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Effect of Residue Management, Row Spacing, and Seeding Rate on Winter Canola Establishment, Winter Survival, and Yield

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Abstract

Winter survival of canola (*Brassica napus* L.) is a challenge for producers using high-residue, no-tillage, or reduced-tillage systems. An innovative residue management system being developed by AGCO Corporation was compared to cooperating canola producers' residue management and planting methods in wheat stubble. This series of on-farm experiments was conducted in 2014-2015 and 2015-2016 at ten locations in central and south-central Kansas. The AGCO treatments were 20- or 30-in. row spacing and three seeding rates (100,000, 150,000, and 200,000 seeds/a) for a total of six treatments. The producer treatment at each location included row spacing, seeding rate, and residue management practices preferred by that producer. Due to winter stand loss, only one of the six experiments planted in the fall of 2014 was harvested for yield in 2015. All four experiments planted in fall 2015 were harvested for yield in 2016. Fall stands usually differed in response to seeding rate and often were greater in 20-in. rows than in 30-in. rows. Spring stands were not as tightly correlated with seeding rate, but were consistently greater in narrow rows, regardless of seeding rate and residue management practices. Winter survival increased with reductions in seeding rate at most locations and was greater in 20-in. rows than in 30-in. rows at three of the five harvested locations. Yields were not affected by residue management, row spacing, or seeding rate at two of the five locations, including the location with yields surpassing 60 bu/a. At the other three locations, yields with the AGCO residue management system equaled or exceeded yields obtained with cooperator practices that typically included much greater seeding rates. Yields seldom responded to seeding rate, but when they did, yields tended to increase as seeding rate decreased.

Keywords

canola, seeding rates, residue management, row spacing

Effect of Residue Management, Row Spacing, and Seeding Rate on Winter Canola Establishment, Winter Survival, and Yield

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Summary

Winter survival of canola (*Brassica napus* L.) is a challenge for producers using high-residue, no-tillage, or reduced-tillage systems. An innovative residue management system being developed by AGCO Corporation was compared to cooperating canola producers' residue management and planting methods in wheat stubble. This series of on-farm experiments was conducted in 2014-2015 and 2015-2016 at ten locations in central and south-central Kansas. The AGCO treatments were 20- or 30-in. row spacing and three seeding rates (100,000, 150,000, and 200,000 seeds/a) for a total of six treatments. The producer treatment at each location included row spacing, seeding rate, and residue management practices preferred by that producer. Due to winter stand loss, only one of the six experiments planted in the fall of 2014 was harvested for yield in 2015. All four experiments planted in fall 2015 were harvested for yield in 2016. Fall stands usually differed in response to seeding rate and often were greater in 20-in. rows than in 30-in. rows. Spring stands were not as tightly correlated with seeding rate, but were consistently greater in narrow rows, regardless of seeding rate and residue management practices. Winter survival increased with reductions in seeding rate at most locations and was greater in 20-in. rows than in 30-in. rows at three of the five harvested locations. Yields were not affected by residue management, row spacing, or seeding rate at two of the five locations, including the location with yields surpassing 60 bu/a. At the other three locations, yields with the AGCO residue management system equaled or exceeded yields obtained with cooperator practices that typically included much greater seeding rates. Yields seldom responded to seeding rate, but when they did, yields tended to increase as seeding rate decreased.

Introduction

Winter survival of canola (*Brassica napus* L.) is a challenge for producers using high-residue, no-tillage, or reduced tillage systems. If seed-to-soil contact is poor, emergence may be delayed, making the plant more susceptible to winter kill. A thick layer of plant residue above the seed row results in lengthening of the hypocotyl above the soil surface, exposing the crown to greater risk of damage from sub-freezing temperatures. The objective of this study conducted in cooperation with AGCO Corporation was to determine the effect of residue management, seeding density, and row spacing on stand establishment, winter survival, and yield.

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Procedures

An innovative residue management system being developed by AGCO Corp. was compared to cooperating canola producers' no-tillage residue management and planting methods in wheat residue. This series of on-farm experiments was conducted in 2014-2015 and 2015-2016 at ten locations across Kansas. The AGCO treatments were 20- or 30-in. row spacing and three seeding rates (100,000, 150,000, and 200,000 seeds/a) for a total of six treatments. The producer treatment at each location included row spacing, seeding rate, and residue management practices preferred by that producer (Table 1). Plots were 30 feet in width and 550 to 626 feet in length depending on location. Fall establishment was determined by counting four sections of rows in each plot, each 3.3 to 10 feet in length. The average number of leaves per plant was determined just before winter dormancy to quantify potential differences in seedling development. The number of living plants was counted after green-up the next spring to determine spring plant density. Winter survival percent was calculated by dividing spring plant density by fall plant density and multiplying by 100. Bloom progression was estimated visually during mid bloom to determine if treatments influenced spring plant development. Cooperators' equipment was used to swath plots at 40 to 60% seed color change and to harvest for yield determination several days after swathing. Weight of canola from each plot was determined with weigh wagons or yield monitors depending on location (Table 1). Seed samples were collected from each plot and sent to the Brassica Breeding and Research program at the University of Idaho (Moscow, ID) for near-infrared spectroscopy (NIRS) oil content estimation. Due to winter stand loss, only one of the six experiments planted in the fall of 2014 was harvested for yield in 2015. All four experiments planted in fall 2015 were harvested for yield in 2016.

