Impact of seed quality on establishment, growth and yield of Argentine canola.

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BACKGROUND

In 2002, representatives of the canola industry in Canada recommended adoption of three laboratory tests for evaluating the quality and vigour of seed lots of spring-type Argentine canola, *Brassica napus* L. (Anonymous 2002). Studies in 1998-2000 indicated that germination of seed lots in the standard germination test (SGT) and pre-chill test (PCT) provided a reliable indication of seedling establishment in warm and cool soils. Seedling weight and leaf area in a seedling assay provided the best indication of seedling growth under diverse growing conditions. The seedling assay was important in the assessment of seed quality because yields were more strongly correlated with seedling growth than with seedling densities. However, the assay was not adopted by commercial seed labs because the test requires more space, better lighting and costly imaging equipment. In canola and other crops, specialized tests including the controlled deterioration test (CDT) and electrical conductivity test (ECT) have been developed to assess potential field performance, particularly under stress conditions (ISTA 1995, Elias and Copeland 1997). Therefore, laboratory and field experiments were initiated to investigate other methods of assessing seed and seedling vigour of canola seed lots. Experiments focussed on the impact of germination, green seed content and electrical conductivity on establishment of open-pollinated Argentine canola in conventional and minimum tillage. A vigour index, based on germination and 1000-seed weight, was developed to assess seedling growth in each tillage system.

EXPERIMENTAL METHODS

<u>Seed samples</u>

Seed lots of an open-pollinated Argentine cultivar (Ebony) were produced in swathing experiments at the Melfort Research Farm in 2000 and 2001. Plots were seeded on two dates and swathed at four different times when the moisture content of seeds at the base of the main raceme averaged 63-70%, 46-56%, 37-45% and 26-38%, respectively.

Laboratory tests

Thousand-seed weights of harvested seed (n=16 seed lots) were determined from five 200-seed subsamples. Green seed content was assessed by crushing 100 seeds and determining the percentage of distinctly green seeds.

Seed lots were evaluated in a modified germination test (MGT) and controlled deterioration test (CDT) (after ISTA 1995). Seeds were placed on moistened filter paper for 60-75 minutes to adjust the moisture content of the seeds to 20%. Seeds were placed in aluminium-foil pouches, equilibrated at 10°C for 24 hours and 20°C (MGT) or 45°C (CDT) for 24 hours. In each test, seeds (n=50 seeds/replicate, four replicates) were placed on a blue blotter in a plastic container (11.4 cm x 11.4 cm), moistened with 13 ml water, covered and placed in a controlled environment chamber. Chambers were maintained at 20 ± 1°C and 16 hours light/8 hours dark photoperiod. Numbers of normal seedlings, abnormal seedlings and ungerminated seeds were assessed at 7 days (Agriculture Canada 1992). The vigour index of each seed lot was calculated by multiplying the 1000-seed weight by % germination/100.

Seed lots were evaluated in an electrical conductivity test (ECT) using modified procedures (ISTA 1995). Seeds (n=200 seeds/replicate, four replicates) were placed on moistened filter paper for 10-15 minutes to adjust the moisture content of the seeds to 10-14%. Seeds were placed in aluminium-foil bags and equilibrated at 7-8°C for 24 hours. Seeds were weighed and placed in 60 ml de-ionized water. Conductivity was assessed with a conductivity meter (VWP Scientific, model 5005) 4 and 24 hours after elution. Electrical conductivity ($\mu S\ cm^{-1}$) was calculated from the conductivity of the seed sample minus the conductivity of the water blank. Adjusted electrical conductivity ($\mu S\ cm^{-1} g^{-1}$) was calculated by dividing the electrical conductivity by the weight of 200 seeds.

Field Tests

Performance of the seed lots was evaluated in conventional tillage and minimum tillage. Each test was replicated four times using a randomized complete block design. Seed lots were treated with a commercial seed dressing (Helix®) and planted in six-row plots at 200 seeds per 6.1 m row in early May. Numbers of seedlings/row were assessed 14 and 21 days after seeding (DAS). Ten plants were collected from the outer rows of each plot 14 and 21 DAS. Shoots were cleaned and weighed to determine shoot fresh weight. Biomass was calculated by multiplying the number of seedlings/m-row by the shoot fresh weight. Plots were harvested at maturity with a small-plot combine to determine seed yield.

