficial in predicting relative performance of canola seed weights.

In addition, a seed vigour index was calculated using the following formula:

(germination percentage / 100) X thousand kernel weight (grams).

The seed vigour index provided very high correlations with canola emergence, seedling fresh weight, total biomass, and canola yield (Table 9). This is a very simple method for predicting relative canola seedlot performance.

The adjusted electrical conductivity test also had a high negative correlation with canola performance indicators (Table 10). The correlations between the adjusted electrical conductivity test and seedling emergence were consistent across all evaluation timings.

Seed vigour index was also a high predictor of canola seed yield (Fig. 5). Ninety-two percent of the variability in canola seed yield could be explained by thousand kernel weight by fitting a second-order polynomial regression line.

Conclusions

Canola seeded prior to May 20 and swathing at less than 20% seed moisture content produced the best performing seedlots. The seed vigour index, derived from germination tests developed at the Saskatoon Research Center, provided a good predictor of the performance of canola seedlots grown under different soil types, tillage practices, seeding dates, and growing conditions.

Table 1. Seeding dates, swathing times and attributes of LG3455 Argentine seed lots produced at Scott in 2003.

Seeding date	Swathing time	Moisture content (%)	Seed Lot	1000-seed weight (g)	% green seed
May 6	SW1	60	1	2.06	3.7
	SW2	20	2	2.74	1.2
	SW3	10	3	2.81	1.0
	SW4	10	4	3.07	0.3
	SC	10	5	3.00	1.2
May 20	SW1	75	6	2.04	4.2
	SW2	55	7	2.38	2.5
	SW3	20	8	2.69	0.8
	SW4	20	9	2.95	1.7
	SC	10	10	2.98	1.8
June 3	SW1	60	11	1.67	7.2
	SW2	20	12	2.27	11.8
	SW3	15	13	2.52	9.0
	SW4	10	14	2.56	7.3
	SC	10	15	2.45	7.3

SC - straight combined.

Table 2: Monthly mean air temperatures and precipitation - 2003 and long-term averages. Scott Research Farm.

Mean Monthly Air Temperatures (°C), Scott							
Year	April	May	June	July	August	Sept.	Mean
2003	4.4	10.7	14.5	17.8	19.8	10.3	12.9
1911-2003 Means	3.1	10.2	14.5	17.1	16.2	10.4	11.9
Monthly Precipitation (mm), Scott							
	April	May	June	July	August	Sept.	Total
2003	24.1	21.8	34.0	66.0	43.8	43.8	233.5
1911-2003 Means	22.5	35.7	60.7	61.4	44.0	31.2	255.0

Table 3: ANOVA of fixed effects for germination and seedling dry weight of seed lots from Standard Germination Test, Accelerated Aging Test, and the Controlled Deterioration Test. 2004

	SGT			CDT			AAT		
	5 days	7 days	Seedling Weight	5 days	7 days	Seedling Weight	5 days	7 days	Seedling Weight
Seed Date (SD)	***	***	***	***	***	***	***	***	***
Swathing Time (ST)	**	**	***	***	***	***	***	***	***
SD X ST	NS	*	***	NS	NS	**	*	*	***

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

Table 4: Performance of Argentine canola seedlots in the standard germination test (SGT), accelerated aging test (AAT), and the controlled deterioration test (CDT). 2004

		SGT			CDT			AAT		
Seeding Date	Swathing Time	5 days	7 days	Seedling wt.(g)	5 days	7 days	Seedling wt.(g)	5 days	7 days	Seedling wt.(g)
6-May	SW1	96.0	96.5	0.0736	91.5	92.5	0.0664	94.5	95.0	0.0738
	SW2	96.0	98.5	0.0931	98.5	99.0	0.0869	99.0	99.0	0.0799
	SW3	95.5	97.5	0.0975	97.5	98.5	0.0861	98.5	98.0	0.0852
	SW4	94.0	96.0	0.0866	97.0	98.5	0.0944	98.5	97.0	0.0918
	SC	97.5	98.5	0.0967	98.5	98.5	0.0914	98.5	98.0	0.0928
20-May	SW1	94.5	95.0	0.0589	91.5	93.5	0.0584	95.5	96.0	0.0698
	SW2	95.5	96.0	0.0779	95.5	96.5	0.0700	97.0	97.0	0.0713
	SW3	95.0	95.0	0.0830	98.0	98.5	0.0847	99.0	99.0	0.0955
	SW4	96.0	98.0	0.0975	97.0	97.5	0.0860	97.5	97.5	0.0886
	SC	98.0	98.0	0.0893	97.5	98.0	0.0863	99.5	99.5	0.0877
3-Jun	SW1	87.0	88.5	0.0514	86.5	88.0	0.0492	87.0	88.5	0.0528
	SW2	93.5	94.5	0.0655	92.0	94.0	0.0686	95.0	95.0	0.0693
	SW3	94.5	94.5	0.0680	89.0	90.0	0.0673	95.0	95.0	0.0674
	SW4	88.0	88.5	0.0655	90.0	90.5	0.0713	89.0	89.0	0.0691
	SC	91.5	92.5	0.0694	87.5	98.0	0.0660	88.0	88.5	0.0667
	$LSD_{0.05}$	**NS**	**2.4**	**0.0074**	**NS**	**NS**	**0.0061**	**3.6**	**3.4**	**0.0068**

Factor Means	SGT			CDT			AAT		
Seeding Date	5 days	7 days	Seedling wt.(g)	5 days	7 days	Seedling wt.(g)	5 days	7 days	Seedling wt.(g)
6-May	95.8	97.4	0.0895	96.6	97.4	0.0850	97.8	97.6	0.0847
20-May	95.8	96.4	0.0813	95.9	96.8	0.0771	97.7	97.8	0.0826
3-Jun	91.0	91.7	0.0639	89.0	90.3	0.0645	90.8	91.2	0.0650
$LSD_{0.05}$	**1.7**	**1.5**	**0.0033**	**2.0**	**1.6**	**0.0027**	**1.6**	**1.5**	**0.0031**
Swathing Time									
SW1	92.7	93.3	0.0613	89.8	91.3	0.0580	92.3	93.2	0.0655
SW2	95.0	96.3	0.0788	95.3	96.5	0.0752	97.0	97.0	0.0735
SW3	95.0	95.7	0.0829	94.8	95.7	0.0794	97.5	97.3	0.0827
SW4	92.7	94.2	0.0832	94.7	95.5	0.0839	95.0	94.7	0.0831
SC	95.7	96.3	0.0851	94.5	95.2	0.0813	95.3	95.5	0.0824
$LSD_{0.05}$	**2.2**	**1.9**	**0.0043**	**2.6**	**2.1**	**0.0035**	**2.1**	**1.9**	**0.0040**

Table 5 : ANOVA of fixed effects for performance of canola seedlots derived from different seeding and swathing dates at nine site-years in Saskatchewan, 2004.

	Seedling emergence(#/m-row)			Canola Fresh Weight (g/plant)			Total Canola Biomass (g/m-row)			Seed
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	Yield
Seed Date (SD)	***	***	***	**	NS	NS	**	*	*	*
Swathing Time (ST)	***	***	***	***	**	**	***	***	***	***
SD X ST	***	**	NS	NS	NS	NS	NS	NS	NS	*

Table 6: Effect of canola seed derived from various seeding dates and swathing times on emergence of canola seedlings. Mean of nine site-years in Saskatchewan. 2004.

