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PROGRESS ON CANOLA PRODUCTION

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ABSTRACT

Establishment and winter survival are two major challenges of growing winter canola (*Brassica napus* L.) in the central Great Plains. The first study evaluated five planting dates between August 15 and October 15 and two tillage methods (conventional tillage and no-till) on winter canola fall plant density, fall crown height, fall vigor, winter survival, spring plant density, spring vigor, and yield. Planting date affected all measurements whereas tillage affected only yield. Conventional tillage yielded 8% more than no-till. Canola needs to be planted earlier than previously recommended, between August 15 and September 1 for successful winter survival and seed production in western Kansas. The second study evaluated two different varieties 'Griffin' and 'Wichita' grown with and without a companion crop (spring triticale, winter triticale, Daikon radish, and Shogoin turnip) and managed with and without fall simulated grazing (hay). Treatment effects (variety, companion crop, and fall grazing) on winter canola fall plant density, fall vigor, winter survival, spring plant density, spring vigor, grain yield, forage yield, forage quality, and grain oil content were quantified. Grazing or haying canola in the fall reduced grain yield 30–50% and decreased the yield of a more upright growth variety (Wichita) more than a prostate growth variety (Griffin). Companion cropping decreased canola fall stand, winter survival, spring stand, and grain yield. Companion crops can improve fall forage production. The results from this study indicate canola grown for grain should not be grown with a companion crop or in a dual-purpose system.

INTRODUCTION

Establishment and winter survival are two major challenges of growing winter canola in the central Great Plains. The first study evaluated the effect of planting date and tillage method on winter canola survival, vigor and yield to determine if planting practices could overcome production challenges. Growing a companion crop or grazing canola in the fall might affect winter survival and grain yield of canola, but it might also provide more options and economic incentive to growing the crop if winter survival or forage production are increased. The second study evaluated the effects of companion cropping and fall grazing on winter canola survival, forage yield, and grain yield.

The southern Great Plains has sufficient growing degree days to produce 120 to 150 days of grazable wheat pasture that can be either grazed out in the spring or harvested for grain after grazing in a dual-purpose system. Producing winter wheat in a dual-purpose system is a unique and economically important resource. Winter wheat provides economical, high-quality forage at a time of the year when few other quality forage sources are available. It is estimated that 3.2 million ha (7.9 million acres) of winter wheat in the southern Great Plains are grazed annually in a dual-purpose system (Carver et al., 2001). Winter wheat that is harvested for grain can be grazed in the late fall and early spring without reducing grain production as long as cattle are removed before wheat development reaches first hollow stem, soil moisture is adequate, and recommended growing practices are implemented (Khalil et al., 2002; Redmon et al., 1996; Virgona et al., 2006). Grazing occasionally increased yield of tall winter wheat varieties by reducing plant height, which resulted in less plant lodging (Redmon et al., 1995). Insufficient information is available on the effects of grazing canola, yet producers need this information. Previous research found companion-cropping winter annual legumes with winter triticale increased survival of the winter legume. Growing a companion crop with winter canola might affect its winter survival and forage yield.

MATERIAL AND METHODS

Field studies were conducted at the Kansas State University Southwest Research-Extension Center in Garden City, KS (37°59’7”N, 100°48’52”W, elevation 2,862 ft). Average annual precipitation was 19.3 in. Soil type was a Ulysses silt loam soil (fine-silty, mixed, superactive, mesic Aridic Haplustolls) with pH 7.8 and 1.8% organic matter in the top 6 in. of soil.

Planting Date

Winter canola was seeded with conventional tillage and no-till every two weeks from August 15 through October 15 from 2007 through 2009 in a randomized complete block with four replications. Winter canola was measured in each plot for fall plant density, vigor, and crown height. The same plot region was resampled for winter survival, and spring plant density and vigor. Plots were harvested with a small plot combine and yield was adjusted to 12% moisture content using a grain analysis computer.

