Developing Practices for Optimum Canola Production in Southwestern North Dakota

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Summary

Canola can be grown profitably in southwestern North Dakota, but hot and dry conditions during mid-summer hinder consistent production success. The objectives of this project were to develop early seeding and tillage reduction strategies that optimize canola production in the region. Canola was dormant seeded with and without a polymer seed coating as a drought avoidance strategy during the 2002 growing season. Canola also was seeded in early spring. Cold temperatures killed many emerged seedlings and < 1 plant/ft^2 remained by mid-May, so plots were reseeded. Seed yields were less than 100 lb/acre for the three seeding methods ($P >$ 0.05). A second field experiment was conducted during the 2002-2003 growing season. Four plants/ft^2 resulted in 2003 from dormant seeding in 2002. Differences in seed yield were not detected between dormant seeded and spring seeded canola and were < 1000 lb/acre across dormant seeded and spring seeded treatments. Results of this study failed to identify benefits of dormant seeding compared with spring seeding of canola. Production of canola was compared following wheat in conventional-tillage (CT), reduced-tillage (RT), and no-tillage (NT) systems in a separate field study in 2002. Cold temperatures in late May injured or killed many young canola plants and plots were reseeded. Differences in seed yield were not detected across tillage systems and averaged less than 400 lb/acre. Wheat yield following canola averaged 32 bu/acre in 2003 and was comparable to the yield of a continuous wheat monoculture. This field study failed to demonstrate advantages of producing canola in reduced- and no-tillage systems compared with a conventional-tillage system, or in following canola with wheat compared with a continuous wheat monoculture. The disappointing results of this project provide little insight into refining strategies for optimizing canola production in southwestern North Dakota. Long-term studies may be needed to better understand the potential for dormant seeding and tillage reduction as strategies for enhancing canola production in southwestern North Dakota.

Introduction

Canola can be grown profitably in southwestern North Dakota, and much of what determines production success is timeliness of the seeding operation. Research at Carrington, Langdon, and Prosper indicated that fewer pods formed on canola plants when seeding was delayed, thereby lowering yield (Johnson et al., 1995). Out of this study evolved the general recommendation that canola should be sown as early in the spring as possible, thereby minimizing exposure to heat and moisture stress during anthesis and seed filling. However, early-spring seeding may not be possible when cool, wet conditions develop.

Frost or dormant seeding is an alternative to early-spring seeding. Yield advantages have been demonstrated when canola was dormant seeded rather than spring seeded in Canada (Kirkland and Johnson, 1998). However, dormant seeding can be a risky practice if bare seed is sown in moist soil and warm fall temperatures subsequently develop. Canola seed which germinates in the fall will die during winter months.

A polymer seed coating has been developed to reduce the risk of dormant seeding canola and other summer annual crops. The seed coating induces a dormancy period lasting app. 21 d that protects the seed from fall germination, thereby providing some flexibility in timing the seeding operation. Unpublished data indicate that coating canola seed increased winter survival of fall-sown seed compared to sowing bare seed in Canada (K. Zaychuk, per. comm.).

Attempts at dormant seeding canola generally were unsuccessful in southwestern North Dakota in the 1999-2000 growing season, whether polymer-coated or bare seed was sown. Environmental factors partially explain why dormant seeding failed, but lack of knowledge about this practice also was a contributing factor. Research on dormant seeding canola is limited and has been confined to Canada, until recently. More importantly, research that identifies the environmental conditions determining the success or failure of dormant seeding is virtually non-existent. Dormant seeding probably will continue to be a poorly understood practice as long as analyses of quantitative environmental data are not available that complement the agronomic data relating to dormant seeding that are being collected.

Tillage regimes affect canola performance, whether the canola is dormant or spring seeded. Seed yield generally increased as tillage was reduced in a Canadian study (Wright, 1989). Similar results have been generated in an ongoing tillage study at Dickinson (unpub. data). Yield increases resulting from reductions in tillage often are attributed to soil moisture considerations, but phenotypic response of plants to changes in tillage implicate other edaphic factors as well. Research is needed which identifies the specific environmental changes resulting from reductions in tillage and how seed yield of canola is affected.