Results

Fall Stand Establishment

Fall plant density typically increased as seeding rates increased (Table 2). The 20-in. row spacing resulted in greater plant density than the 30-in. row spacing at a given seeding rate and averaged across seeding rates in three of five locations. Cooperator seeding rates often were substantially greater than all AGCO seeding rates and resulted in significantly greater fall stands in three of five locations. At these three locations (Kingman 2015, Conway Springs 2015, and Kiowa 2015), cooperators also planted canola in row spacings ranging from 10 to 15 inches. At one location (Stafford 2015) the AGCO treatments resulted in fall plant densities comparable to those achieved with cooperator practice. At another location (Andale 2014), AGCO seeding rates were greater than targeted and resulted in plant densities significantly greater than for the cooperator practice.

Spring Plant Density

Spring plant density was not consistently related to seeding rate, indicating that plant density tended to equalize during the winter, regardless of how many seeds were planted (Table 3). Spring plant density was consistently greater in row spacings less than 30 in., regardless of seeding rate and residue management system. Reduced intra-plant competition in narrow row spacings may have allowed more plants to survive the winter.

Winter Survival
Winter survival increased with decreasing seeding rates in 20-in. rows at four of the five locations (Table 4). Although winter survival followed a similar pattern in 30-in. rows only at Kiowa 2016 (winter survival increased with decreasing seeding rate), winter survival for the highest seeding rate was either equal to or less than that for the lowest seeding rate. Winter survival was greater in 20-in. vs. 30-in. rows at three of the five locations. Winter survival was negatively correlated with fall plant density at Andale 2015 (r = -0.36 and $P = 0.0590$), and Stafford 2016 (r = -0.45 and $P = 0.0178$), across all seeding rates and row spacings. These results suggest that greater intra-plant competition within the row resulting from greater seeding rates and/or wider row spacing likely increased the probability of plant death during the winter.

Plant Growth and Seed Oil Concentration
Although leaf number and bloom progression differed between treatments at some locations, no consistent patterns were evident for fall or spring plant growth response to residue management, row spacing, or seeding rate (data not shown). Seed oil concentration differed between treatments only at Andale 2015, where oil concentration was greatest in the AGCO 20-in. row treatment with the lowest seeding rate. The cooperator practice treatment resulted in the lowest oil concentration. Even though treatment differences could be detected, the total range in oil concentration at this location was small, 39.5 to 41.1%. The range of plant populations and plant to plant spacings achieved in these experiments did not have a consistent effect on plant development or seed oil concentration.

Yield
Yield response to management practices was not consistent at all locations. Yields were not affected by equipment, row spacing, or seeding rate at the Conway Springs 2016 and Kiowa 2016 locations, representing almost the extremes of the yield range across locations (Table 5). The relatively strong negative correlations between both fall establishment and spring stands versus yield at Kingman 2016 (r = -0.84, $P = <0.0001$, r = -0.85, and $P = <0.0001$, respectively) and at Conway Springs 2016 (r = -0.49, $P = 0.0125$, r = -0.46, and $P = 0.0188$, respectively) were likely related to plant stress resulting from periods of limited rainfall in fall and early spring at these environments. At Kiowa, where plants were under less drought stress, and yields were greater, there was a positive correlation between both fall establishment (r = 0.36 and $P = 0.0706$) and spring stands (r = 0.49 and $P = 0.0112$) and yield. These contrasting correlations at different locations reveal the influence of specific growing conditions on yield response to plant density. All AGCO treatments, including those with seeding rates substantially less than most cooperators' practice, produced yields that were either similar to or greater than those achieved using cooperator practices across a wide range of yield levels. This yield advantage was most consistent in 20-in. rows, but row spacing had a significant influence on yield only at Andale in 2015. These results indicate that seeding rates likely can be reduced from those typically used by canola producers in high residue, no-tillage or reduced tillage systems if residue can be adequately removed from the seed row. Seeding rates of 100,000 seeds/a (0.9 to 1.1 pounds per acre depending on seed size) resulting in spring plant densities as low as 50,000 plants/a (~1.1 plants/ft^2) supported yields ranging from 800 to 3100 lb/a.