Seeding Date	Canola seedlings (#/m row) 14 DAS	Canola seedlings (#/m row) 21 DAS	Canola seedlings (#/m row) 28 DAS
6-May	20	21	21
20-May	20	20	21
3-Jun	17	18	18
$LSD_{0.05}$	**1.4**	**1.2**	**1.1**
Swathing Time			
SW1	15	15	16
SW2	18	19	20
SW3	20	21	21
SW4	20	21	21
SC	20	21	21
$LSD_{0.05}$	**1.0**	**1.0**	**1.0**

Table 7: Effect of canola seed derived from different swathing dates on canola fresh weight (g/plant) 14, 21, and 28 DAS. Means of nine site-years in Saskatchewan. 2004.

Swathing Time	Canola Fresh Wt. (g/plant) 14 DAS	Canola Fresh Wt. (g/plant) 21 DAS	Canola Fresh Wt. (g/plant) 28 DAS
SW1	0.048	0.253	1.149
SW2	0.061	0.317	1.281
SW3	0.068	0.362	1.469
SW4	0.068	0.365	1.383
SC	0.070	0.359	1.400
$LSD_{0.05}$	**0.008**	**0.056**	**0.176**

Table 8: Effect of canola seed derived from different seeding dates and swathing times on total canola biomass production (g/ m-row) and canola seed yield . Mean of nine site-years in Saskatchewan. 2004.

Seeding Date	Total canola biomass (g/m-row) 14 DAS	Total canola biomass (g/m-row) 21 DAS	Total canola biomass (g/m-row) 28 DAS	Canola Yield (kg/ha)
6-May	1.39	6.90	29.37	2147
20-May	1.33	7.18	28.23	2108
3-Jun	0.99	4.91	22.59	2053
$LSD_{0.05}$	**0.20**	**1.70**	**5.04**	**65**
Swathing Time				
SW1	0.73	3.91	18.46	1922
SW2	1.21	5.89	25.62	2119
SW3	1.41	7.16	30.32	2164
SW4	1.39	7.27	29.17	2178
SC	1.44	7.43	30.08	2128
$LSD_{0.05}$	**0.22**	**1.46**	**5.24**	**94**

Table 9: Correlations between initial seed attributes and performance of Argentine seed lots at nine site-years in Saskatchewan. 2004.

	Seedling emergence			Canola Fresh weight (g/plant)			Total Canola Biomass (g/m-row)			Yield
Seed attribute	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	
SGT - 5 days	0.65**	0.68**	0.70**	0.48	0.50	0.43	0.48	0.50	0.60*	0.51
- 7days	0.65**	0.68**	0.70**	0.49	0.53*	0.45	0.49	0.53*	0.62*	0.54*
seedling weight	0.83***	0.84***	0.86***	0.79***	0.78***	0.64**	0.79***	0.78***	0.81***	0.77***
vigour index	0.90***	0.93***	0.94***	0.92***	0.91***	0.78***	0.92***	0.91***	0.92***	0.86***
CDT - 5 days	0.79***	0.80***	0.81***	0.67**	0.70**	0.55*	0.81***	0.79***	0.74**	0.64*
- 7 days	0.76***	0.77***	0.78***	0.61*	0.67**	0.50	0.71***	0.76***	0.70**	0.61*
seedling weight	0.89***	0.89***	0.91***	0.85***	0.87***	0.75**	0.93***	0.89***	0.88***	0.83***
vigour index	0.88***	0.91***	0.93***	0.90***	0.91***	0.75**	0.95***	0.92***	0.89***	0.84***
AAT - 5days	0.74**	0.76**	0.77***	0.56**	0.63*	0.52*	0.71**	0.73**	0.70**	0.58*
- 7days	0.70**	0.72**	0.73**	0.50**	0.58*	0.47	0.66**	0.69**	0.66**	0.52*
seedling weight	0.84***	0.86***	0.86***	0.76**	0.79***	0.69**	0.86***	0.85***	0.83***	0.71***
vigour index	0.91***	0.95***	0.94***	0.89***	0.92***	0.76***	0.95***	0.94***	0.91***	0.84***

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

Table 10: Correlations between electrical conductivity and adjusted electrical conductivity and performance of Argentine canola seed lots at nine site-years in Saskatchewan 2004.

	Seedling emergence			Canola Fresh weight (g/plant)			Total Canola Biomass (g/m-row)			Yield
Seed attribute	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	
EC - 4 hours	-0.62*	-0.66**	-0.65**	-0.58*	-0.65**	-0.47	-0.70**	-0.75**	-0.66**	-0.43
- 24 hours	-0.52*	-0.54*	-0.53*	-0.43	-0.52*	-0.39	-0.59*	-0.64**	-0.56*	-0.30
AEC - 4 hours	-0.82***	-0.85***	-0.86***	-0.81***	-0.85***	-0.67***	-0.89***	-0.90***	-0.83***	-0.70**
- 24 hours	-0.83***	-0.85***	-0.86***	-0.80***	-0.84***	-0.68***	-0.90***	-0.90***	-0.69**	-0.69**

