Effects of Low Initial Stand Density on Canola Performance

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Introduction

Canola (*Brassica napus* L.) emerged as an alternative crop in North Dakota after 1985 when the U. S. Food and Drug Administration granted its oil generally recognized as safe (GRAS) status (Berglund and McKay, 2002). Canola production has rapidly increased from 7300 ha in 1991 to 526 000 ha in 2002 (USDA-NASS, 2003).

Adequate stand establishment is essential in attaining optimum canola performance. Use of ideal tillage-planting systems can reduce the risk of poor stands; however, uncontrollable factors, such as unfavorable weather, may cause less than optimum stands. The commercialization of herbicide-resistant canola cultivars has given producers the ability to control increased weed pressure caused by poor stands. Although herbicide-resistant canola eases weed control in poor stands, low stand densities that result in reduced yield compromise crop performance. Verification of canola performance at low stand densities would benefit producer decisions regarding replanting of canola or an alternative crop.

The objective of this research was to evaluate the effect of stand density on the performance of canola by considering cultivar, row spacing, and stand density effects on yield with specific emphasis on determining the point at which it becomes prudent to re-plant.

Materials and Methods

Field studies were conducted in North Dakota during 2002 and 2003 at Prosper (46° 58’ N, 97° 4’ W, elevation 220 m) and Carrington (47° 30’ N, 99° 08’ W, elevation 489 m) and at Langdon (48° 46’ N, 98° 21’ W, elevation 492 m) in 2003. Fertility was raised to a level sufficient to attain a 2800-kg ha^{-1} canola yield. Current best management practices were followed. Previous crop was hard red spring wheat at Carrington and Prosper, and fallow at Langdon. Roundup Ready® hybrid ‘Hyola 357 RR’ and open-pollinated ‘Minot RR’ were sown on a pure live seed basis in 15- and 30-cm rows to target plant stand densities of 11, 22, 32, 43, 54, 97, and 140 plants m^{-2}. The seed treatment, Helix XTra®, was used to protect against seedling fungal diseases and flea beetles (*Phyllotreta cruciferae* Goeze). The insecticide Capture® was applied as necessary for additional flea beetle control. Weed control was achieved by applying trifluralin at

Prosper and Langdon and glyphosate as necessary at all locations. Data were determined from an area 1.2 by 7.6 m from the interior of each plot. Plots were swathed at maturity, 20 to 30% of seeds on main stem have turned brown (Berglund and McKay, 2002), and combine-harvested when dry. Study management dates appear in Table 1.

Table 1. Study management dates at Carrington and Prosper during 2002, and Carrington,

Langdon, and Prosper during 2003.

		Initial	Swathing		Combining	
Environment	Seeding	stand count	H357†	Minot‡	H357	Minot
Carrington 2002	14 May	11 June	9 August	9 August	16 August	16 August
Carrington 2003	1 May	4 June	7 August	14 August	14 August	29 August
Langdon 2003	14 May	18 June	18 August	18 August	2 September	2 September
Prosper 2002	18 May	18 June	1 August	9 August	5 August	14 August
Prosper 2003	3 May	2 June	31 July	6 August	11 August	13 August

† H357, Hyola 357 RR

‡ Minot, Minot RR

The experimental design was a split-plot arrangement of a randomized complete-block with four replicates. Row spacing was considered the whole plot with sub-plots a factorial arrangement of cultivar and stand density. Means separation was performed using a Fisher’s-protected LSD at the 0.05 level of significance (Steel and Torrie, 1980). One location in one year was termed an environment and considered a random effect. All other factors were considered fixed effects.

To further explain the significant cultivar by stand density interaction for yield, least squares regression analysis was performed. Linear, quadratic, and cubic coefficients were tested for significance at the 0.05 level with the residual mean square and appropriate curves fit. A different regression equation was fit for each cultivar.

Results and Discussion

A significant environment by stand density interaction for yield indicated the stand densities performed differently among environments (Table 2). Dry conditions and temperatures well below average at the Carrington 2002 and Prosper 2002 environments delayed planting and inhibited early plant development and therefore yield. Kirkland and Johnson (2000) reported that planting canola in late April or very, early May in Scott, SK produced higher yield compared to planting in mid-May.

Another factor that may have contributed to the low yield at the Carrington 2002 and Prosper 2002 environments was the number of hot days during flowering and pod development. Angadi et al. (2000) showed that a daily maximum air temperature of 28°C during early pod development reduced yield in a growth chamber study. Prosper averaged 11 d with daily maximum air temperatures at or above 28°C, while Carrington and Langdon averaged 5 d at or above 28°C. Nuttal et al. (1992) reported that grain yield in canola was positively correlated to total precipitation and negatively correlated to mean maximum daily temperature for the months of July and August at Melfort, SK. This corresponds to the time for flowering and pod development in that area and agrees with Angadi et al. (2000).

At Carrington 2003, a cool, wet period during emergence slowed development. These cool wet conditions hindered timely herbicide application and may have allowed emerging weeds to compete and reduce yield. Martin et al. (2001) concluded that canola should be kept weed-free until the four- to six-leaf stage to avoid greater than 10% yield loss. They also determined that the length of the necessary weed-free period was shorter when planting was delayed. This supports the conclusion that even though the early weather conditions were similar at Carrington 2002 and Carrington 2003, the lower stands were able to tolerate the early season weeds and produce greater yield at Carrington 2002 because they were planted later. Additionally, lingering cool conditions at the Carrington 2003 environment resulted in slowed plant development and lower than regional average yields.

At the Langdon 2003 and Prosper 2003 environments, temperatures were near normal, with significant rainfall in May followed by dry conditions throughout the rest of the growing season. Yields were good to exceptional for their respective regions. Canola followed fallow at the Langdon 2003 environment, which probably enhanced yield.