Companion Crop and Grazing

The experimental design was a randomized split-plot with four replications. Main plot treatment was canola variety (Griffin or Wichita) and companion crop treatment (none, spring triticale, winter triticale, radish, and turnip), and split-plot treatment was managed with or without simulated fall grazing (haying). Winter canola was planted in the fall on August 30, 2010, and September 6, 2011, into a conventional-tillage seedbed. Wheat was grown preceding canola in 2010, and corn was grown preceding canola in 2011. Both Griffin and Wichita were planted at 5 lb/a, 0.75 in. deep, using a double disk opener and fluted coulter with 8-in. row spacing. Companion crops were planted with canola in 2010. In 2011, canola and cover crops were planted in alternate 8-in. rows, so canola and companion crops were planted using 16-in. row spacing. Companion crops were seeded using 38 lb/a for spring triticale, 35 lb/a for winter triticale, 4.5 lb/a for Diakon radish, and 1.75 lb/a for Shogoin turnip. Preplant herbicides consisted of 1.43 lb a.i./a pendimethalin (Prowl) and 0.75 lb a.e./a glyphosate. On September 17, 2010, 0.094 lb a.i./a clethodim (Select) plus 1% v/v crop oil concentrate was applied to control volunteer wheat in the plots without triticale; on April 1, 2011, 0.055 lb a.i./a quizalofop (Assure II) plus 1% crop oil v/v concentrate was applied to control volunteer wheat and triticale in all plots; and on March 20, 2011, 0.094 lb a.i./a clethodim plus 1% v/v crop oil concentrate was applied to control volunteer wheat and triticale in all plots. On

October 12, 2010, 0.062 lb a.i./a lambda-cyhalothrin (Warrior) was applied to control Diamondback moth. Insect pest densities were not great enough during the 2011–2012 growing season to require an insecticide application. One-half of each main plot was clipped 1.75 in. high and bagged (hay) to simulate grazing on October 26, 2010, and November 4, 2011.

Irrigation was applied with an overhead sprinkler throughout the growing season using an irrigation scheduling program with irrigation applied at 50% available soil water (Clark et al., 2002), with 12.68 in. applied in 2010–2011 and 14.58 in. applied in 2011–2012. Fertilizer was applied based on soil test recommendations. In 2010, 5.5 lb nitrogen (N)/a and 26 lb phosphorus (P_2O_5)/a as monoammonium phosphate (11-52-0 N-P-K), plus 9 lb sulfur (S)/a was applied at seeding banded 1 in. to the side and 2 in. deep (1 × 2). An additional 70 lb N/a was broadcast-applied as urea (46-0-0) on October 18, 2010, and March 14, 2011, for a total of 140 lb N/a. In 2011, 5.5 lb N/a and 26 lb P_2O_5/a as monoammonium phosphate (11-52-0), plus 9 lb S/a was applied at seeding banded 1 in. to the side and 2 in. deep (1 × 2). An additional 110 lb N/a was broadcast-applied as urea (46-0-0) on February 29, 2012.

Within each plot, four permanently marked 3-ft rows were used for fall and spring plant density to determine winter survival. Fall plant density and vigor were quantified mid-November, and spring plant density and vigor were quantified early April. Plant vigor was visually determined using a scale of 1 to 10 (0 = dead and 10 = robust plant). Canola was harvested July 7, 2011, and June 19, 2012, from a 6.5-ft-wide by 30-ft-long area using a plot combine (Delta, Wintersteiger Inc., Salt Lake City, UT). A seed subsample was collected at harvest and moisture content was measured with a grain analysis computer (GAC 2100, Dickey John, Auburn, IL). Data were analyzed with PROC MIXED, residual maximum likelihood method, in SAS (SAS Institute Inc., Cary, NC). Replication and replication × year were considered random effects, and all other effects including year were considered fixed in the model. Treatment effects were considered significant at $P \leq 0.05$, and least squares means were separated by independent pairwise *t*-tests at a significance level of $P \leq 0.05$ (PDIFF option).

