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Effect of Planting Methods on Spring Canola (*Brassica napus* L.) Establishment and Yield in the Low-Rainfall Region of the Pacific Northwest

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Abstract

Growers are becoming interested in producing canola (*Brassica napus* or *B. rapa*) in the dryland, wheat-fallow region of the Pacific Northwest. Currently, agronomic research for spring canola in this region has not been initiated. This study evaluated the effect of no-till planting methods on stand establishment, crop yield, and seed oil quantity of spring canola in Washington and Oregon in 2009 and 2010. The treatments included: double disk opener; broadcast; broadcast plus rolled; Kile opener; Cross-Slot opener; and hoe opener (at Washington only). In this study, canola establishment was generally greatest with the double disk opener and least in the broadcast or broadcast plus rolled treatments at all four site-years. Yield was least in the broadcast treatment and rolling broadcast seed increased yield only 50% of the time. In three out of four site-years, canola planted with the various no-till openers yielded higher than broadcast seed. The adoption of spring canola in the wheat-fallow region of the Pacific Northwest would improve pest management strategies, diversify markets, and increase sustainability.

Introduction

In the Pacific Northwest, more than 60% of the wheat (*Triticum aestivum*) producing land is characterized by a rotation of winter wheat-dust mulch summer fallow that has produced wheat for more than a century. The dust mulch layer is formed during the summer fallow period by tilling the soil which creates a loose unstructured surface layer that reduces soil moisture evaporation (12). For the past 15 years, scientists and growers have sought alternative crops and crop rotations for the region (13,16). Recently oilseed crops, especially canola, have gained interest among growers and scientists to diversify cropping systems and markets and fulfill state and federal mandates to decrease dependence on foreign oil.

Spring canola research has been extensive in the northern Great Plains of the United States and Canada where summer rainfall is prevalent. Research has included pest management; fertility; planting date, rate, and methodology; row spacing and seedbed preparation; varieties; and planting equipment. In contrast, very limited research has been conducted on spring canola in the Pacific Northwest with the exception of variety testing in the intermediate to high (15 to > 23 inches) rainfall zones (3,9) and irrigated systems (7). Agronomic research for spring canola in the low-rainfall, dryland area has been limited to a cropping systems study when spring canola was planted one year in lieu of a failed winter canola crop (16).

The low rainfall, wheat-fallow region is characterized by high rates of soil loss by wind and tillage. No research has been conducted on no-till planting methodology for spring canola in this area. Planting methodology studies have been conducted in other spring canola production regions. Broadcast seeding has gained popularity in Canada (2,15), has been successful in Britain (8), and is being examined in the high-rainfall, high-residue region of the Pacific Northwest (9). A recent study was conducted which investigated the effect of disk and hoe seed openers on spring canola performance when planted into different crop residues (6). In addition, a study was conducted examining the effect of seed openers, packing wheels, and packing wheel force on several crops including canola (10). The objective of this study was to compare various no-till planting methods for spring canola establishment, yield, and seed oil quantity.

Field Description

A 2-year field study was conducted near Ralston, WA (2009 and 2010), Echo, OR (2009), and Adams, OR (2010). Soils near Ralston and Echo are Ritzville silt loams (coarse-silty, mixed superactive, mesic Calcidic Haploxerolls) and at Adams, they are Walla Walla silt loams (coarse-silty mixed, superactive mesic Type Haploxerolls). Soil organic matter is 1.9% at Ralston, 0.7% at Echo, and 1.2% at Adams. Crop rotation at Ralston prior to seeding spring canola each year was no-till spring wheat-chemical fallow. Preceding rotations at both Echo and Adams, OR, were winter wheat-chemical fallow.

Planting Methods

Three no-till methods of planting were employed including drilling, broadcasting, and broadcasting followed by rolling (Table 1). Drilling uses a seed opener to place the seed into a furrow at a specific depth and cover the seed with moist soil whereas broadcasting involves scattering the seed over the soil surface. Broadcasting followed by rolling attempts to improve contact of the seed with the soil.

Table 1. Seed drills, features, and seeding rates used to plant spring canola at Ralston, WA, and Echo and Adams, OR, in 2009 and 2010.

Drill	**Seed delivery**	**Opener type**	**Row spacing** (inches)	**Seeding rate** (lb/acre)
Double disk JD 8300	gravity	double disk	7	6.2
Double disk IH 5300	gravity	double disk	6	6.2
Double disk + B[x]	gravity	double disk	6	6.2
Double disk + B + R[x]	gravity	double disk	6	6.2
No-till	pneumatic	Kile	10	5.5
No-till	pneumatic	cross-slot	10	5.7
No-till	gravity	hoe (Mac 3)	7	6.2

[x] Conventional broadcast seeding with either the IH 5300 (Washington) or JD 8300 (Oregon) drill, and seed tubes pulled out of opener units.
Abbreviations: B = broadcast; R = rolled.