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

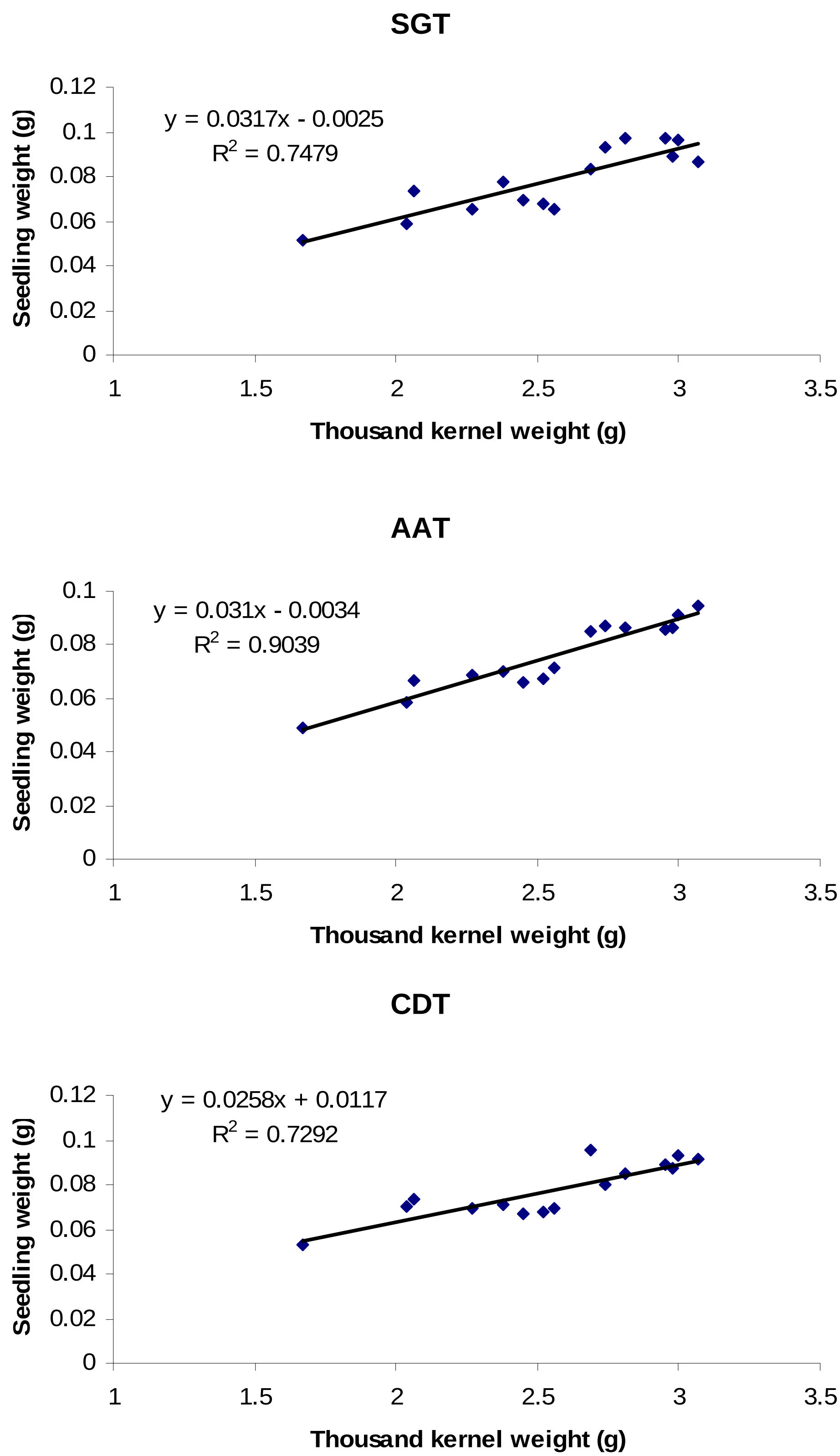

Figure 1: Relationship between seedling weight (g) and thousand kernel weight when seed was subjected to a standard germination test (SGT), the accelerated aging test (AAT), and the controlled deterioration test (CDT).

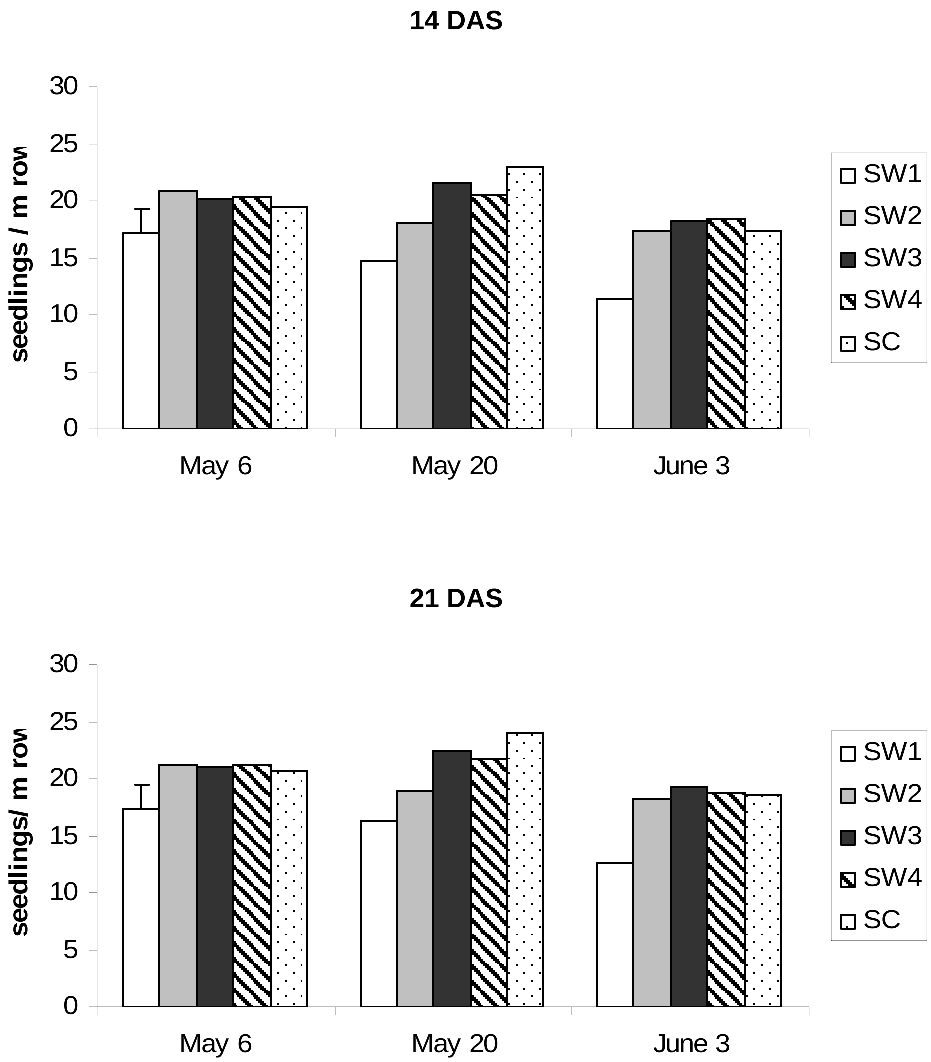

Figure 2: Effect of canola seed derived from different seeding dates and swathing times on canola seedling emergence at 14 and 21 DAS. Mean of nine site-years, Saskatchewan. 2004. Bar represents the $LSD_{0.05}$ for the seeding date X swathing time interaction.

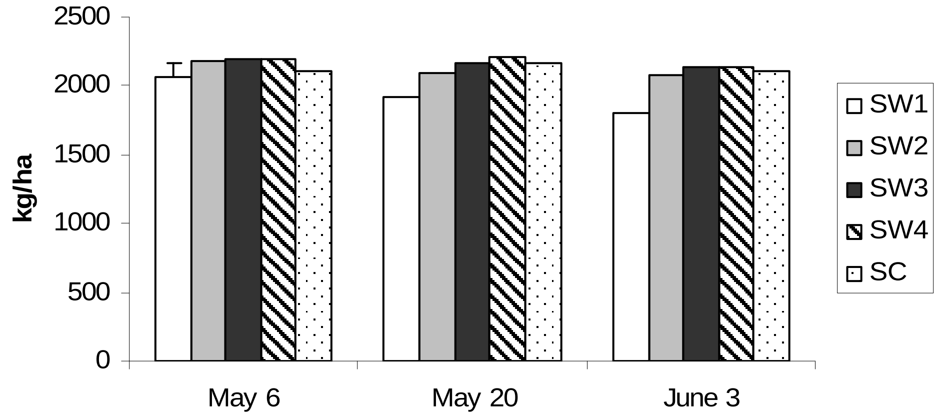

Figure 3: Effect of canola seed derived from different seeding dates and swathing times on canola yield. Mean of eight locations in Saskatoon. Mean of nine site-years, Saskatchewan. 2004. Bar represents the $LSD_{0.05}$ for the seeding date X swathing time interaction**.**

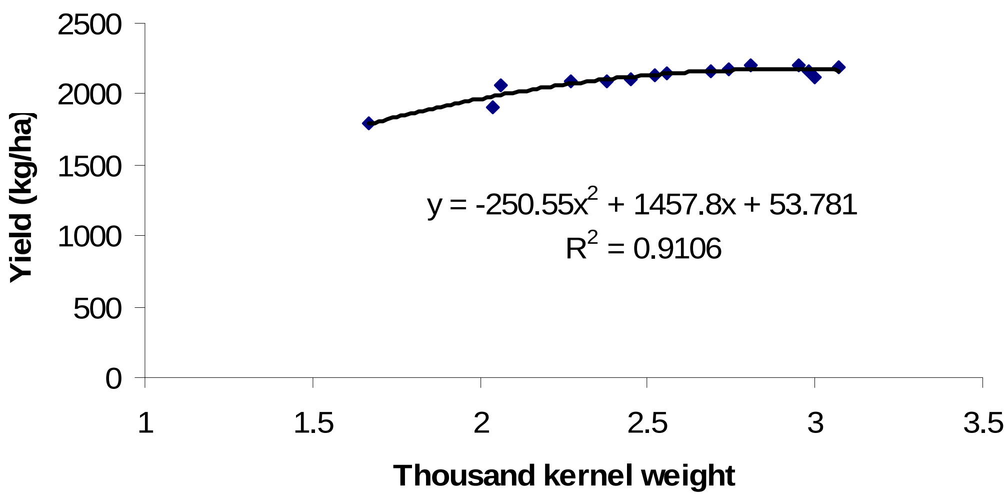

Figure 4: Relationship between canola seed thousand kernel weight and final seed yield. Mean of nine site-years. Saskatchewan. 2004.