Conclusions

Cooperator practice tended to produce the greatest fall and spring plant densities, unless the AGCO seeding rate was greater than targeted (e.g. Andale 2015). Winter survival tended to increase as seeding rate decreased in 20-in. rows at four of the five locations. This could have been a result of greater intra-row plant spacing achieved with narrower rows. Yield increased as seeding rate decreased in AGCO treatments when row spacing was 20 in. at three locations. At Kingman 2016, all AGCO treatments yielded more than the cooperator practice. Reduced seeding rates in 20- and 30-in. row spacings using the AGCO residue management system produced yields similar to or superior than cooperator practice in all environments. Using the AGCO system, lower seeding rates produced superior yields regardless of row spacing in two environments, and 20-in. rows out-yielded 30-in. rows in one environment. These results indicate that seeding rates can be reduced from those typically used by canola producers in high residue, no-tillage systems if residue can be adequately removed from the seed row, and that row spacing less than 30 inches may increase establishment and winter survival.

Table 1. Producer field operations for experiments comparing AGCO Corporation's residue management system with two different row spacings and three seeding rates with producer planting practices at five locations in Kansas in 2014-2016

Management factor	Andale 2014-2015	Stafford 2015-2016	Kingman 2015-2016	Conway Springs 2015-2016	Kiowa 2015-2016
Residue management	Burned	Strip tillage	Vertical tillage	No-tillage	Vertical tillage
Planting equipment	John Deere 1750 row crop planter	John Deere 1790 row crop planter	John Deere 1890 air drill, disk openers	John Deere 1790 row crop planter	John Deere 1870 air hoe drill, Conservapak hoe openers
Row spacing (inches)	30	30	10	15	12
Cultivar	Mercedes	HyClass 115 W	DKW 44-10	HyClass 125 W	DKW 45-25
Seeds/a	191,600	312,500	684,000	562,500	380,000
Planting	September 19	September 11	September 14	September 17	September 25
Fertilizer, -Fall lb/a N-P_2O_5-K_2O-S	25-15-0-5	30-30-30-32		None	30-40-0-10
Fertilizer, -Spring lb/a N-S	47-9	11-22		73-8	30-8.5
Swathing	June 21	June 1	June 4	May 29	May 30
Harvest	June 25	June 6	June 9	June 4	June 7
Grain weight	Weigh wagon	Green Star™ Harvest Monitor™	Weigh wagon	Ag Leader Yield Monitoring	Grain cart with scales

Table 2. Fall plant establishment of canola planted with AGCO Corporation's residue management system, including two different row spacings and three seeding rates, and canola planted with cooperator practices at five Kansas locations in 2014 and 2015

	AGCO planter						
	20-in. row spacing			30-in. row spacing			
	Seeding rate (seeds/a)			Seeding rate (seeds/a)			
Environment	100,000	150,000	200,000	100,000	150,000	200,000	Cooperator practice‡
	plants/a						
Andale 2014	217,747 bc†	244,965 b	310,024 a	154,495 d	201,814 c	236,335 b	115,365 e
Stafford 2015	111,895 c	139,501 b	169,013 a	107,593 cd	81,748 d	93,654 cd	135,375 b
Kingman 2015	122,186 bc	122,839 bc	133,294 b	70,567 e	86,684 ed	105,125 cd	236,240 a
Conway Springs 2015	52,272 d	71,003 c	90,823 b	51,256 d	60,548 cd	90,460 b	200,046 a
Kiowa 2015	72,527 de	91,040 cd	93,872 c	67,808 e	95,542 c	114,853 b	190,108 a

	Seeding rate (seeds/a)			Row spacing	
	100,000	150,000	200,000	20-in.	30-in.
Andale 2014	186,103 c†	223,390 b	273,179 a	257,579 a†	197,536 b
Stafford 2015	109,982	123,856	119,205	140,803 a	94,559 b
Kingman 2015	96,377 b	104,762 b	119,209 a	126,106 a	87,459 b
Conway Springs 2015	51,746 c	65,776 b	90,641 a	71,366	67,421
Kiowa 2015	70,168 b	93,291 a	104,363 a	85,813	92,734

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

‡See Table 1 for details regarding producer field operations and practices at each location.