The importance of rotation in cropping systems is again being emphasized (Beck, 1998). The enhancement in wheat yield when canola is incorporated into wheat-based cropping systems is recognized, but the mechanisms responsible for this enhancement remain poorly understood. Research is needed which identifies how the soil environment is modified when canola is inserted into a wheat-base cropping system, and why yield and quality of a subsequent wheat crop are affected.

The objectives of this project were to: (i) develop seeding strategies for optimum economic returns of canola produced in southwestern North Dakota, (ii) develop tillage strategies for optimum economic returns of canola produced in southwestern North Dakota, and (iii) determine the impact of canola on wheat in a wheat-canola rotation compared with continuous wheat.

Materials and Methods

Duration of the project was expected to be from 2000 through 2002. However, freezing temperatures and snow occurred earlier than expected so the project was begun in 2001.

Develop seeding strategies for optimum economic returns of canola produced in southwestern North Dakota.

A field experiment was conducted during the 2001-2002 growing season. Three seeding strategies were established in a NT seedbed: (i) dormant seeding polymer-coated canola seed by mid-November or when the soil temperature at a 1-in (2.5-cm) depth remained # 40°F over a 5-d period preceding sowing, whichever was first; (ii) dormant seeding bare seed when the soil temperature remained # 36°F over a 5-d period preceding sowing; and (iii) seeding bare seed at spring warm-up (soil temperature at a 1-in depth remained $ 40°F over a 3-d period preceding sowing). A low-disturbance JD-750 planter with a grass-seed box was used to sow all plots.

Dormant seeding polymer-coated seed occurred on 16 November and on 29 November for bare seed in 2001, based on soil temperatures in dormant seeded plots (Fig. 1) and at a NDAWN weather station within 200 ft of the experimental site. Other climatic data also were collected at a NDAWN weather station. Bare seed was spring seeded on 12 April in 2002. All canola plots were reseeded on 28 May because of poor canola plant stands that occurred in both dormant seeded and spring seeded treatments.

A second field experiment was conducted during the 2002-2003 growing season. Dormant seeding occurred on 22 November for polymer coated seed and on 2 December for bare seed in 2002. Bare seed also was spring seeded on 10 April 2003. Canola plant stands were adequate in dormant seeded and spring seeded treatments and no reseeding was needed.

Transgenic (RR) canola was seeded in both field experiments. The canola hybrid Hyola 223 was seeded on all dates at a rate of 11 pure live seed (PLS)/ft^2 in the 2001-2002 field experiment. 'Minot' was seeded at 17 PLS/ft^2 in the 2002-2003 field experiment

The seeding treatments for canola were established in plots with dimensions of 10 × 100 ft. The seeding treatments were arranged in a randomized block design with seeding treatments replicated five times. Spring wheat was harvested in late summer prior to establishing the canola seeding treatments in both field experiments.

Soil samples were collected from each plot and analyzed for organic matter and plant nutrients prior to establishing the dormant seeding treatments. Adequate N, P, and S were applied in the spring using a small push-type broadcast spreader around the time of spring seeding for a yield goal of 2000 lb/acre, based on soil test results. No damage to canola plants was observed in dormant seeded plots that resulted from using the broadcast spreader.

Glyphosate was applied at a rate of 1.6 pt/acre on 1 June and at 1.3 pt/acre on 26 June to control grass and broadleaf weeds in 2002. Seed was treated with Helix to control insect pests, but a post-emergence application of Warrior occurred on 19 June at 3 oz/acre to control flea beetles. Similarly, glyphosate was applied at 0.67 pt on 25 April and again on 16 June at 1 pt/acre to control weeds in 2003, while Warrior was applied on 21 May to control flea beetles

Canola plants were counted in the center of each plot within a 5.4-ft^2 (0.5-m^2) area at approximately 10, 20, 30, and 40 days after spring warmup. Crop development stages were determined for 10 plants randomly selected in each plot at these same times. Fifteen plants were excavated plants and dried so plant-water concentration could be determined. Whole plant samples also were collected and analyzed for N, P, K, S, Ca, Mg, Zn, Fe, Mn, Cu, and B concentrations prior to harvesting seed.