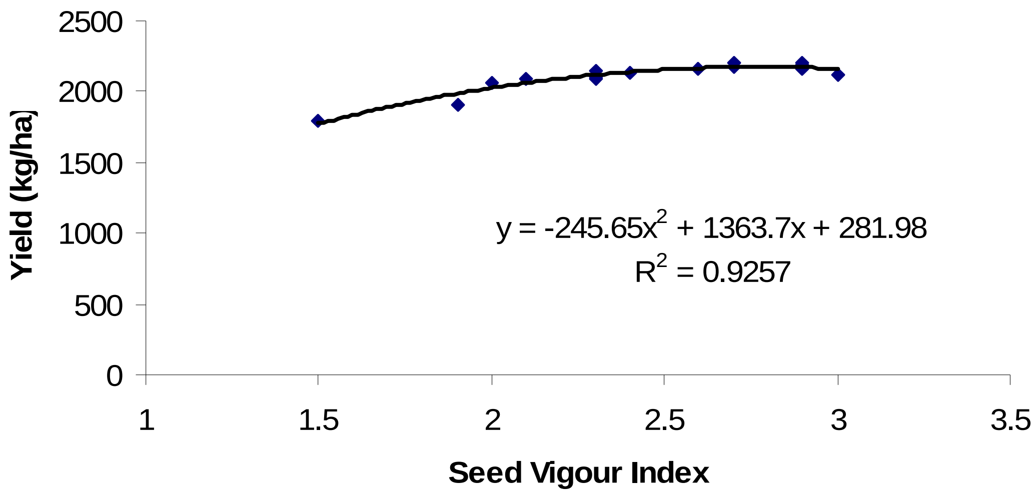

Figure 5: Relationship between seed vigour index and canola seed yield. Mean of nine site-years. Saskatchewan. 2004.

2003 Study

Materials and Methods

In 2000 and 2001, Cecil Vera from the Melfort Research Farm evaluated the effect of seeding date and swathing time on canola production. Sixteen seedlots (*cv.* Ebony) produced from the treatments were retained and used in this trial. Details on the seeding dates and swathing treatments are listed in Table 1.

The seedlots were characterized by thousand kernel weight and green seed content (Table 2). The seedlots were then subjected to three laboratory tests: the standard germination test, the accelerated aging test, and the controlled deterioration test. The seed was also subjected to an electrical conductivity test.

The seedlots were seeded in a randomized complete block design at six sites in 2003. The sites were Scott (dark brown soil zone), Loon Lake (grey soil zone), Saskatoon (conventional till) (dark brown soil zone), Saskatoon (minimum till) (dark brown soil zone), Melfort (thick black soil zone) and Indian Head (thin black soil zone). The Scott and Loon Lake sites were seeded on tilled fallow, while the Indian Head and Melfort sites were direct seeded into standing cereal stubble. Two tests were conducted at Saskatoon; one was conducted under conventional till; the second under minimum till.

The plots were seeded at a rate of 200 seeds per 6 meters of row (33 seeds/ m row). Plot size varied by site. Fertilizer nutrients were applied according to soil test recommendations.

Seeding dates at the sites were:

Loon Lake – May 19, 2003
Scott – May 22, 2003
Melfort – May 26, 2003
Indian Head – May 15, 2003
Saskatoon (Minimum Till) – May 23, 2003
Saskatoon (Conventional Till) – May 22, 2003

Weed control was accomplished with registered herbicides and hand weeding.

Data collection included seedling emergence counts at 14, 21, and 28 days after seeding, canola seedling fresh weight at 14, 21, and 28 days after seeding, and canola seed yield. Canola seedling fresh weight was determined by randomly collecting 10 canola plants per plot and weighing immediately.

Both laboratory and field results were subjected to analysis of variance using PROC GLM in SAS. For the field results, sites were considered a random effect and only a combined analysis is presented.

Results and Discussion

The environmental conditions at Melfort during the production of the seedlots in 2000 and 2001 are shown in Table 3. The 2000 and 2001 mean growing season air temperatures were slightly below and above the long-term average, respectively (Table 3). Similarly, the 2000 production received above normal precipitation while the 2001 growing season received approximately 40% of the long-term average.

Laboratory results

The ANOVA for the standard germination test, the accelerated aging test, and the controlled deterioration test are shown in Table 4, while means are presented in Table 5. The early swathing dates from both seeding dates in 2001 were the only two seedlots that would not meet the No. 1 certified seed standards of 90% germination within 7 days (Table 5). ANOVA indicated that the year the seed was produced had a significant effect on % germination for all three tests (Table 4). Seed produced under the more favorable conditions of 2000 had between 4 and 22% higher germination than seed produced in 2001 (Table 5). Differences were much higher with the accelerated aging test and the controlled deterioration test relative to the standard germination test.

Seeding date effects were not evident for germination when the seed was subjected to the standard germination and accelerated aging tests (Table 4). Early seeded canola had 4 to 6% higher germination than late seeded canola when subjected to the controlled deterioration test (Table 5). There were significant differences for seedling weights for all three tests. Early seeded canola had 9, 12, and 18% higher seedling weights than late seeded canola for the standard, accelerated aging, and controlled deterioration tests, respectively (Table 5).

Swathing time had the greatest effect and significant differences were detected with all three tests for all variables measured (Table 4). Generally, early swathing resulted in reductions in germination and seedling weight (Table 5).

There were a number of two and three-way interactions; however, the relevance of the interactions is covered in the discussion of field results.

Field results

Seedling emergence

The three factors (production year, seeding date, and swathing time) had a significant effect on seedling emergence at 14, 21, and 28 days after seeding (Table 6). In addition there was a two-way production year X swathing date interaction as well as a three-way production year X seeding date X swathing date interaction. Since the results were consistent over the three sampling dates, only the 28 DAS data are presented.

The seed produced under the favorable environmental conditions of 2000 resulted in about 10% higher seedling emergence than did the seed produced in 2001 (Fig. 1). Early swathing produced fewer seedlings and this was more pronounced with 2001 produced seed compared to 2000 produced seed. In other words, swathing date was much more critical under stressful environmental conditions. The three-way interaction suggests that early swathing had no effect on seedling emergence with the 2000 early seeded treatments; while early swathing was detrimental with both seeding dates in 2001.

Canola seedling fresh weight (g/plant)

Swathing date was the only factor that had a significant effect on seedling fresh weight at all three sampling dates (Table 6).