Table 3. Spring plant density of canola planted with AGCO Corporation's residue management system, including two different row spacings and three seeding rates, and canola planted with cooperator practices at five Kansas locations in 2015 and 2016

	AGCO planter						
	20-in. row spacing			30-in. row spacing			
	Seeding rate (seeds/a)			Seeding rate (seeds/a)			Cooperator
Environment	100,000	150,000	200,000	100,000	150,000	200,000	practice‡
	plants/a						
Andale 2015	96,260 a†	79,000 b	59,084 c	29,210 d	29,653 d	34,078 d	37,914 d
Stafford 2016	79,465 bc	87,035 ab	95,205 a	59,197 de	48,497 e	56,892 e	70,277 cd
Kingman 2016	80,368 de	107,375 bc	116,523 b	59,096 f	68,825 ef	91,766 cd	206,910 a
Conway Springs 2016	44,649 d	57,717 cd	68,825 b	39,494 d	47,771 cd	58,806 bc	150,830 a
Kiowa 2016	66,429 b	71,656 b	64,033 bc	47,045 d	53,288 cd	64,324 bc	140,235 a

	Seeding rate (seeds/a)			Row spacing	
	100,000	150,000	200,000	20-in.	30-in.
Andale 2015	62,735	54,326	46,581	78,114 a†	30,980 b
Stafford 2016	69,288	66,937	79,479	88,844 a	54,958 b
Kingman 2016	69,732 c†	88,100 b	104,145 a	101,422 a	73,229 b
Conway Springs 2016	40,072 c	52,744 b	63,815 a	57,064 a	48,690 b
Kiowa 2016	56,737	62,472	64,178	67,373 a	54,886 b

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

‡See Table 1 for details regarding producer field operations and practices at each location.

Table 4. Winter survival of canola planted with AGCO Corporation's residue management system, including two different row spacings and three seeding rates, and canola planted with cooperator practices at five Kansas locations in 2015 and 2016

	AGCO planter						
	20-in. row spacing			30-in. row spacing			
	Seeding rate (seeds/a)			Seeding rate (seeds/a)			
Environment	100,000	150,000	200,000	100,000	150,000	200,000	Cooperator practice‡
	%						
Andale 2015	47.9 a†	34.7 b	18.9 c	21.1 c	15.2 c	15.5 c	34.1 b
Stafford 2016	74.7 a	66.6 ab	60.6 bc	55.1 bc	66.8 ab	61.2 bc	53.9 c
Kingman 2016	69.4 c	86.8 ab	88.2 ab	84.9 ab	81.2 b	89.2 a	87.6 ab
Conway Springs 2016	86.4 a	81.4 ab	75.5 b	77.5 b	80.4 ab	66.0 c	76.5 b
Kiowa 2016	92.2 a	80.3 b	69.5 c	72.9 bc	57.4 d	56.9 d	75.9 bc

	Seeding rate (seeds/a)			Row spacing	
	100,000	150,000	200,000	20-in.	30-in.
Andale 2015	34.5 a†	24.9 b	17.2 b	33.8 a†	17.3 b
Stafford 2016	64.9	62.2	66.3	67.9	61.0
Kingman 2016	77.2 b	84.0 a	88.7 a	81.4	85.1
Conway Springs 2016	82.0 a	80.9 a	70.8 b	81.1 a	74.7 b
Kiowa 2016	82.5 a	68.9 b	63.2 b	80.6 a	62.4 b

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

‡See Table 1 for details regarding producer field operations and practices at each location.

Table 5. Yield of canola planted with AGCO Corporation's residue management system, including two different row spacings and three seeding rates, and canola planted with cooperator practices at five Kansas locations in 2015 and 2016

	AGCO planter						
	20-in. row spacing			30-in. row spacing			
	Seeding rate (seeds/a)			Seeding rate (seeds/a)			Cooperator
Environment	100,000	150,000	200,000	100,000	150,000	200,000	practice[‡]
	bu/a						
Andale 2015	34.5 a†	33.4 ab	31.9 abc	29.9 bc	27.7 c	30.3 abc	32.2 abc
Stafford 2016	17.4 a	16.2 ab	16.8 ab	18.3 a	16.3 ab	22.3 a	12.5 b
Kingman 2016	24.2 a	21.9 ab	20.2 b	23.1 a	22.1 ab	19.9 b	15.7 c
Conway Springs 2016	23.5	23.6	23.1	23.2	23.7	23.3	21.9
Kiowa 2016	63.5	62.6	61.7	63.5	62.6	61.7	65.6

	Seeding rate (seeds/a)			Row spacing	
	100,000	150,000	200,000	20-in.	30-in.
Andale 2015	32.2 a†	30.5 b	31.2 c	33.3 a†	29.3 b
Stafford 2016	17.7	16.3	19.8	19.0	16.8
Kingman 2016	23.6 a	22.0 b	20.1 c	22.1	21.7
Conway Springs 2016	23.4	23.7	23.2	23.4	23.4
Kiowa 2016	63.5	62.6	61.7	62.6	62.6

†Values within a row followed by the same letter are not different at $\alpha = 0.10$.

‡See Table 1 for details regarding producer field operations and practices at each location.