Alternative seeding dates (fall and April) affect *Brassica napus* canola yield and quality

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Kirkland, K. J. and Johnson, E. N. 2000. **Alternative seeding dates (fall and April) affect *Brassica napus* canola yield and quality.** Can. J. Plant Sci. **80**: 713–719. *Brassica napus* L. canola production on the Canadian prairies often is limited by hot, dry growing conditions in early July and a short growing season. *Brassica napus* canola seeded in the fall just prior to freeze-up or in the early spring as soon as fields are passable may allow canola to avoid these adverse conditions. Our objective was to determine if late October (fall), or mid- to late April (April) seeding dates improve canola yield and quality relative to a mid-May (15 to 20 May) seeding date. Plant density and height, phenological development, seed yield, seed weight and seed oil content were assessed in plots sown to herbicide-tolerant *B. napus* canola at three seeding dates on five fallow sites and three stubble sites at Scott, SK, from 1994 to 1998. A thinner plant stand occurred for the fall compared with spring seeding dates; however, this difference rarely corresponded with less canola yield. Fifty percent flowering occurred 20 d earlier (June rather than July), reproductive growth (50% flowering to maturity) was 10 d longer, plants were 23 (fall) or 8 (April) cm shorter, and maturity occurred 13 d earlier when canola was seeded in the fall and April compared with mid-May seeding. Canola seed yield was 38% greater when seeded on the alternative dates rather than the more traditional mid-May seeding date. The yield advantage for alternative seeding dates was greater and more consistent on stubble than on fallow likely because of lack of soil crusting and temperature and wind protection from stubble. The response of seed weight to seeding date was similar to that for seed yield, indicating that a portion of the positive yield response to alternative seeding dates was associated with larger seed size. Oil content also was greater for the fall and April compared with mid-May seeding dates, but the improvement was smaller (6%) than that for seed yield. Fall- and April-seeded canola tolerated spring frosts and avoided adversely hot, dry weather during the flowering period, thus improving canola seed yield and quality. Alternative seeding dates provide canola producers in semi-arid regions with a sustainable option to diversify their cropping systems.

**Key words:** Seeding date, dormant, stubble, fallow, herbicide tolerant, alternative cropping practice.

Kirkland, K. J. et Johnson, E. N. 2000. **Effets de la date de semis, automne ou avril, sur le rendement et la qualité de *Brassica napus* (type canola).** Can. J. Plant Sci. **80**: 713–719. La production du colza (*Brassica napus* L.) de type canola dans les prairies canadiennes est souvent plafonnée par le temps chaud et sec qui sévit en début de juillet et par la longueur insuffisante de la saison de végétation. Le semis réalisé en automne, juste avant l’installation du gel ou en début de printemps dès que les champs sont praticables permettrait éventuellement d’éviter ces mauvaises conditions. Dans cette optique, nous avons voulu établir l’efficacité, au plan du rendement et de la qualité, de semis effectués en fin d’octobre et du milieu à la fin d’avril par rapport aux semis normalement pratiqués à la mi-mai (15 au 20). Les caractères étudiés étaient la densité de peuplement et la hauteur du couvert, la phénologie, le rendement grainier, le poids des graines et leur teneur en huile. Un cultivar de canola résistant aux herbicides était semé à 3 époques de 1994 à 1998 à 5 emplacements sur jachère et à 3 emplacements sur chaume de céréales à Scott en Saskatchewan. Le peuplement était moins dense en semis d’automne qu’en semis de printemps, quoique cette différence se traduisait rarement par une baisse de rendement. Par comparaison avec le semis à la mi-mai, le stade 50 % de floraison arrivait 20 jours plus tôt, c.-à-d., en juin plutôt qu’en juillet; la phase reproductive (de 50 % floraison à la maturité) était de 10 j plus longues, les plantes étaient plus courtes de 23 cm (semis d’automne) ou de 8 cm (semis d’avril) et enfin la maturité était de 13 j plus précoce, lorsque le semis avait lieu en automne ou en avril. En outre, le rendement grainier était en moyenne de 38 % supérieur, l’avantage étant plus prononcé et plus constant dans les parcelles installées sur chaume que sur celles établies sur jachère, vraisemblablement à cause de l’absence de formation de croûte à la surface du sol et de la protection contre la chaleur et le vent assurée par le chaume. Quant au poids des graines, la réponse à la période de semis était semblable à celle observée pour le rendement, ce qui indique que la réponse positive du rendement tient en partie à la grosseur plus grande des graines. La teneur en huile des graines était également supérieure pour les semis d’automne et d’avril, encore que l’avantage soit plus faible (seulement 6 %) que dans le cas du rendement grainier. Le canola semé en automne et en avril tolérait bien les gelées de printemps et sa floraison survenait avant l’arrivée des chaleurs excessives et de la sécheresse ce qui se répercutait favorablement sur le rendement et sur la qualité des graines. Les producteurs de canola des régions semi-aridies disposent donc d’une solution praticable et durable pour diversifier leurs systèmes culturaux. **Mots clés:** Date de semis, dormant, jachère, tolérant aux herbicides, système cultural de remplacement