The three-way interaction at 14 DAS was not evident at 21 and 28 DAS (Table 6). At 21 DAS, there was a production year by swathing date interaction and swathing time was the only factor where there were significant differences at 28 DAS. This indicates that seeding date and production year effects declined as the crop developed. At 21 DAS, the earliest swathing date in 2000 produced significantly lower biomass than the latest swathing date, while the two earliest swathing dates in 2001 produced significantly lower biomass than the latest swathing date (Fig. 2). At 28 DAS, the two earliest swathing dates produced significantly lower seedling fresh weight than the latest swathing date and this was consistent over production year and seeding date (Figure 3).

Total canola biomass (g/ m-row)

Total canola biomass was calculated by multiplying fresh weight per seedling by seedling emergence. As with the seedling emergence and seedling fresh weight data, swathing timing had a significant effect (Table 6). At all sampling timings, there were significant production year X swathing date interactions (Figure 4). Total fresh weight taken 28 DAS was highly correlated with final crop yield (r^2 = 0.92; p<0.001), which suggests that this variable is a good predictor of final canola yield.

At 21 and 28 DAS, the production year X swathing date interaction indicates that the earliest swathing date in 2000 produced lower total fresh weight than the latest swathing date (Figure 5). The two earliest swathing dates in 2001 produced significantly lower total fresh weight than the latest swathing date. As was discussed in the section on seedling emergence, this indicates that the negative impact of early swathing on seed vigour is much more pronounced in a dry year with above normal air temperatures.

Canola seed yield

Swathing time had a significant effect on canola seed yield (Table 6). As with the other variables measured, there was a swathing timing X production year interaction (Figure 5). The earliest swathing date from seed produced in 2000 resulted in 13 % lower yields than the latest swathing date. Yields were 25 and 11% lower for the first and second swathing date from the 2001 produced seed. These results are consistent with the total fresh weight data and support the discussion on the effect of environment and swathing timing on canola seed quality.

There was also a strong relationship between thousand kernel weight and canola seed yield. A second-order polynomial equation was used to fit the relationship (Figure 6). Seventy-five percent of the variability in canola seed yield could be explained by thousand kernel weight. This relationship would suggest that maximum canola seed yield with this cultivar would be achieved at thousand kernel weights of approximately 3.5 grams.

Correlation between germination/ vigour tests and field performance

All three tests (standard germination, accelerated aging, controlled deterioration) had high correlations with seedling emergence, biomass and final yield (Table 7) and appear to be good predictors of performance of canola seedlots. The accelerated aging test had higher correlations for seedling emergence than the other two tests. Seedling weights obtained from the three tests were more highly correlated with seedling emergence, canola biomass, and yield than was % germination. Therefore, measuring canola seedling weight in addition to germination percentage appears to be beneficial in predicting relative performance of canola seedlots. The seed vigour index is calculated using the following formula:

(germination percentage/100) X thousand kernel weight (grams)

The seed vigour index also provided very high correlations with canola fresh weight, biomass and yield and is a simple method of predicting canola seedlot performance. The adjusted electrical conductivity test also had a high negative correlation with canola seed performance (Table 8).

Regression analysis also indicates a strong relationship between seed vigour index and canola yield (Fig. 7). A second-order polynomial equation indicates that eighty-six percent of the variability in canola seed yield could be explained by the seed vigour index.

Conclusions

Environmental conditions, seeding date and swathing time can all have an effect on the vigour of canola seed. The impact of early swathing appears to be more pronounced when environmental conditions are stressful. Any stress that reduces seed size or does not allow the seed to reach full maturity may result in a less productive seedlot. The seed vigour index, derived from germination tests developed at the Saskatoon Research Center, provided a good predictor of the performance of canola seedlots grown under different soil types, tillage practices, seeding dates, and growing conditions.

Table 1: Seeding dates and swathing times for seedlots produced at Melfort in 2000 and 2001.

Seed Lot	Production Year	Seeding Date	Swathing Time
L4	2000	May 5 (EM)	60-70% moisture, 0% colour change (SW1)
L1			45-55% moisture; 10% colour change (SW2)
L6			35-45% moisture; 40% colour change (SW3)
L7			25-35% moisture; 95% colour change (SW4)
L16		June 5 (LM)	60-70% moisture, 0% colour change (SW1)
L13			45-55% moisture; 10% colour change (SW2)
L14			35-45% moisture; 40% colour change (SW3)
L5			25-35% moisture; 95% colour change (SW4)
L12	2001	May 16 (EM)	60-70% moisture, 0% colour change (SW1)
L10			45-55% moisture; 10% colour change (SW2)
L9			35-45% moisture; 40% colour change (SW3)
L8			25-35% moisture; 95% colour change (SW4)
L3		June 15 (LM)	60-70% moisture, 0% colour change (SW1)
L11			45-55% moisture; 10% colour change (SW2)
L2			35-45% moisture; 40% colour change (SW3)
L15			25-35% moisture; 95% colour change (SW4)

Table 2: Thousand kernel weights and % green seed of seedlots produced in Melfort , 2000-01.

Seed Lot	Production Year	Seeding Date	Swathing Time	Seed wt. g/1000)	% green seed
L4	2000	early May	SW 1	2.08	0
L1			SW 2	2.71	0.2
L6			SW 3	3.00	2.0
L7			SW 4	3.48	0.6
L16		late May	SW 1	1.80	2.4
L13			SW 2	2.55	1.6
L14			SW 3	2.82	3.2
L5			SW 4	3.05	2.2
L12	2001	early May	SW 1	2.01	10.6
L10			SW 2	2.63	1.2
L9			SW 3	3.32	1.6
L8			SW 4	3.56	0.4
L3		late May	SW 1	1.76	8.0
L11			SW 2	2.68	7.2
L2			SW 3	3.30	4.8
L15			SW 4	3.54	2.2

Table 3: 2000-01 and long-term environmental conditions at Melfort

Mean Monthly Air Temperatures (°C), Melfort							
Year	April	May	June	July	August	Sept.	Mean
2000	3.1	9	13.5	17.5	16.2	11.1	11.7
2001	3.5	11.5	14.1	18.6	19	13.3	13.3
1951-2000 Means	2.4	10.7	15.6	17.5	16.4	10.5	12.2

Monthly Precipitation (mm), Melfort							
	April	May	June	July	August	Sept.	Total
2000	15	42.6	73.6	111.4	49.4	25.4	317.4
2001	17.7	12	20.4	46.4	11.4	10.6	118.5
1951-2000 Means	22.6	43.5	63.9	71.2	55	40.7	296.7

Table 4: ANOVA of fixed effects for germination and seedling dry weight of seed lots from Standard Germination Test, Accelerated Aging Test, and the Controlled Deterioration Test.