Statistical analyses

Data were analyzed using the General Linear model procedure (SAS Institute 1999). Laboratory data were correlated with field data to identify seed attributes that provided the best indication of seedling emergence, seedling establishment, shoot fresh weight, biomass and seed yield. Linear regression was used to quantify the relationship between attributes of seed lots in the lab with their performance in the field.

RESULTS AND CONCLUSIONS

Statistical correlations

Attributes of seed lots in the laboratory tests were correlated with their performance in conventional tillage (Table 1). Germination at 7 days in the MGT was positively correlated with seedling emergence after 14 days (r=0.65) and seedling establishment after 21 days (r=0.82). Greed seed content and adjusted electrical conductivity of the seed lots after 4 or 24 hours elution were negatively correlated with emergence (-r=0.58-0.72) and establishment (-r=0.88-0.93). Thousand-seed weights and vigour indices of seed lots in the MGT or CDT were positively correlated with shoot fresh weights (r=0.78-0.93), biomass (r=0.78-0.87) and seed yield (r=0.61-0.64). Correlation coefficients indicated that germination in the MGT, green seed content and adjusted electrical conductivity provided the best indication of seedling establishment in conventional tillage. Thousand-seed weights and vigour indices in the MGT provided the best indication of shoot growth, biomass accumulation and seed yield in conventional tillage.

Table 1. Correlations between attributes of canola seed lots in the laboratory and performance in conventional tillage.

Attributes	Seedlings/row 14 DAS	Seedlings/row 21 DAS	Shoot fresh weight 14 DAS	Shoot fresh weight 21 DAS	Biomass 14 DAS	Biomass 21 DAS	Seed yield
MGT-germ 7 days	0.65***	0.82***	0.37	0.74***	0.50*	0.77***	0.45
CDT-germ 7 days	0.37	0.71**	0.10	0.40	0.19	0.48	0.22
Green seed content	-0.58*	-0.88***	-0.40	-0.64**	-0.49	-0.72**	-0.42
AEC-4 h elution	-0.69***	-0.93***	-0.64**	-0.73**	-0.70**	-0.80***	-0.57*
-24 h elution	-0.72**	-0.91***	-0.60*	-0.73**	-0.68**	-0.79***	-0.57*
1000-seed weight	0.55*	0.76***	0.93***	0.79***	0.86***	0.81***	0.64*
MGT-vigour index	-	-	0.90***	0.85***	0.87***	0.87***	0.66**
CDT-vigour index	-	-	0.81***	0.78***	0.78***	0.84***	0.61*

*, **, *** Pearson correlation coefficient (n=16 seed lots) significant at $P\leq0.05$, $P\leq0.01$ and $P\leq0.001$, respectively. MGT-modified germination test, CDT-controlled deterioration test, AEC-adjusted electrical conductivity.

Attributes of seed lots in the laboratory were correlated with their performance in minimum tillage (Table 2). Germination at 7 days in the MGT and 1000-seed weights were positively correlated with seedling establishment after 21 days (r=0.64 and 0.76, respectively). Adjusted electrical conductivity of the seed lots after 4 or 24 hours elution was negatively correlated with emergence (-r=0.52-0.57) and establishment (-r=0.71-0.76). Correlation coefficients indicated that adjusted electrical conductivity provided the best indication of emergence and establishment in minimum tillage. Thousand-seed weights and vigour indices in the MGT or CDT provided the best indication of shoot growth (r=0.78-0.88) and biomass accumulation (r=0.87-0.91) after 21 days in minimum tillage. Germination in the MGT, vigour indices in the MGT and adjusted electrical conductivity had the highest correlations with seed yield (r=0.58-0.63).

Table 2. Correlations between attributes of canola seed lots in the laboratory and performance in minimum tillage.