Table 2. Yield at five environments and seven stand densities, averaged across two row spacings and two cultivars.

	Environment				
Stand density	Carrington 2002	Carrington 2003	Langdon 2003	Prosper 2002	Prosper 2003

plants m^{-2}	kg ha^{-1}				
11	521	261	682	71	641
22	770	414	1616	163	1270
32	865	613	2097	239	1590
43	999	786	2590	294	1703
54	1003	896	2774	382	2039
97	1168	1117	3382	440	2421
140	1148	1333	3787	510	2681
LSD (0.05)	153				

The cultivars yielded differently in response to stand density. The main effects of cultivar and stand density were also significant. Hyola 357 RR yielded more than Minot RR at all stand densities (Table 3). The more vigorous hybrid cultivar, Hyola 357 RR, compensated better for low stands than the open-pollinated, Minot RR.

Table 3. Yield of two cultivars and seven stand densities, averaged across five environments and two row spacings.

	Cultivar	
Stand density	Hyola 357 RR	Minot RR
plants m^{-2}	kg ha^{-1}	
11	648	218
22	1207	487
32	1452	709
43	1680	868
54	1801	1036
97	2093	1319
140	2295	1489

LSD (0.05)	122

Regression analysis of the cultivar by stand density interaction generated regression equations for each cultivar between stand densities of 11 plants m^{-2} and 140 plants m^{-2}. Figure 1 shows a plot of the observed yield and the yield predicted by the regression equations for each cultivar. The regression equation for Hyola 357 RR is:

$$Y = 132.39 + 57.28x - 0.59x^2 + 0.0020x^3$$

The regression equation for Minot RR is:

$$Y = 25.30 + 22.98x - 0.09x^2$$

Where Y is yield in kg ha^{-1} and x is stand density in plants m^{-2}. These regression equations can reasonably predict yield at any stand density between 11 and 140 plants m^{-2} for these two cultivars even though only seven of those stand densities were evaluated in the trial. With these equations a grower could use his input costs and potential return to calculate the yield necessary to achieve the break-even point, and then calculate the necessary stand density. This would greatly simplify the decision whether to replant when less than optimum stand density occurs. Using 1000 kg ha^{-1} as the minimum yield goal, the minimum necessary stand density for Hyola 357 RR would be 19 plants m^{-2}, while Minot RR would require 54 plants m^{-2}. Future research could investigate the validity of these equations for other cultivars.

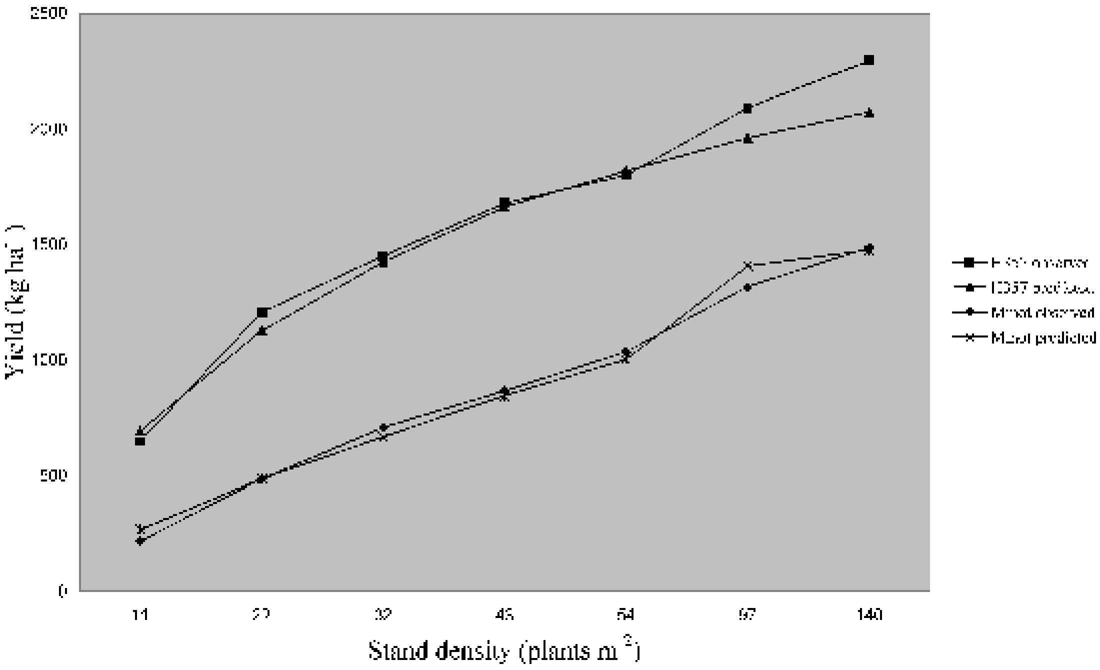

Fig. 1. Regression analysis of the cultivar by stand density interaction for yield showing

observed and predicted values for Hyola 357 RR (H357) and Minot RR (Minot).

Summary

The objective of this research was to evaluate the influence of row spacing, cultivar, and stand density on canola yield under lower than recommended stand densities. A significant cultivar by stand density interaction showed both Hyola 357 RR and Minot RR produce higher yield at higher stand densities, but Hyola 357 RR produces higher yield than Minot RR at all stand densities. Regression analysis showed that the open-pollinated cultivar, Minot RR, needed a higher stand density than the more vigorous hybrid cultivar, Hyola 357 RR, to achieve similar yield. Using 1000 kg ha^{-1} as the minimum yield goal, the minimum necessary stand density for Hyola 357 RR would be 19 plants m^{-2}, while Minot RR would require 54 plants m^{-2}.

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