	SGT			AAT			CDT		
Source	5 days	7 days	seedling weight	5 days	7 days	seedling weight	5 days	7 days	seedling weight
Production Year (Pyr)	**	***	*	***	***	*	***	***	NS
Seeding Date (SeD)	NS	NS	**	NS	NS	***	***	**	***
Swathing Time (SwT)	**	***	*	***	***	***	***	***	***
Pyr X SeD	NS	NS	NS	***	***	*	***	**	NS
Pyr X SwT	**	***	NS	***	***	***	***	***	***
SeD X SwT	NS	NS	NS	***	***	**	***	***	**
Pyr X SeD X SwT	**	***	*	***	***	**	***	***	*

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

Table 5: Performance of Argentine seedlots in the standard germination test (SGT), accelerated aging test (AAT), and the controlled deterioration test (CDT)

		SGT			AAT			CDT		
Seeding Date	Swathing Time	5 days	7 days	seedling wt.(g)	5 days	7 days	seedling wt.(g)	5 days	7 days	seedling wt.(g)
early May	SW1	94.5	95.5	0.059	97.5	98.5	0.061	92.0	93.5	0.065
	SW2	97.0	98.5	0.080	99.0	99.5	0.076	99.0	99.0	0.076
	SW3	91.0	94.5	0.095	94.0	96.0	0.095	90.0	95.5	0.095
	SW4	87.5	92.0	0.096	96.0	96.5	0.104	82.5	94.5	0.109
late May	SW1	88.0	91.0	0.049	90.5	91.5	0.050	91.5	95.0	0.052
	SW2	94.5	97.0	0.076	92.5	93.0	0.072	97.0	98.5	0.072
	SW3	96.5	98.5	0.080	93.0	94.5	0.082	93.0	95.0	0.087
	SW4	90.0	95.0	0.088	94.5	97.0	0.087	86.5	94.0	0.083
early May	SW1	72.5	77.5	0.056	47.0	49.0	0.027	61.0	64.5	0.040
	SW2	86.5	92.0	0.081	88.0	93.0	0.077	91.0	96.0	0.086
	SW3	94.5	99.5	0.098	98.0	99.5	0.098	91.5	96.0	0.109
	SW4	94.5	97.5	0.105	98.0	98.0	0.109	92.5	97.5	0.116
late May	SW1	84.5	87.0	0.045	83.5	87.5	0.044	73.0	79.5	0.042
	SW2	91.0	95.5	0.078	86.0	88.0	0.063	86.5	89.0	0.075
	SW3	86.0	91.5	0.095	85.0	89.5	0.090	81.0	85.5	0.090
	SW4	89.0	92.5	0.101	85.0	88.5	0.092	50.5	73.5	0.090
$LSD_{0.05}$		**5.4**	**3.9**	**0.008**	**7.0**	**6.5**	**0.005**	**6.4**	**7.0**	**0.009**
<u>Factor Means</u>										
Year	2000	92.4	95.3	0.078	94.6	95.8	0.078	91.44	95.63	0.080
	2001	87.3	91.6	0.082	83.8	86.6	0.075	78.38	85.19	0.081
Seeding	Early	89.8	93.4	0.084	89.7	91.3	0.081	87.4	92.1	0.087
Date	Late	89.9	93.5	0.077	88.8	91.2	0.073	82.4	88.8	0.074
Swathing	SW1	84.9	87.8	0.052	79.6	81.6	0.046	79.4	83.1	0.050
Time	SW2	92.3	95.8	0.079	91.4	93.4	0.072	93.4	95.6	0.077
	SW3	92.0	96.0	0.092	92.5	94.9	0.091	88.9	93.0	0.095
	SW4	90.3	94.3	0.098	93.4	95.0	0.098	78.0	89.9	0.100

Table 6: ANOVA of fixed effects for performance of canola seedlots at six site-years in Saskatchewan, 2003.

	Seedling Emergence (#/m-row)			Canola Seedling Fresh Weight (g/plant)			Total Canola Biomass (g/m-row)			Seed
Source	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	Yield
Production Year (Pyr)	*	**	**	NS	*	NS	NS	*	NS	NS
Seeding Date (SeD)	*	***	***	NS	NS	NS	*	***	***	NS
Swathing Time (SwT)	***	***	***	***	***	***	***	***	***	***
Pyr X SeD	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Pyr X SwT	*	***	***	*	**	NS	*	***	*	**
SeD X SwT	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Pyr X SeD X SwT	*	NS	*	**	NS	NS	*	NS	NS	NS

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

Table 7: Correlations between initial seed attributes and performances of Argentine seed lots at six site-years in Saskatchewan 2003

	Seedling Emergence (#/m-row)			Canola Seedling Fresh Weight (g/plant)			Total Canola Biomass (g/m-row)			Seed
Seed attribute	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	Yield
SGT - 5 days	0.77***	0.75***	0.74***	0.51**	0.57***	0.46*	0.68***	0.67***	0.65***	0.72***
- 7days	0.83***	0.81***	0.81***	0.61**	0.65***	0.58**	0.77***	0.75***	0.74***	0.79***
seedling weight	0.65***	0.75***	0.78***	0.93***	0.91***	0.93***	0.85***	0.87***	0.88***	0.83***
vigour index	0.70**	0.79***	0.81***	0.96***	0.95***	0.95***	0.90***	0.92***	0.92***	0.90***
CDT - 5 days	0.60**	0.52**	0.50**	0.10*	0.09*	0.03*	0.38*	0.32*	0.34*	0.26*
- 7 days	0.79***	0.73***	0.71***	0.35*	0.37*	0.30*	0.61**	0.57**	0.58***	0.49*
seedling weight	0.74***	0.82***	0.85***	0.89***	0.89***	0.86***	0.88***	0.90***	0.90***	0.82***
vigour index	0.80***	0.87***	0.88***	0.91***	0.90***	0.88***	0.93***	0.93***	0.94***	0.91***
AAT - 5days	0.81***	0.77***	0.75***	0.55**	0.59***	0.51**	0.72***	0.70***	0.68***	0.67***
- 7days	0.80***	0.75***	0.74***	0.56**	0.59***	0.53**	0.71***	0.68***	0.68***	0.68***
seedling weight	0.79***	0.86***	0.88***	0.94***	0.94***	0.92***	0.94***	0.94***	0.94***	0.87***
vigour index	0.78***	0.85***	0.86***	0.96***	0.95***	0.94***	0.93***	0.94***	0.94***	0.86***

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

Table 8: Correlations between electrical conductivity and adjusted electrical conductivity and performances of Argentine seed lots at six site-years in Saskatchewan. 2003.

	Seedling Emergence (#/m-row)			Canola Seedling Fresh Weight (g/plant)			Total Canola Biomass (g/m-row)			
Seed attribute	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	Seed Yield
EC - 4 hours	-0.79***	-0.74***	-0.73**	-0.55*	-0.55*	-0.46	-0.70**	-0.65**	-0.63**	-0.64**
- 24 hours	-0.58*	-0.50*	-0.47	-0.27	-0.28	-0.18	-0.44	-0.38	-0.35	-0.44*
AEC - 4 hours	-0.91***	-0.90***	-0.90***	-0.80***	-0.81***	-0.75***	-0.90***	-0.87***	-0.86***	-0.86***
- 24 hours	-0.88***	-0.87***	-0.86***	-0.78***	-0.80***	-0.74***	-0.88***	-0.85***	-0.83***	-0.87***