Fig. 1. Conventional double disk openers showing seed tubes attached for drilling seed and unattached for broadcasting seed (International Harvester, Racine, WI, or John Deere, Moline, IL).

Drilling involved the use of different ground openers that were either dedicated to a specific drill or attachable to the standard shank of a no-till drill. The former included the conventional double disk type on John Deere 8300 and International Harvester 5300 planters. The latter included a hoe-type opener and chisel-type opener for soil penetration with minimum disturbance; and inverted T shaped slot opener for self-closure and soil moisture conservation (Figs. 1 to 4). The hoe-type opener selected for this study was the Mac III opener (Cheney, WA). The narrow chisel-type opener was the Kile opener (Kile Machine and Mfg. Inc., Rosalia, WA) and the inverted T slot opener was the Cross-Slot (Cross-Slot Inc., Pullman, WA). All openers are commercially available and drills were not equipped with residue management options.

Fig. 2. Kile opener (Kile Machine, St. John, WA).

Fig. 3. Cross-slot opener (Cross Slot Inc., Pullman, WA).

Fig. 4. Hoe opener (Mac III, Cheney, WA).

Each opener has certain advantages and disadvantages. A double disk opener creates a narrow "V" shaped furrow, but excess crop residue can interfere with opening and closing of the furrow and sufficient seed-soil contact. A hoe opener produces a "U" shaped furrow. An optimal seed zone microenvironment is produced; however, the soil is disturbed that causes loss of moisture. The inverted T slot opener disturbs the soil lightly, compacts the soil around the seed, and produces a microclimate conducive to seed germination and seedling growth. Therefore, we expected the best performance from the T slot opener.

For the broadcast and broadcast plus roll seeding methods, seed tubes were disconnected from the double disk openers (Fig. 1), so that seed could be broadcast rather than placed in rows. In the broadcast plus rolled treatment, seed was pressed into the soil using a cast-iron pea roller (Fig. 5). Drill width varied from 8 to 12 ft and row spacing was 6 to 10 inches (Table 1). Drills were calibrated for a target seeding rate of 6.0 lbs/acre and ranged from 5.5 to 6.2 lbs/acre. To alleviate the rate discrepancy among drills, we analyzed crop populations as percent of planted seed that emerged (see description below).

Fig. 5. Pea roller (Ed-Ka Mfg., Garfield, WA).

Cultural Practices

Spring canola was planted on 14 April 2009 and 23 and 25 March 2010 at Ralston, 9 April 2009 at Echo, and 23 March 2010 at Adams. In 2010, spring canola was planted in the broadcast and broadcast plus roll plots on 23 March at Ralston to ensure excellent soil surface moisture. The remaining treatments were seeded on 25 March. The planter with the hoe-openers was not used at either Oregon site.

The spring canola variety "Hyola 357 Magnum" (glyphosate tolerant) was planted the first year at Washington and both years at Oregon. In 2010, "Invigor 8440" (glufosinate tolerant) was planted at Washington. Not all drills were capable of placing fertilizer at the time of seeding so fertilizer was applied with a spoke-wheel injector prior to seeding both years in Washington and in 2010 at Adams, OR. At Echo in 2009, fertilizer was applied through the openers of a no-till drill prior to seeding. Fertilizer rates were 70 lbs N/acre and 15 lbs S/acre both years in Washington. At Echo, 70 lbs N/acre and 53 lbs S/acre were applied, whereas 40 lbs N/acre and 3 lbs S/acre were applied at Adams.

Canola was harvested with a plot combine at physiological maturity near the end of July or beginning of August each year. To avoid border effects, the grain was harvested from an area equal to the cutting width of the combine (5-ft) times the plot length, which was 225 ft at Ralston, 200 ft at Echo, and 153 ft at Adams. Weeds were controlled with timely applications of glyphosate in the "Hyola" experiments and glufosinate in the "Invigor" experiment. Canola populations were recorded in eight, 1-yd rows in the drilled plots and eight, 342-inch^2 areas in the broadcast and broadcast plus rolled treatments. Populations were converted to plants/yd^2. Data is expressed as percent of plant establishment and was calculated by dividing the number of plants per unit area by the number of seeds planted per unit area for each drill (corrected for 90% germination for each variety as stated on the label). Seed oil quantity was determined by using a scaled oil extractor to simulate an industrial scale process (4).