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Canola production in most regions of the Canadian prairies often is limited by a short frost-free growing season, hot, dry periods in July during flowering and seed set, and cool wet
conditions at harvest in September. Alternative management practices such as fall and early spring seeding dates would be a major economic benefit to prairie producers because they would allow canola to better utilize moisture from the spring snow melt and avoid environmental stress.

Interest in fall- and early spring-seeded canola began in the early 1970s with a 4 yr study conducted at the University of Saskatchewan (Austenson and Kirkland 1975). Fall-seeded Argentine rapeseed (*Brassica napus* L.) yield was 22% (as high as 90%) greater than spring-seeded rapeseed. This average yield advantage occurred despite one year when yield was 81% lower with fall vs. spring seeding date. The failure with fall-seeded rapeseed was attributed to warm weather in November that promoted germination, resulting in frost damage and consequently a thin stand in the spring. Inadequate control of winter annual weeds also was identified as a factor contributing to the failure of fall-seeded rapeseed in the early 1970s.

Early spring compared with traditional mid-May seeding dates offer many of the same advantages that are obtained with fall seeding. Canola sown in the first 2 wk of May rather than at the end of May increased *B. napus* seed yields from 24% (Degenhardt and Kondra 1981; Kondra 1977) to greater than 50% (Johnson et al. 1995), and oil concentrations by 1% (Johnson et al. 1995). Johnson et al. (1995) observed that emerged canola seedlings tolerated temperatures down to as low as −6°C. Furthermore, they found that canola seeded before mid-May avoided hot and dry periods during critical reproductive growth periods. Results from another study confirmed that cooler and moister growing conditions during flowering and seed set explained improved canola yield and quality (Nuttall et al. 1992).

Past research suggests that canola seeded in the fall or early spring can survive low spring temperatures, and will encourage flowering and seed set in cooler and wetter conditions. Better weed control options with herbicide tolerant canola cultivars will improve winter annual weed control. Maintaining better stubble retention and late winter snow cover with direct seeding systems, which are being rapidly adopted by producers, should reduce the risk of premature germination of fall seeded canola. Reduced potential for weed competition and premature germination reduce the risks associated with seeding canola at dates earlier than the traditional mid-May seeding date. The objective of this study was to determine if alternative seeding dates in late October and mid- to late April could be used to advance canola plant development, thus improving seed yield and quality relative to traditional mid-May seeding dates.

### MATERIALS AND METHODS

#### Site Description and Experimental Design

The study was conducted at the Agriculture and Agri-Food Canada Research Farm located near Scott, SK, from 1994 to 1998. The soil type is a Dark Brown Chernozem (Typic Boroll) with loam texture (sand = 31%, silt = 42% and clay = 27%), pH = 6.0, and organic matter content of 3 – 4%. Sites were established on tilled fallow (1993–1998) and stubble (1995–1998).

### Table 1. The calendar dates when seeding operations occurred for the seeding date treatments at Scott, SK.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall</th>
<th>April</th>
<th>Mid-May</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>27 Oct</td>
<td>25 Apr</td>
<td>10 May</td>
</tr>
<tr>
<td>1995</td>
<td>28 Oct</td>
<td>1 May</td>
<td>9 May</td>
</tr>
<tr>
<td>1996</td>
<td>31 Oct</td>
<td>2 May</td>
<td>23 May</td>
</tr>
<tr>
<td>1997</td>
<td>28 Oct</td>
<td>25 Apr</td>
<td>15 May</td>
</tr>
<tr>
<td>1998</td>
<td>30 Oct</td>
<td>16 Apr</td>
<td>19 May</td>
</tr>
</tbody>
</table>

*Fall seeding dates occurred in the previous year.