RESULTS AND DISCUSSION

Planting Date

Fall growth

Plant density was greatest at later planting dates (Table 1). Earlier planting dates had larger plants and more intraspecific competition, which resulted in fewer plants. Final plant density is more critical for determining yield than fall density, but fall density and winter survival need to be sufficient for an adequate final plant density.

Crown height decreased with later planting dates (Table 1), because later planted canola was smaller. Canola planted September 15 or later did not have an elevated crown. Crown height averaged across years was 0.69 in. when planted August 15 and 0.17 in. when planted September 1.

Winter survival

Winter survival is one of the greatest challenges of producing canola. Winter injury was greatest in 2009 (89%), although the earliest fall killing freeze and coldest temperatures occurred in 2010. In 2009 only the earliest planting date, August 15, had survival greater than 50%. The optimum planting date for winter wheat in the region is October 1, and winter canola was thought to be similar. Averaged across years, winter survival was greatest for planting dates of August 15 (57%) and September 1 (56%). Winter survival decreased with a later planting date, and no canola survived any year when planted October 15 (Table 2).

Producers reported greater canola winter injury when plant crowns were elevated above the soil surface. In this study higher crown heights caused by large plants and abundant fall growth did not cause winter injury ($P < 0.05$); rather, large plants and abundant fall growth improved winter survival. This study indicated that planting early and establishing a large plant was more critical to winter survival than crown height.

Tillage did not affect winter survival, although several other studies found survival improved with tillage. In Oklahoma, minimum tillage improved winter survival compared to no-till and was similar to conventional tillage. Oklahoma on-farm evaluations of a high-disturbance seed opener increased winter canola survival in no-till. In this study planting canola into soybean residue rather than winter wheat residue and using a coulter ahead of the seeding disk might have increased no-till winter survival.

Spring growth

Canola spring plant density is determined by fall plant density and winter survival. Spring plant density was greatest when planted between August 15 and September 15 (Table 2). Winter injury appeared to be caused primarily by canola breaking dormancy in the spring when temperatures start to warm (February and March) followed by temperatures dropping below freezing as in 2009. The slower spring regrowth of the earliest planted canola might have helped it avoid the early spring temperature fluctuations, thus suffer less winter injury.

Yield

Canola planted after September 15 did not consistently survive the winter or produce seed. Yields were greater when canola was planted September 1 (2,000 lb/a) than August 15 (1,700 lb/a) or September 15 (1,700 lb/a) (Table 3). In 2009 plots were not harvested because the border area planted on September15, 2008, winter-killed. In 2009, based on winter survival and spring plant density, only the August 15 or September 1 planting dates would have produced enough seed to harvest. Yields were reduced 8% with no-till (1,434 lb/a) compared to conventional tillage (1,556 lb/acre) ($P < 0.05$, LSD 93).

<u>Companion Crop and Grazing</u>

Growing Season

The 30-year average cumulative precipitation from September 1 through July 1 (typical growing season) was 13.95 in., and the average total annual precipitation was 19.19 inches. Between 2010 and 2012, precipitation was well below average, and irrigation was necessary. During the 2010–2011 growing season, 12.68 in. of irrigation was applied and 6.21 in. of precipitation was received between planting and harvest, for a total of 18.9 in. of moisture. During the 2011–2012 growing season, 14.58 in. of irrigation was applied and 8.69 in. of precipitation was received between planting and harvest, for a total of 23.3 in. The winter of 2011–2012 was a more favorable winter growing season than 2010–2011. During the winter of 2010–2011, temperatures fell below 0°F for 11 days on four separate occasions, reaching a low of -13°F. During 2011–2012 the lowest temperature reached was 0°F on only one occasion. Fall vigor, forage yield, winter survival, and spring stand were all greater in 2012 than 2011, which was likely due to warmer fall and winter conditions in 2011–2012 than 2010–2011. Grain yield was greater in 2011 than 2012, and test weight and 1,000-seed weight were greater in 2012 than 2011. Grain yield was likely greater in 2011 than 2012 due to a longer growing season in 2011. In 2012, temperatures increased early in the spring and canola was harvested about 3 weeks earlier than normal (canola was harvested July 7, 2011, and June 19, 2012). Temperature during grain fill was lower in 2012 than 2011, which created more favorable conditions for grain fill, resulting in greater test weight and seed weight in 2012.