Planting Methods Experiment

Each experiment was designed as a randomized complete block with four replications. The multi-year data were analyzed using SAS PROC MIXED version 9.2 (SAS Institute Inc., Cary, NC). Sources of variation included in the model were year, planting method, and year-by-planting method interaction. Replication within year was treated as a random effect. Data were logarithmically transformed when necessary to improve concordance with the assumptions of normality and homogeneity of variance. For presentation in tables, data were then back transformed. Significant year-by-planting method interactions required that mean comparisons among planting methods be conducted within years for each location. Fisher's protected LSD was used to identify significant treatment differences.

Precipitation

Long-term average 5-month (March through July) precipitation at Ralston is 4.0 inches, and at Echo and Adams it is 4.2 inches and 6.8 inches, respectively (Table 2). In the inland Pacific Northwest, only about 25% of the annual rainfall occurs from April through June when most wheat growth occurs (14). In addition, rainfall in May and June contributes more to yields of spring wheat and winter wheat than April precipitation.

Table 2. Five-month precipitation during the growing season at Ralston, WA, and Echo and Adams, OR, in 2009 and 2010.

	Precipitation (inches)			
	Ralston		**Echo**	**Adams**
Month	**2009**	**2010**	**2009**	**2010**
March	1.93	0.71	1.86	1.43
April	0.96	1.19	0.75	2.80
May	0.77	1.33	0.91	2.80
June	0.18	1.21	0.48	2.39
July	0.25	0.81	0.03	0.03
Total	4.09	5.25	4.03	9.45

Canola Establishment

At Ralston, the greatest and least plant establishment as affected by planting method were consistent in both years. Canola establishment (almost 30% to 43%) with the double disk opener (Table 3) equated to a plant population (*data not shown*) that was in the low-end of the optimum plant population for spring canola in Canada (2). Both the broadcast and broadcast plus rolled had very low establishment each year. We observed seeds located on the ground in the broadcast treatment had unprotected seedlings emerging from the seed coat that were being killed by frost. This agrees with researchers from Canada (2,15) that one of the disadvantages to broadcast seeding is frost kill. Increasing seeding rate by 25 to 30% has been proposed (2,15) as a way to improve seedling population (establishment). We did not do this because of the prohibitive cost of genetically modified organism (GMO) spring canola seed ($10/lb).

Plant establishment at Ralston in 2009 and 2010 were similar for the chisel, inverted T slot, and hoe openers but less than the double disk opener with the exception of 2009 when plant establishment for the double disk opener and chisel opener were similar (Table 3). In contrast, a study in Manitoba, Canada (6), found canola populations (establishment) were equal with both a disk opener and hoe opener; however, canola emergence was quicker with the disk opener.

The broadcast and broadcast plus rolled treatments had the lowest canola establishment both years in Oregon (Table 3). The highest canola establishment was with the inverted T slot opener and the second highest establishment was with the conventional double disk opener and chisel opener in 2009. At Adams in 2010, canola establishment was quite low, varied only slightly among treatments, and ranged from 4.8% to 10.3% establishment.

Table 3. Percent of spring canola seed established for six planting methods at Ralston, WA, and Echo and Adams, OR, in 2009 and 2010.

Planting method	Percent of planted seed (%)			
	Ralston, WA		Echo, OR	Adams, OR
	2009[y]	2010	2009	2010
Double disk	42.8d	29.3c	24.0b	7.4ab
Double disk+B[x]	0.5a	1.2a	18.8a	5.4a
Double disk +B+R[x]	4.1b	3.0a	19.7a	4.8a
Kile	32.5cd	13.2b	24.5b	10.3b
Cross-slot	19.3c	14.0b	39.0c	7.7ab
Hoe	15.4c	15.8b	–	–

[x] Conventional broadcast seeding with either the IH 5300 (Washington) or JD 8300 (Oregon) drill, and seed tubes pulled out of opener units. Abbreviations: B = broadcast; R = rolled.

[y] Means in each column with the same letter are not significantly different at $P = 0.05$.

Canola Yield and Oil Quantity

In the Pacific Northwest, spring canola yield varies considerably based on variety, location, and year (11). Average yield in the 10-inch to 15-inch rainfall zone is estimated to be 1,000 lbs/acre based on growers' experience and variety trials. Spring canola yields of ≥1,000 lbs/acre were realized at Ralston in 2010 and Echo in 2009 (Table 4) and thus reflected the region's estimated yield. In contrast, spring canola yielded <1,000 lb/acre at Ralston in 2009 and Adams in 2010, and were similar to those received in a cropping systems study conducted previously at Ralston (16). In every site-year, broadcast seeding was the lowest yielding treatment often producing only 30% to 65% of the highest yielding drilled treatment (Table 4). These results agree with research in Canada where broadcast seeding generally performed worse than drilled seeding of spring canola (6,15) due to poor contact between seed and soil. Thomas (15) found yields of broadcast spring canola inferior to that of drilled spring canola in nine of 18 site-years. On average, the yield of broadcast canola was from 5% to 20% less than the yield of drilled canola.