Attributes	Seedlings/row 14 DAS	Seedlings/row 21 DAS	Shoot fresh weight 14 DAS	Shoot fresh weight 21 DAS	Biomass 14 DAS	Biomass 21 DAS	Seed yield
MGT-germ 7 days	0.42	0.64**	0.61*	0.57*	0.50*	0.61*	0.63**
CDT-germ 7 days	0.44	0.52*	0.46	0.36	0.49	0.42	0.37
Green seed content	-0.38	-0.59*	-0.59*	-0.55*	-0.58*	-0.87***	-0.50*
AEC-4 h elution	-0.57*	-0.76***	-0.71**	-0.67**	-0.66**	-0.72**	-0.58*
-24 h elution	-0.52*	-0.71**	-0.70**	-0.65**	-0.62*	-0.69**	-0.58*
1000-seed weight	0.44	0.76***	0.78***	0.85***	0.58*	0.87***	0.50
MGT-vigour index	-	-	0.81***	0.88***	0.61*	0.91***	0.58*
CDT-vigour index	-	-	0.81***	0.87***	0.68**	0.91***	0.55*

*, **, *** Pearson correlation coefficient (n=16 seed lots) significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$, respectively. MGT-modified germination test, CDT-controlled deterioration test, AEC-adjusted electrical conductivity.

Seedling establishment

Germination of seed lots in the MGT ranged from 78-99% (Figure 1). Establishment of the seed lots after 21 days in conventional tillage and minimum tillage increased as germination increased. Establishment was higher in conventional tillage than in minimum tillage. Coefficients of determination indicated that germination in the MGT provided a better indication of establishment in conventional tillage (R^2=0.68) than in minimum tillage (R^2=0.41). Slopes of regression equations indicated that seedling establishment increased 1.2-1.3% with each 1.0% increase in germination. Seed lots with 98-99% germination had the best establishment in each tillage system.

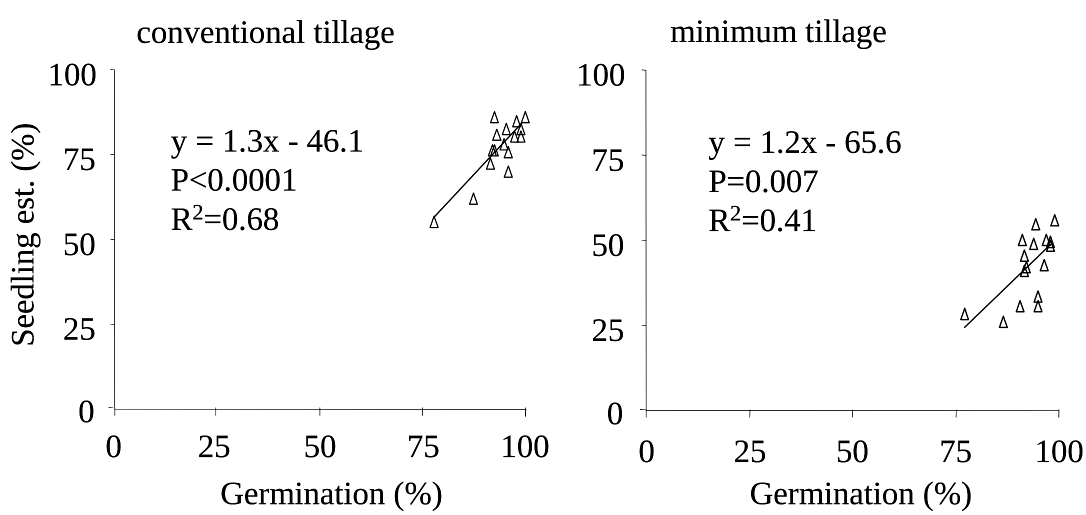

Fig. 1. Relationship between germination and establishment of open-pollinated Argentine canola in early May plantings in 2003.

Green seed content had a significant effect on establishment of the seed lots in conventional tillage and minimum tillage (Fig. 2). Green seed content ranged from 0-10.6% depending on when they were swathed. Establishment declined as the green seed content increased. With each 1.0% increase in green seed, establishment declined 2.5% in conventional tillage and 1.9% in minimum tillage. Seed lots with a green seed content of less than 2.0% usually had the best establishment. Green seed content was more closely associated with establishment in conventional tillage (R^2=0.76) than in minimum tillage (R^2=0.35).