Variety

Griffin grows more prostate than Wichita, but both varieties are well adapted to being grown in Kansas. Griffin and Wichita had similar fall and spring stand densities, plant vigor, winter survival, test weight, and forage yield. Averaged across 2011 and 2012, Griffin yielded 162 lb/a more grain than Wichita (Table 4).

Simulated Grazing (Haying)

Haying reduced yield of both varieties (Table 5), but the yield of Wichita was reduced more than Griffin. Haying reduced the yield of Griffin 34% and Wichita 48% (Table 4). Griffin's prostate growth likely protected the plant more from the damage of haying than the more upright growth of Wichita. The apical meristem of canola is elevated above the ground, whereas in wheat it remains in the crown until it begins to elongate at first hollow stem. This difference in growth allows the growing point in wheat to be protected from fall grazing but makes canola susceptible to injury. Haying canola reduced fall stand density, winter survival, spring stand density, and grain yield (Table 5).

Companion Crop

Companion cropping reduced canola yield in 2011, so companion crops were planted in alternate rows with canola in 2012 to attempt reducing the negative impact of companion cropping on grain yield; however, both planting methods (planted within row or alternate row) reduced yield equally (Table 6). Spring triticale had the least negative effect on yield and turnip had the most negative impact on yield. Spring triticale was terminated early in the fall with freezing temperatures plus herbicide applications. Some turnip and radish overwintered in 2012 due to the mild winter conditions and competed with canola. Turnip and radish reduced canola fall stand, winter survival, spring stand, and test weight (Table 6). Companion crops increased fall forage yield and varied by canola variety (Tables 4 and 6). Radish and turnip planted with Griffin produced more forage yield than radish or turnip planted with Wichita, and spring triticale and winter triticale planted with Griffin or Wichita produced similar forage yield (Table 4). The prostate growth of Griffin might have allowed more growth of turnip and radish, resulting in greater forage yield.

Table 1. Effect of planting date and year on canola fall plant density, fall crown height, and fall vigor from 2008 through 2010.

Planting date	2008	2009	2010	Planting date average[2]
		Fall plant density, plants/a		
August 15	187,000d	189,000d	223,000c	204,000c
September 1	270,000c	285,000bc	274,000c	283,000b
September 15	255,000c	302,000ab	329,000b	301,000b
October 1	362,000b	330,000a	494,000a	402,000a
October 15	484,000a	255,000c	514,000a	423,000a
LSD (0.05)[1]	46,000	38,000	54,000	26,000
Year average	311,000b	303,000b	368,000a	
		Fall crown height, in.		
August 15	0.7	0.6	0.7	0.7a
September 1	0.2	0.1	0.2	0.2b
September 15	0.0	0.0	0.0	0.0c
October 1	0.0	0.0	0.0	0.0c
October 15	0.0	0.0	0.0	0.0c
LSD (0.05)	0.1	0.1	0.1	0.1
Year average	0.2a	0.1b	0.2a	
		Fall vigor (0-10)		
August 15	9.5a	8.0a	7.5b	8.4a
September 1	9.3a	7.5a	8.8a	8.5a
September 15	8.3a	7.3a	7.4b	7.7b
October 1	6.3b	2.3b	4.3c	4.3c
October 15	2.0c	0.8c	4.0c	2.3d
LSD (0.05)	1.3	0.9	0.7	0.5
Year average	7.1a	4.7c	6.4b	

[1] Average of years 2008, 2009, and 2010.