Results of research conducted in the high residue, high rainfall, annual cropping zone of the Pacific Northwest showed yield of broadcast spring canola to be similar to yield of no-till spring canola because standing residue protected the emerging broadcast canola from spring frosts (9). As discussed earlier, seedlings in our broadcast treatment were killed by frost where heavy residue was lacking. Broadcasting followed by rolling increased yield from 40% to 140% compared to only broadcasting at Ralston depending on the year (Table 4). At Echo and Adams, yields were similar for both broadcast and broadcast plus rolled treatments.

Table 4. Spring canola grain yield and oil content for six planting methods at Ralston, WA, and Echo and Adams, OR, in 2009 and 2010.

		2009		2010	
		Yield[y] (lbs/acre)	**Oil**[y] (%)	**Yield**[y] (lbs/acre)	**Oil**[y] (%)
Planting method[x]	**Opener**	**Ralston, WA**			
Broadcast	–	235a	32.7a	750a	28.9b
Broadcast + Roll	–	565b	35.6b	1,050b	29.0b
Drill	Double disk	750c	36.0b	1,115b	27.1ab
Drill	Chisel	635bc	35.3b	995b	28.4ab
Drill	Inverted T slot	785c	36.5b	1,085b	28.8b
Drill	Hoe	725c	36.0b	1,110b	26.5a
Planting method[x]	**Opener**	**Echo, OR**		**Adams, OR**	
Broadcast	–	920a	28.0a	315a	34.0a
Broadcast + Roll	–	900a	28.6a	470ab	34.1a
Drill	Double disk	1,295b	30.4a	550b	33.9a
Drill	Chisel	1,405b	30.0a	395ab	32.7a
Drill	Inverted T slot	1,340b	29.5a	430ab	32.7a

[x] Conventional broadcast seeding with either the IH 5300 (Washington) or JD 8300 (Oregon) drill, and seed tubes pulled out of opener units. Abbreviations: B = broadcast; R = rolled.

[y] Means in each column within year and location with the same letter are not significantly different at $P = 0.05$.

In general, the spring canola yields for the three no-till openers (chisel-type, inverted T type, and hoe) and double disk opener were similar to each other at all four site-years (Table 4) thus suggesting that each drilled treatment achieved good seed-soil contact. However, the conventional double disk opener resulted in seed yields that were either the greatest, or similar to the greatest yielding no-till opener at all four site-years (Table 4). The high yields (Table 4) and excellent crop establishment (Table 3) with this opener were probably because the previous crops' residue was low (except at Adams in 2010) and soil was wet which eliminated the straw-stuffing problem in high residue regions of the Pacific Northwest. This is the first reported use of conventional double disk openers for no-till spring canola.

Though canola establishment in the spring differed significantly among the double disk, inverted T, and hoe opener treatments, these treatments had final yields that were similar. Apparently, canola compensates for variations in plant establishment by changing number and size of branches and pods with very little effect on final yield (1,2). This also suggests that canola is able to compensate for differences among drill openers in terms of the physical attributes of their resulting furrows.

Though not directly comparable, yield was greater at Ralston in 2010 than in 2009. The higher yield probably resulted from earlier seeding date in combination with greater precipitation during May and June. In 2010, precipitation was 0.56 inch and 1.03 inch greater in May and June respectively than in May and June of 2009. Precipitation in May and June is important for flowering and seed filling in spring canola. In 2010, plant populations and seed yields were much lower at Adams than at Echo despite a greater yield potential. The low productivity at Adams, OR, resulted from cold spring temperatures and heavy residue that prevented establishment and rapid growth of seedlings.

Seed oil concentration was similar for all treatments within each location in Oregon (Table 4). Although there were differences in percent oil at the Ralston site, results were not consistent (Table 4). In 2009 the lowest percent oil was in the broadcast treatment and in 2010, the lowest percent oil was in the hoe opener treatment.

Conclusion

Spring canola has the potential to be an alternative crop in the wheat-fallow region of the Pacific Northwest either as a replant crop in instances of winter-killed, fall-planted canola, or as an opportunity crop during cycles of above normal precipitation. The results of this research indicate that drilled seeding is better than broadcast seeding for spring canola in this region. Similar yields were obtained with attachable openers that are designed for no-till drills. Frequently, however, the highest yields were obtained with double disk openers that are dedicated to conventional planters already possessed by growers. Therefore, growers interested in producing no-till spring canola in the 10-inch to 15-inch rainfall zone would not need to purchase additional planting equipment for their farm.

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