The experimental design was a randomized complete block with four replicates and canola seeding date as the treatment. Canola was seeded in: (1) late October (fall-seeded) close to the time when surface soil temperatures were near 0°C; (2) mid- to late April (April-seeded) as soon as fields were passable with seeding equipment; and (3) the more traditional 15 – 20 May period (mid-May seeded) (Table 1). Glyphosate was applied to mid-May seeded plots just prior to seeding operations at a rate of 450 g a.i. ha⁻¹ with flat fan nozzles at a pressure of 275 kPa and 50 L ha⁻¹ of water. Pre-seeding weed control was not necessary for fall- and April-seeded canola. Herbicide tolerant *Brassica napus* L. canola (RT-73, Quest) was seeded into 4 m × 5 m plots with a hoe drill equipped with 1.9 cm wide hoe-openers at a row spacing of 23 cm spacing with on-row packing wheels. Fertilizer N, P, K and S were applied with the seed at rates according to yearly soil test recommendations for all seeding dates for a particular site. Nitrogen requirements exceeding safe rates within the seed row were mid-row banded during seeding operations. Postemergent weed control was achieved with glyphosate at 450 g a.i. ha⁻¹ applied at the 2 – 3 leaf stage of canola with flat fan nozzles at a pressure of 275 kPa and 50 L ha⁻¹ of water.

Canola plant density was determined by counting seedlings in two 1 m row lengths, one at the front and the other at the back of each plot, 2 wk after emergence. The timing of major plant development stages (seedling emergence, 50% flowering, maturity, grain harvest) was recorded during the growing season. One assessment of plant development stages was made for all plots of a given treatment. The date when seed rows were visually distinguishable was noted as the date of emergence. Date of 50% flowering was determined by recording when 50% of the flowers occurred on the main raceme (Lancashire et al. 1991). The vegetative growth period was considered as the number of days between emergence and 50% flowering. The reproductive growth was considered as the number of days between 50% flowering and maturity. Plant height was measured just prior to harvest. Plots were windrowed with a swather 3.7 m in width. Canola seed samples were harvested with a small-plot combine, dried to 10% moisture content, cleaned and weighed to determine seed yield. A 1000-seed subsample was weighed to determine seed weight. Infrared spectroscopy was used to measure the oil content of each seed sample (Robertson and Morrison 1974).
Statistical Analysis
Data from the fallow and stubble sites separately were analyzed with the PROC MIXED procedure of the SAS Institute Inc. (Littel et al. 1996), with blocks considered as a random effect, and site and seeding date as fixed effects. The SLICE option of PROC MIXED was used to investigate the effect of seeding date for each year when significant year by seeding date interactions were detected. A second analysis was conducted with sites and blocks as a random effect, and seeding date as a fixed effect, to obtain more general (inference beyond the sites included in the study) conclusions regarding the average influence of canola seeding dates. Treatment effects were declared significant at \( \alpha = 0.05 \).

RESULTS AND DISCUSSION
Emergence and Seedling Density
Canola emergence occurred as early as 21 April for fall-seeded canola and as early as 30 April for April seeded canola (Fig. 1). On average, fall-seeded canola emerged 30 d earlier (range of 19 to 36 d) and April-seeded canola emerged 18 d earlier (range of 7 to 26 d) than canola seeded in mid-May. Generally, canola seedling density was greater on the April and the mid-May seeding dates in the fallow experiment (Table 2). Surface crusting occurred on the fallow sites in 1996, contributing to sparser seedling stands for the fall seeding date. Canola plant density on fallow in 1994 survived eight consecutive nights of frost, with temperatures dropping as low as \(-8^\circ\)C. Researchers in North Dakota also observed that canola seedlings were able to tolerate temperatures of \(-6^\circ\)C without significant reductions in plant stand (Johnson et al. 1995). However, frost caused significant damage to fall-seeded canola at another location, not included in this portion of the overall study, in 1998 (unpublished data). Others also have shown that canola seeded prior to 8 May suffered significant frost damage (Gross 1963). Furthermore, late winter and early spring temperature fluctuations were detrimental to the survival of volunteer canola seedlings (Sparrow et al. 1990).

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The ability of canola to tolerate freezing temperatures may
be a function of growth stage. Gusta and O’Connor (1987) reported that canola leaves acclimated better to temperatures between –7°C to –10°C than cotyledons. Their results indicated that canola must have at least its first true leaf stage to properly acclimate to freezing temperatures. The ability of stubble to dampen daytime heating fluctuations at the soil surface that could cause premature germination, in addition to reduced soil crusting and wind damage, explains why fall- and April-seeded canola consistently had better seedling stands on stubble than on fallow.