[2] Planting date means in columns or year means in rows followed by different letters are statistically different at P = 0.05.

Table 2. Effect of planting date and year on canola winter survival, spring plant density, and spring vigor from 2008 through 2010.

Planting date	2008	2009	2010	Planting date average[2]
		Winter survival, %		
August 15	65b	54a	50b	57a
September 1	78a	19b	72a	56a
September 15	74ab	7bc	67a	49b
October 1	52c	0c	0c	17c
October 15	0d	0c	0c	0d
LSD (0.05)[1]	12	16	9	6
Year average	54a	11c	37b	
		Spring plant density, plants/a		
August 15	119,000b	112,000a	110,000c	114,000b
September 1	209,000a	62,000ab	196,000b	156,000a
September 15	189,000a	25,000bc	224,000a	143,000a
October 1	188,000a	0d	0d	63,000c
October 15	0c	0d	0d	0d
LSD (0.05)	56,000	5,000	19,000	21,000
Year average	141,000a	30,000c	103,000b	
		Spring vigor (0-10)		
August 15	6.3a	6.7a	7.0b	6.6a
September 1	6.8a	4.0b	8.3a	6.3a
September 15	6.5a	2.0c	6.9b	5.0b
October 1	4.5b	0.0d	0.0c	1.5c
October 15	0.0c	0.0d	0.0c	0.0d
LSD (0.05)	1.4	1.9	1.1	0.7
Year average	4.8a	1.8b	4.4a	

[1] Average of years 2008, 2009, and 2010.

[2] Planting date means in columns or year means in rows followed by different letters are statistically different at P = 0.05.

Table 3. Effect of planting date and year on canola yield in 2008 and 2010.

Planting date	2008	2009	2010	Planting date average[1]
			Yield, lb/a	
August 15	1,249	-[3]	2,196	1,744b
September 1	1,443	-	2,550	2,032a
September 15	1,172	-	2,344	1,745b
October 1	941	-	0	942c
October 15	0	-	0	0d
LSD (0.05)[2]	148	-	319	156
Year average	962b	-	1,427a	

[1] Average of years 2008 and 2010.

[2] Planting date means in columns or year means in rows followed by different letters are statistically different at P = 0.05.

[3] Canola was not harvested in 2009.

Table 4. Canola variety (Griffin and Wichita) stand, winter survival, grain yield, and forage yield differences affected by simulated fall grazing (haying) and companion crop.

Canola Variety	Spring Stand	Winter Survival	Grain Yield (9% moisture)		Forage Yield (DM)	
	$Plants^{-1}$ m row	%	kg/ha (lbs/acre)		kg/ha (lbs/acre)	
Griffin	10a†	58a	1494	1334a	3046	2719a
Wichita	10a	54a	1311	1171b	2730	2438a
			ANOVA P>F			
Source of Variation						
	NS	<0.1	<0.05		<0.1	
LSD 0.05	1	5	117	104	416	372
Variety*Hay						
Griffin Not-Hayed	-	-	1796	1603a	-	-
Griffin Hayed	-	-	1184	1057b	-	-
Wichita Not-Hayed	-	-	1727	1542a	-	-
Wichita Hayed	-	-	906	809c	-	-
			ANOVA P>F			
Source of Variation						
	NS	NS	<0.1		NS	
LSD 0.05	-	-	165	147	-	-
Variety*Companio						
Griffin None	13ab	-	-	-	2591	2313c
Griffin Spring	11bcd	-	-	-	2703	2413bc
Griffin Winter	12abc	-	-	-	2236	1996c
Griffin Radish	7e	-	-	-	3583	3199ab
Griffin Turnip	10bcd	-	-	-	4317	3855a
Wichita None	10bcd	-	-	-	2322	2073c
Wichita Spring	13abc	-	-	-	2682	2395bc
Wichita Winter	14a	-	-	-	2773	2476bc
Wichita Radish	10cde	-	-	-	2940	2625bc
Wichita Turnip	8de	-	-	-	2936	2621bc
			ANOVA P>F			
Source of Variation						
	<0.1	NS	NS		<0.1	
LSD 0.05	3	-	-	-	932	832

†Letters within a column and heading represent differences at LSD 0.05.