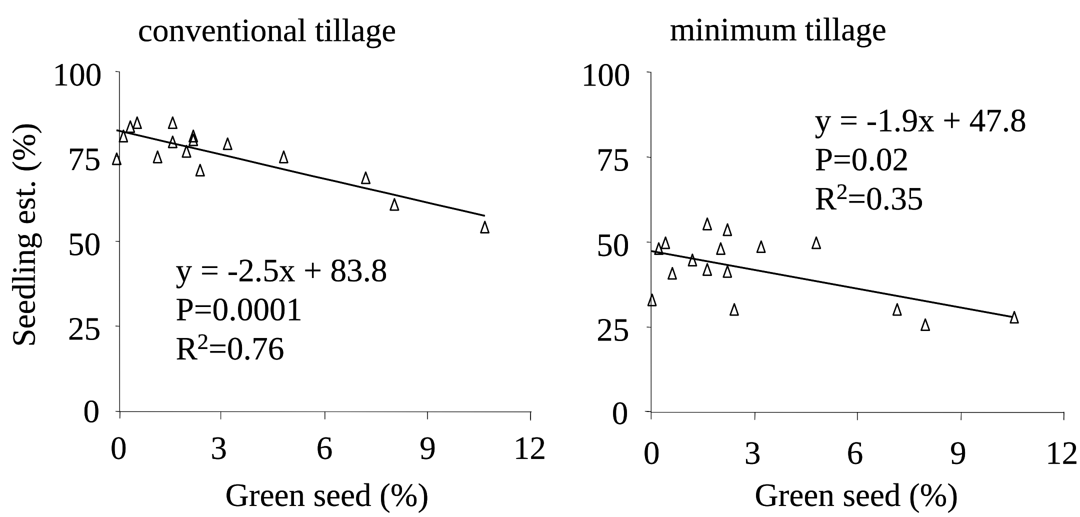

Fig. 2. Relationship between % green seed and establishment of open-pollinated Argentine canola in early May plantings in 2003.

Adjusted electrical conductivity of the seed lots ranged from 16-115 µS $cm^{-1}g^{-1}$ after 4 hours elution and from 55-236 µS $cm^{-1}g^{-1}$ after 24 hours elution (Fig. 3). Establishment in each tillage system declined as conductivity increased. Establishment declined 3.0% with each 10 µS $cm^{-1}g^{-1}$ increase in conductivity after 4 hours elution and 2.0% with each 10 µS $cm^{-1}g^{-1}$ increase in conductivity after 24 hours elution. R^2 values indicated that conductivity measurements after 4 hours elution provided the best indication of establishment in conventional tillage (R^2=0.86) and minimum tillage (R^2=0.58). Seed lots with conductivity of less than 30 µS $cm^{-1}g^{-1}$ after 4 hours elution had the best establishment in each tillage system.

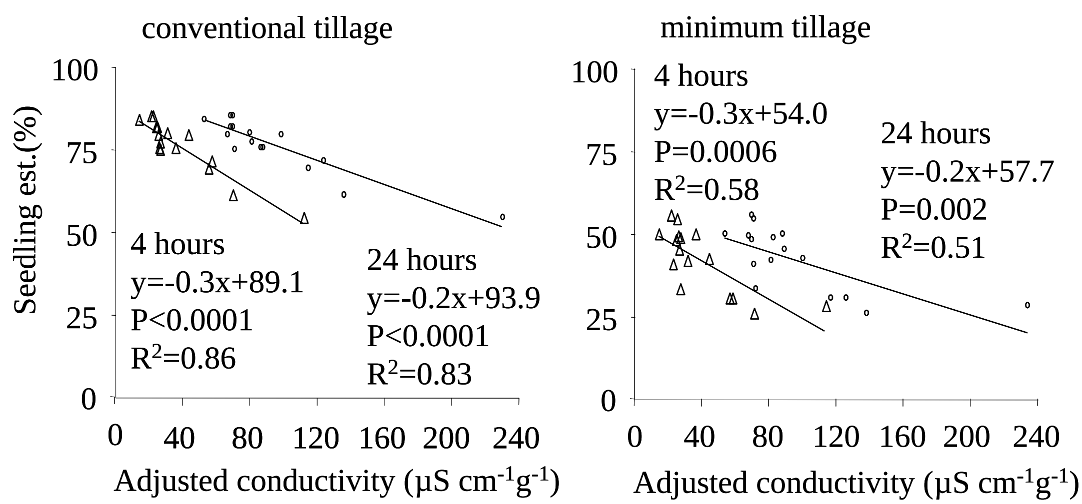

Fig. 3. Relationship between adjusted electrical conductivity and establishment of open-pollinated Argentine canola in early May plantings in 2003.