*, **, *** significant at p=0.05, p=0.01 and p=0.001, respectively

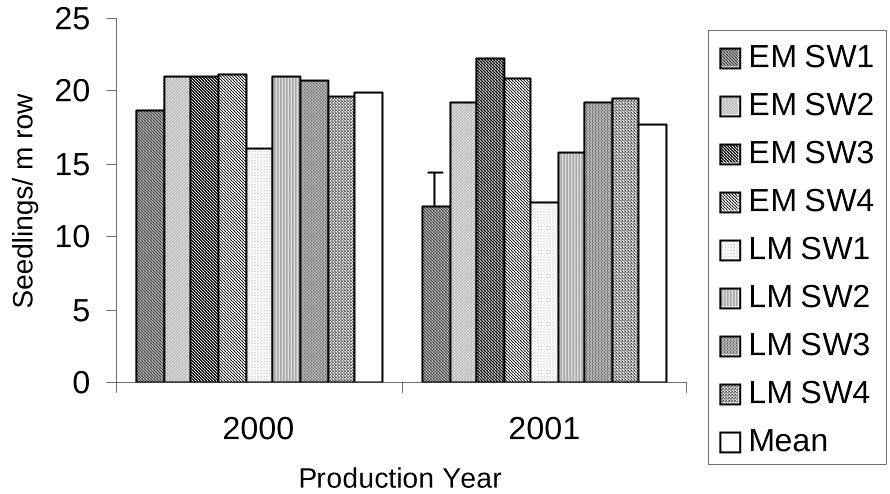

Figure 1: Effect of canola seed derived from different production years, seeding dates and swathing times on emergence of canola seedlings 28 DAS. Mean of six site-years, Saskatchewan. 2003. Bar represents the $LSD_{0.05}$ for the three-way production year X seeding date X swathing time interaction**.**

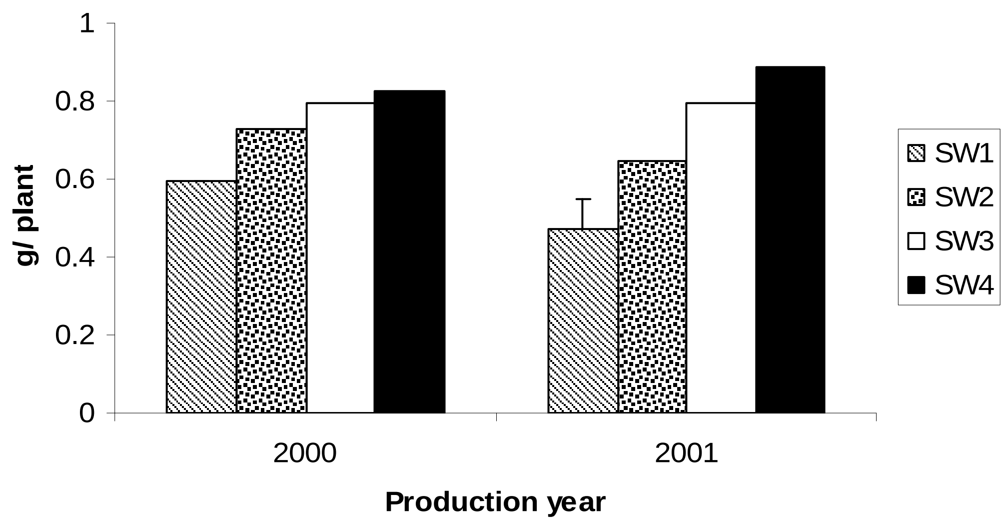

Figure 2: Effect of canola seed derived from different production years, seeding dates and swathing times on canola seedling fresh weight 21 DAS. Mean of six site-years, Saskatchewan. 2003. Bar represents the $LSD_{0.05}$ for the two-way production year X swathing time interaction.

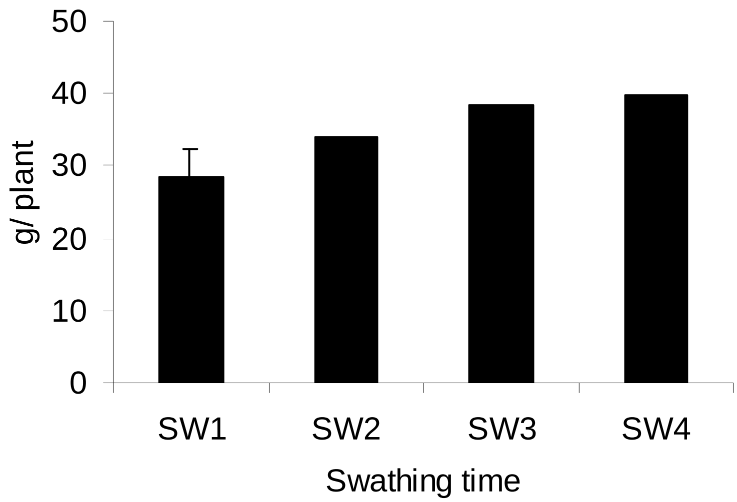

Figure 3: Effect of canola seed derived from different swathing times on canola fresh weight 28 DAS. Mean of six site-years, Saskatchewan. 2003. Bar represents the $LSD_{0.05}$

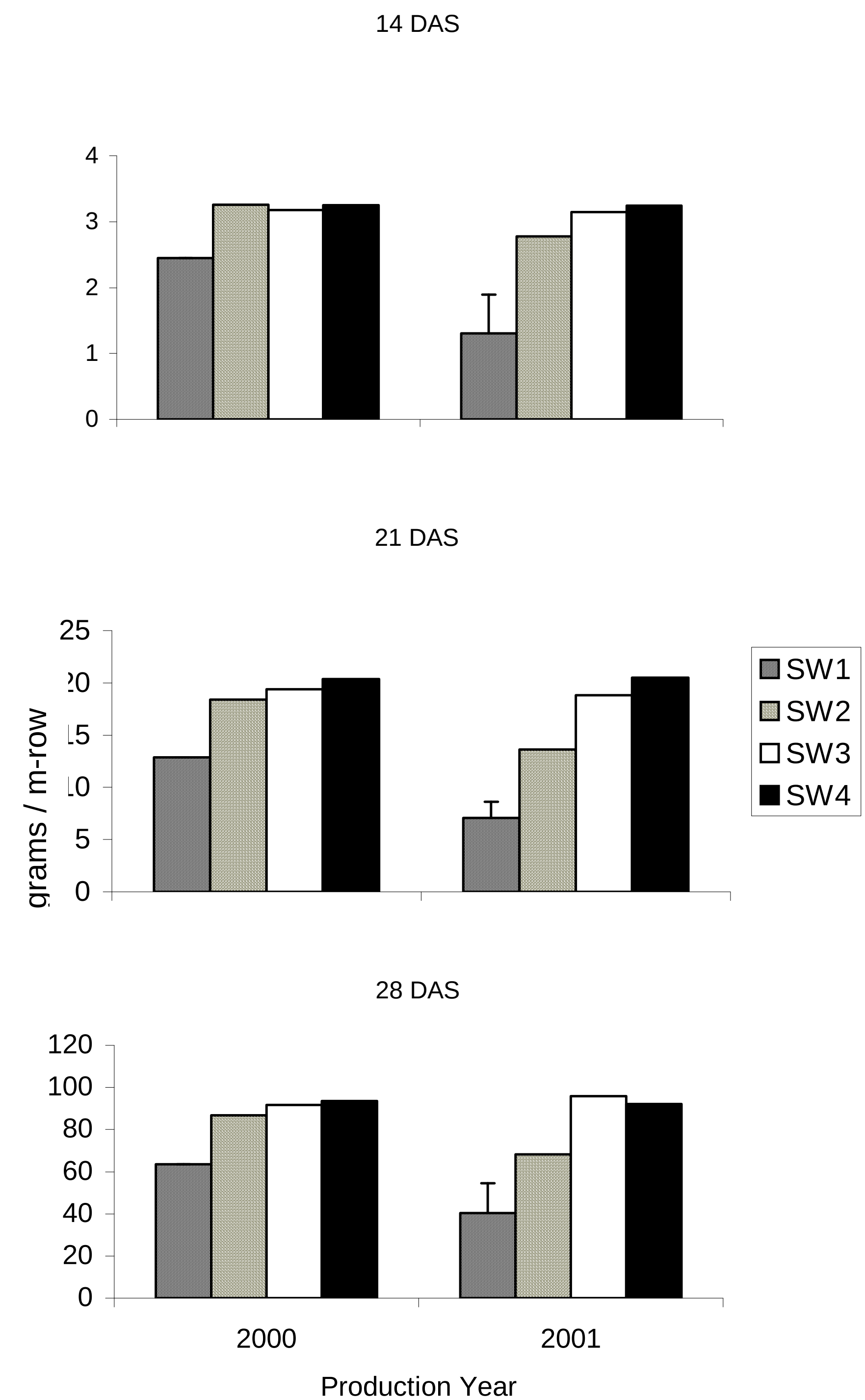

Figure 4: Effect of canola seed derived from different production years, seeding dates and swathing times on total canola fresh weight 14, 21, and 28 DAS. Mean of six site-years, Saskatchewan. 2003. Bar represents the $LSD_{0.05}$ for the two-way production year X swathing time interaction.