Mid-season Plant Development
Fall-seeded canola reached 50% flower 26 d earlier (range of 8 – 35 d) than canola seeded in mid-May, on average (Fig. 1). April-seeded canola emergence and 50% flower occurred about 2 wk later than for fall-seeded canola. The length of the vegetative growth period (emergence to 50% flower) did not differ among seeding dates when averaged across the fallow and stubble sites. Fifty percent flowering generally occurred in the first 2 wk of June or near to mid-June for earlier seeding dates compared with the first part of July for the mid-May seeding date. Fall-seeded canola flowered an average of 10 – 15 d longer than canola seeded in mid-May, although the length of the flowering period varied widely between years (results not shown). For example, the flowering period in 1997 was 21 d for the fall seeding date and 11 d for the mid-May seeding date. The reproductive growth period (50% flower to maturity) was 10 d longer for the fall seeding date (50 d) compared with the April and mid-May seeding dates (40 d). Reproductive growth was sustained an additional 19 d by seeding canola in the fall in 1996. Chronological differences between seeding dates diminished nearer to harvest, with swathing (maturity) and harvesting operations occurring 15 d (range of 7 – 21 d) earlier for fall seeding, and 11 d (range of 3 – 18 d) earlier for April seeding, compared with the mid-May seeding. In other studies, the number of days from planting to first flower appearance was greater with canola planted in mid- to late April and the first 2 wk of May rather than the last 2 wk of May (Gross 1963; Degenhardt and Kondra 1981; Johnson et al. 1995). However, seeding date had minimal effects on the duration of flowering and reproductive periods (Degenhardt and Kondra 1981; Johnson et al. 1995). Therefore, alternative seeding dates advanced canola development throughout

Table 3. The effect of seeding date on canola height for two experiments at Scott, SK

<table>
<thead>
<tr>
<th>Experiment / year</th>
<th>Fall</th>
<th>April</th>
<th>May</th>
<th>LSD</th>
<th>ANOVA a (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow 1996</td>
<td>78</td>
<td>78</td>
<td>79</td>
<td></td>
<td>0.946</td>
</tr>
<tr>
<td>1997</td>
<td>84</td>
<td>84</td>
<td>88</td>
<td>7</td>
<td>0.550</td>
</tr>
<tr>
<td>1998</td>
<td>71</td>
<td>93</td>
<td>122</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>All</td>
<td>78</td>
<td>85</td>
<td>96</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Stubble 1996</td>
<td>69</td>
<td>66</td>
<td>85</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>1997</td>
<td>60</td>
<td>77</td>
<td>69</td>
<td>10</td>
<td>0.001</td>
</tr>
<tr>
<td>1998</td>
<td>61</td>
<td>87</td>
<td>114</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>All</td>
<td>63</td>
<td>77</td>
<td>89</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>All w</td>
<td>70</td>
<td>81</td>
<td>93</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

a The LSD for the effect of seeding date in each year.

The LSD to compare means averaged across years for each experiment.

Means and the LSD to compare means averaged across the random effect of the experiment by year combinations.

Fig. 2. The effect of seeding date on canola seed yields for two experiments at Scott, SK. The LSD 0.05 is presented to compare means for each year by seeding date combination, averaged across years for each experiment, or averaged across the random effect of the experiment by year combinations. The P value represents the ANOVA results for the effect of seeding date in each year.
the growing season, with fall seeding particularly hastening flowering and prolonging the reproductive period.

Canola height was greatest with the mid-May seeding date in all years on stubble and in 1998 on fallow (Table 3). Shorter plant height for fall and April seeding dates would reduce the potential for lodging, a common problem with canola. A more upright plant canopy would reduce the risk of losses from diseases such as sclerotinia in sub-humid regions (*Sclerotinia sclerotiorum* Lib.) (R. Kutcher and K. Turkington, personal communication) and make harvest operations easier.

**Yield and Quality**

Fallow-seeded canola seed yields for the fall and April seeding dates were approximately 300 kg ha\(^{-1}\) greater than the mid-May seeding date, on average (Fig. 2). On a year-by-year basis, seeding date had inconsistent effects on fallow-seeded canola yield in 4 of 5 yr and no effect in the remaining year. Stubble-seeded canola seed yield was 51 – 126% higher for the fall and April seeding dates compared with the mid-May seeding date in all years with one exception. In 1997, canola seeded into stubble yielded similarly when seeded in April or mid-May. Oil content of canola seed was 5 – 20% greater for the fall and/or April seeding dates compared with the mid-May seeding date in five of the 16 possible fallow/stubble by year combinations (Table 4). Seeding date otherwise had no effect on oil content, with the exception of reduced oil content for canola seeded into stubble in April rather than mid-May in 1997. The effect of seeding date on seed weight generally was similar to that for seed yield across all study sites (Table 5). Canola seeded in the fall and April rather than mid-May had greater seed yield, seed weight and oil content with site as a random effect in the analysis (Fig. 2 and Tables 4 and 5). Others also have found that higher seed yield and oil content occurred when canola was seeded in early May rather than toward the middle or end of May (Kondra 1977; Degenhardt and Kondra 1981; Johnson et al. 1995). Canola yield and quality can be improved by seeding canola in late fall or early spring seeding dates rather than closer to the more traditional mid-May seeding date, especially when seeded into stubble.