<u>Seedling growth</u>

Thousand-seed weights had a significant effect on shoot fresh weight after 21 days in conventional tillage and minimum tillage (Fig. 4). Seed weights ranged from 1.8-3.6 g. Shoot weights in each tillage system increased as seed weights increased. With a 1.0 g increase in 1000-seed weight, shoot fresh weight increased by 26% in conventional tillage and by 43% in minimum tillage. Seed lots with 1000-seed weight above 3.0 g usually had the highest shoot weight after 21 days. R^2 values indicated that seed weights were more closely associated with shoot weights in minimum tillage (R^2=0.72) than in conventional tillage (R^2=0.62).

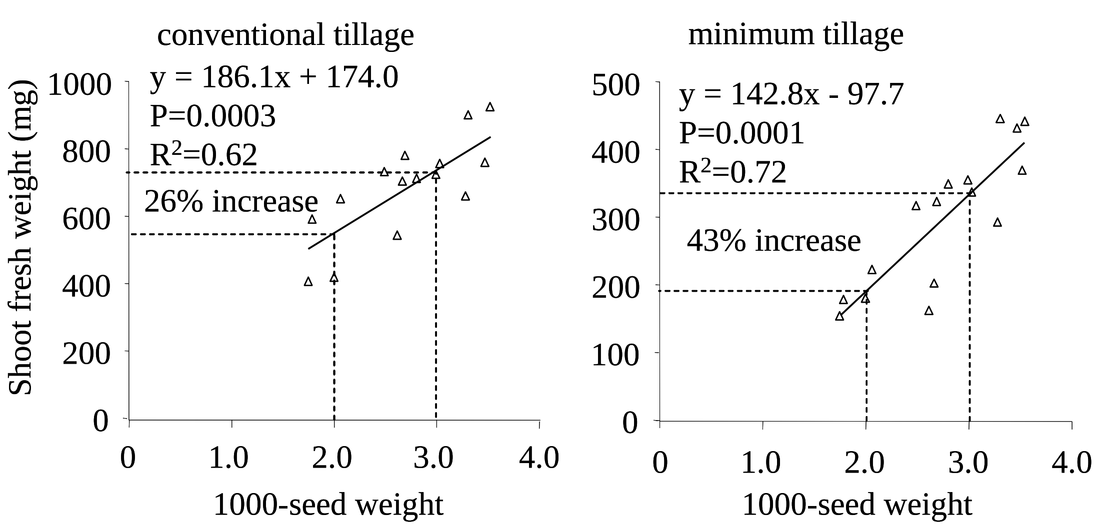

Fig. 4. Relationship between seed weight and shoot fresh weight of open-pollinated Argentine canola after 21 days in early May plantings in 2003.

Vigour indices of seed lots in the MGT ranged from 1.5-3.5 (Fig. 5). Biomass of the seed lots after 21 days in each tillage system increased as the vigour index increased. With a 1.0 unit increase in the vigour index, biomass increased by 34% in conventional tillage and by 54% in minimum tillage. R^2 values indicated that vigour indices of seed lots in the MGT provided an excellent indication of seedling growth in conventional tillage (R^2=0.76) and minimum tillage (R^2=0.83). Seed lots with vigour indices above 3.0 had the highest biomass after 21 days in each tillage system.