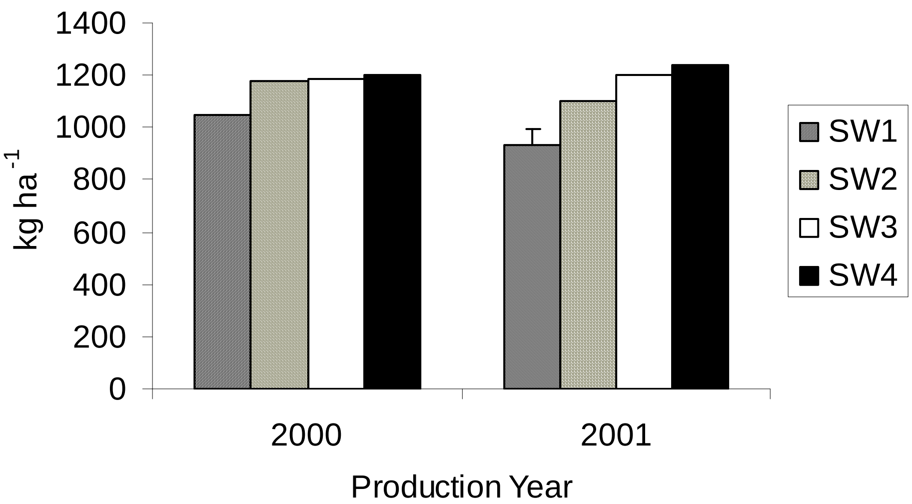

Figure 5: Effect of canola seed derived from different production years, seeding dates and swathing times on canola seed yield. Mean of six site-years, Saskatchewan. 2003. Bar represents the $LSD_{0.05}$ for the two-way production year X swathing time interaction.

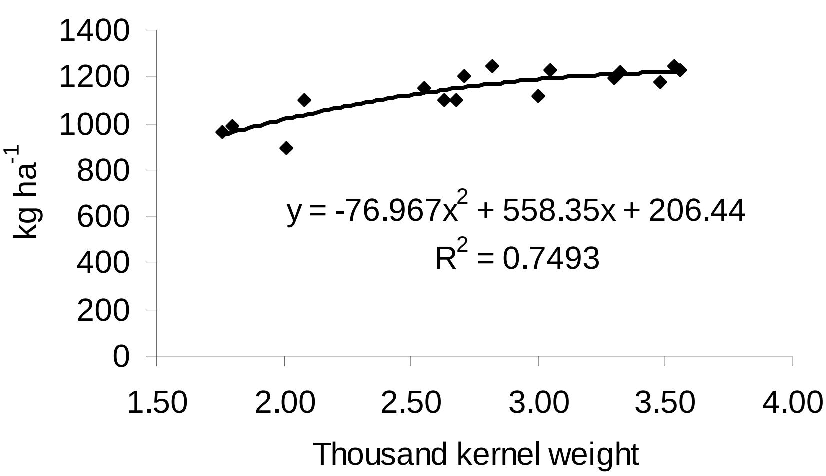

Figure 6: Relationship between canola seed thousand kernel weight and final seed yield. Mean of six site-years, Saskatchewan. 2003.

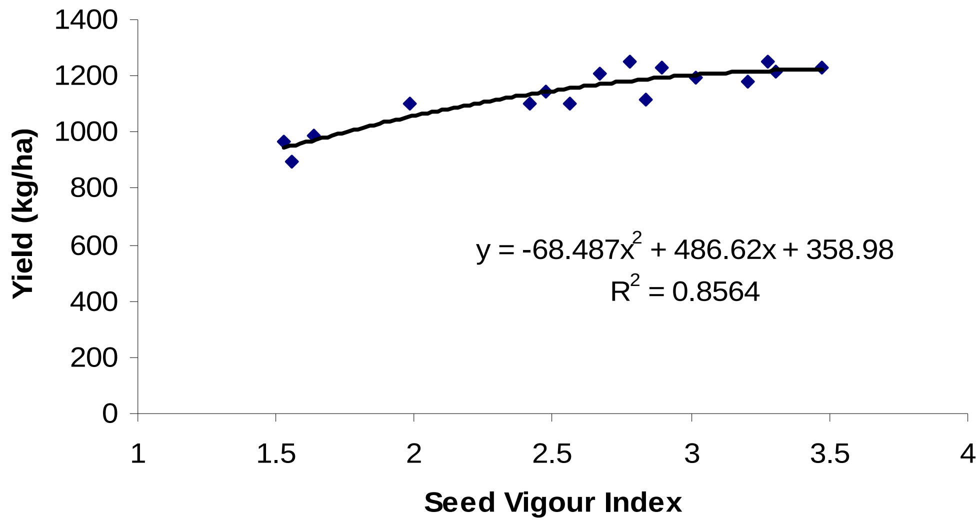

Figure 6: Relationship between canola seed vigour index and canola seed yield. Mean of six site-years, Saskatchewan. 2003.

EVALUATING THE AGRONOMIC AND ECONOMIC VALUE OF HIGH QUALITY CANOLA SEED
AAFC PROJECTS A03611 (Saskatoon) and A03733 (SPARC)
STATEMENT AS AT: MARCH 1, 2005

AUTHORIZED BUDGET	$40,000.00			
Budget Received	$36,000.00			
% of Budget Rcvd to date	**90.00%**			
	Total Budget	Funds Available/Received	Total Expenditures/forecast	Variance/Unexpended Balance
Saskatoon (Scott)				
Salary	$18,500.00	$15,400.00	$17,907.57	($2,507.57)
M&S	$2,271.00	$1,892.60	$2,271.00	($378.40)
Overhead	$3,115.00	$2,593.40	$2,981.00	($387.60)
	$23,886.00	**$19,886.00**	**$23,159.57**	**($3,273.57)**
Interest Received		$296.02		**($2,977.55)**
SPARC				
Salary	$12,500.00	$12,500.00	$12,500.00	$0.00
M&S	$1,513.00	$1,513.00	$1,746.81	($233.81)
Overhead	$2,101.00	$2,101.00	$2,101.00	$0.00
	$16,114.00	**$16,114.00**	**$16,347.81**	**($233.81)**
Interest Received		$233.81		**$0.00**
Sub-total from SCDC		**$36,000.00**		
Balance Surplus/(Deficit)	**$40,000.00**	**$36,529.83**	**$39,507.38**	**($2,977.55)**