Table 5. Simulated grazing (hay) effects on stand, survival, and grain yield.

Hay	Fall Stand	Spring Stand	Winter Survival	Grain Yield (9% moisture)	
	Plants^{-1} m row	Plants^{-1} m row	%	kg/ha (lbs/acre)	
Not-Hayed	20a	14a	68a	1762	1573a†
Hayed	18b	8b	44b	1041	930b
			ANOVA P>F		
Source of Variation					
	<0.01	<0.0001	<0.0001	<0.0001	
LSD 0.05	2	1	5	117	104

†Letters within a column represent differences at LSD 0.05

Table 6. Companion crop effects on stand, survival, grain yield, test weight, and forage yield.

Companion	Canola Fall Vigor	Fall Stand	Spring Stand	Winter Survival	Grain Yield (9% moisture)		Test Weight		Forage Yield (DM)	
	(0-10)	Plants^{-1} m row	Plants^{-1} m row	%	kg/ha (lbs/acre)		kg/m^3 (lb/bu)		kg/ha (lbs/acre)	
None	9a	19ab	11ab	63a	1636	1460a†	620	48a	2456	2193c
Spring Triticale	7bc	19ab	12a	60a	1479	1321ab	626	49a	2693	2405bc
Winter Triticale	8b	21a	13a	59a	1451	1296b	618	48ab	2504	2236c
Radish	7c	17b	8c	48b	1388	1240b	602	47c	3261	2912ab
Turnip	7bc	17b	9bc	51b	1024	914c	604	47bc	3581	3197a
					ANOVA P>F					
Source of Variation										
	<0.0001	<0.05	<0.001	<0.01	<0.0001		<0.001		<0.01	
LSD 0.05	1	3	2	8	185	165	14	1	659	588

†Letters within a column represent differences at LSD 0.05.

CONCLUSIONS

These studies found that by using best planting practices and growing a variety adapted to the region winter survival and stand establishment challenges can be overcome. Establishing canola in the semi-arid region of the central Great Plains without irrigation will be challenging due to canola's shallow seeding requirement and the region's frequently dry soil conditions. Winter survival was affected by environment and planting practice. The largest factor that affected winter survival was planting date. In this region, canola must be seeded one month earlier than winter wheat or between August 15 and September 1 for successful production. In this study tillage did not impact winter survival, although other research found tillage or high disturbance seed openers increased winter survival. The high residue disturbance seed opener used in this study might have improved winter survival in no-till. Yield was affected most by winter survival. Yields in conventional tillage were 8% more than no-till. With more research, no-tillage winter canola yields might be increased and similar to convention-tillage. Grazing or haying canola in the fall reduced grain yield at least 30% with currently grown varieties. Varieties with prostate growth were affected less by grazing than varieties with more upright growth, yet grain yield of a prostate growth variety was still reduced. At this time, growing canola in a dual-purpose system is not recommended unless a 30–50% decrease in crop yield is acceptable. If growing canola in a dual-purpose system, producers should select a variety with the most prostate growth available. Companion cropping did not increase winter survival as it had with winter annual legumes and tended to decrease canola fall stand, winter survival, spring stand, and grain yield. Companion crops can improve fall forage production. Spring triticale had the least negative impact on grain yield, yet had some positive impact on fall forage production. Turnip and radish had the most negative impact on grain yield, but also increased fall forage production the most. Companion crops should not be grown with canola if the primary intent is to harvest canola for grain. The results of this study indicate canola grown for grain should not be grown with a companion crop or in a dual-purpose system.

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