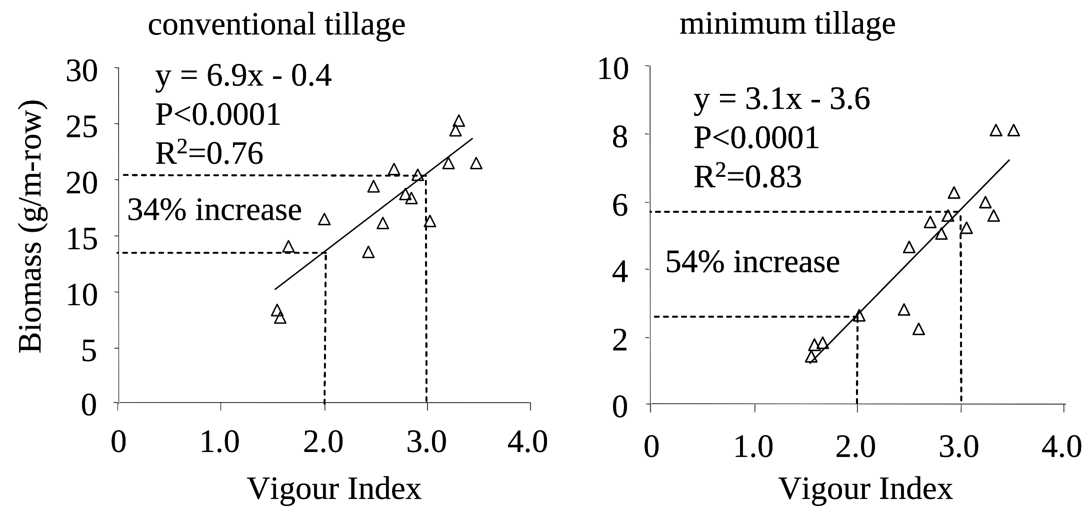

Fig. 5. Relationship between vigour index and biomass of open-pollinated Argentine canola after 21 days in early May plantings in 2003.

Seed yields in each tillage system increased as the vigour index increased (Fig. 6). With a 1.0 unit increase in the vigour index, yield increased by 12% in conventional tillage and by 13% in minimum tillage. R^2 values indicated that vigour indices were more closely associated with yield in conventional tillage (R^2=0.44) than in minimum tillage (R^2=0.34). In most instances, seed lots with vigour indices above 3.0 had the highest yield in each tillage system.

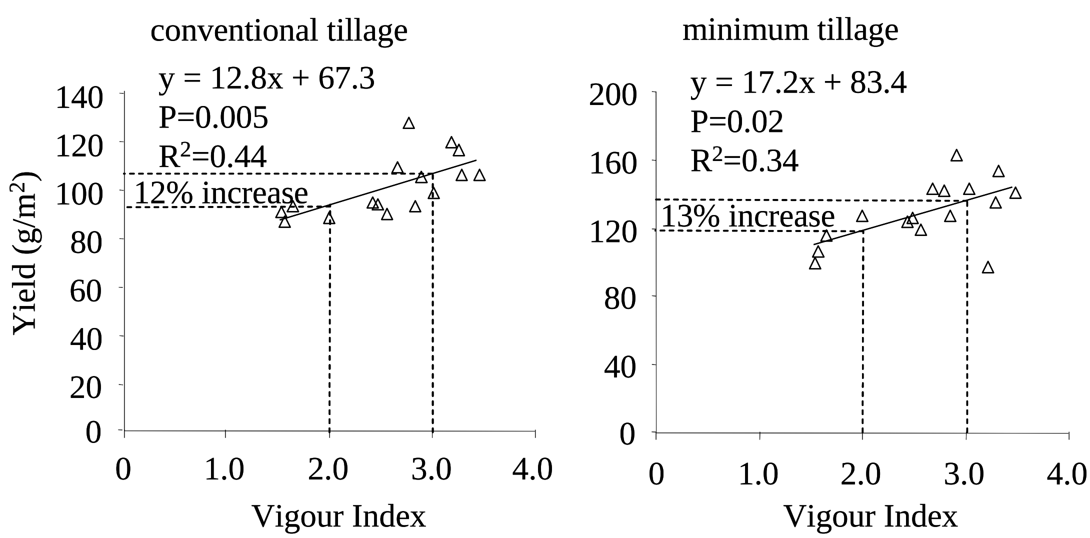

Fig. 6. Relationship between vigour index and seed yield of open-pollinated Argentine canola in early May plantings in 2003.

ACKNOWLEDGMENTS

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