The influence of alternative seeding dates on canola yield and quality often occurred through factors other than plant density. Lower seedling density corresponded with less seed yield with the fall and mid-May seeding dates compared with the April seeding date at the fallow sites in 1996 and 1997, and at the stubble site in 1996. With the exception of the fallow site in 1996, the seeding date effect on canola stand density was much greater than that for seed yield. At the other sites, the effect of canola seeding date on seed yield often did not correspond with effects on plant density. Therefore, the influence of seeding date on canola seedling density was not a primary factor determining yield responses. Past research showed that lower canola seeding rates had minimal effects on seed yield (Kondra 1975; Degenhardt and Kondra 1981). Apparently, canola yield components can compensate for thinner plant stands, especially when more of the growing season is made available for the additional growth. The compensatory nature of canola explains why the occasional occurrence of additional seedling mortality with fall seeding was not detrimental to yield.

Most of the advantage with alternative canola seeding dates likely was associated with the avoidance of extreme growing conditions. Planting canola just prior to soil freezing in late October or just after fields are passable in mid- to late April allowed canola to flower in early to mid-June rather than early to mid-July. Mean daily air temperatures almost always were about 2°C cooler in all of June compared with the first 2 wk of July (Table 6). Maximum daily
air temperatures in the first 2 wk of June were as much as 5°C cooler than in the time period spanning from mid-June to mid-July. Cumulative precipitation was 39% greater in the last 2 wk of June than in the first 2 wk of June or July. Lower daily mean and maximum temperatures in June, and moister conditions in the later part of June, would allow canola seeded in the fall or April to flower during cooler and wetter growing conditions, the conditions best suited to canola production. Ideal growing conditions for canola flowering and seed development would explain why seed yield, and to a lesser extent oil content, were greater for the alternative seeding dates. Higher than normal air temperatures in the first 2 wk of June in 1997 corresponded with seed weight and oil content for the fall or April seeding dates that were similar or reduced to those for the mid-May seeding date, thus reiterating the importance of extreme temperatures as a yield-controlling factor. Another study found that the seed yield of canola sown in mid-May was in the early stages of flowering during the last 2 wk of June. The warm, humid conditions that characterized this growth period (Table 6) would be ideal for the development of sclerotinia infections (Turkington et al. 1991), and consequently could contribute to lower yields with the mid-May seeding date (R. Kutcher and K. Turkington, personal communication). Therefore, alternative seeding dates also could be an integrated management option to minimize canola disease losses, especially in sub-humid regions.

The yield advantage of seeding canola in the fall, as first reported by Austenson and Kirkland (1975) two decades ago, can now be realized consistently on a field scale basis. Late fall seeding into standing stubble shows considerable potential to improve the yield and quality of canola, especially in semi-arid regions, by encouraging early reproductive growth when air temperatures are cooler. Previously reported problems with the control of winter annual weeds are no longer an issue with the herbicide-tolerant canola cultivars available to producers. Also, the availability of equipment that can effectively seed directly into standing stubble will decrease the risk of fall germination compared with fall-seeded canola sown on fallow. Furthermore, our results indicate that early spring seeding dates offer similar benefits when the fall seeding date is not a viable option. Alternative seeding dates also would spread out seeding operations for producers with larger acreages.

Topographic variation and associated changes in environmental conditions across a field may determine the successful establishment of canola seeded in the fall or in April. An understanding of this variation may provide insight into the successes and failures that producers observe with alterna-
tive seeding dates at the field scale. Development of dormancy enhancers and/or seed protectants would prevent imbibition of water during the late fall, with their effects completely disappearing when the soil thaws in the spring. Therefore, the successful development of enhancers/protectant products could reduce the risks associated with erratic temperature fluctuations and permit seeding 10 – 15 d earlier in October, a more practical window to carry out seeding operation. Further research into the most appropriate seeding depth, seeding rates, seeding methods, nutrient placement and the importance of fungicide seed treatments and factors affecting acclimation (e.g., seedling vigour), also may improve the viability of fall and early spring seeding dates.

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