Seed yield, moisture content, and test weight were determined by swathing and then harvesting each plot on 27 August in 2002 and 26 July in 2003. Seed weight was determined for a 100-seed subsample from each plot. Oil concentration was determined for a separate sub-sample of seed using near infrared reflectometry.

Data were analyzed within each year using the PROC ANOVA procedure available from SAS (SAS Institute, 2001). Seeding treatments were considered fixed effects while blocks were considered random. Mean comparisons using a protected LSD were made to separate seeding treatments where F-tests indicated that significant differences existed ($P < 0.05$).

Develop tillage strategies for optimum economic returns of canola produced in southwestern North Dakota, and develop tillage strategies for optimum economic returns of canola produced in southwestern North Dakota, and (iii) determine the impact of canola on wheat in a wheat-canola rotation compared with continuous wheat.

Tillage treatments had been established and maintained since 1993 in 30 × 40 ft plots arranged in a randomized complete block with treatments replicated four times. The tillage treatments consisted of three systems: (i) CT plots were disced in the Fall and then disced and leveled in the Spring until < 30% residue cover remained prior to sowing; (ii) RT plots were lightly disced in the Spring so that > 30% residue cover remained after sowing; and (iii) no tillage occurred in NT plots. Canola was seeded in the spring in the three tillage systems in 2002. Soil nutrient concentration, plant moisture content, crop growth, seed production and seed quality were determined as already was described.

Canola data were analyzed using the PROC ANOVA procedure available from SAS (SAS Institute, 2001). Tillage treatments were considered fixed effects while blocks were considered random. Mean comparisons using a protected LSD were made to separate tillage treatments where F-tests indicated that significant differences existed ($P < 0.05$).

Canola had been rotated with wheat in CT, RT, and NT systems since 1999 with both phases of the rotation occurring each year. A continuous wheat monoculture also had been maintained within each tillage system. Individual tillage plots were 90 × 40 ft. Cropping system subplots were 30 × 40 ft. Tillage and cropping system treatments were arranged in a randomized complete block with tillage and cropping system factors in a split plot arrangement. Tillage systems comprised whole plots and cropping system (wheat-canola, and continuous wheat) comprised sub-plots. Grain yield, crude protein concentration, test weight, and kernel weight were determined for wheat following canola and in the continuous wheat monoculture.

Grain yield and quality data were analyzed separately each year using the PROC GLM procedure available from SAS (SAS Institute, 2001). Tillage and cropping system factors were considered fixed while blocks were considered random. Mean comparisons using a protected LSD were made to separate tillage treatments and cropping systems where F-tests indicated that significant differences existed ($P < 0.05$).

Results

Develop seeding strategies for optimum economic returns of canola produced in southwestern North Dakota.

Canola seedlings did emerge in 2002 from dormant seeding in 2001. However, many seedlings died from what seemed a result of cold temperatures that occurred following emergence. Air temperatures in late April dropped as low as 13^oF after several days of air and soil temperatures exceeding 45^oF. Less than 1 canola plant/ft^2 occurred in dormant seeded and spring seeded plots by mid-May (data not presented). Canola plots were reseeded in late May to ensure there was adequate crop competition to minimize weed infestations in plots. Seed yield averaged less than 100 lb/acre across seeding treatments after reseeding (data not presented). These results support current NDSU recommendations that low seed yields should be expected when canola is seeded beyond mid-May, particularly when hot, dry conditions develop during July as occurred in 2002.

An average of 4 plants/ft^2 resulted in 2003 from dormant seeding in 2002 (Table 1). The number of plants in plots supported maintenance of dormant seeded plots since a stand of 2 plants/ft^2 from dormant seeding is considered adequate for economic seed yields in Canada (B. Irvine, personal communication, 2002). Seeding polymer coated or bare seed did not affect plant numbers in dormant seeded plots.

More plants resulted from spring seeding compared with dormant seeding in 2003 (Table 1). However, spring seeded canola plants appeared two to three weeks behind in development throughout the growing season compared with dormant seeded plants, as is suggested by plant heights measured on 2 June. Differences in mature plant height were not detected between seeding treatments, although there was a trend for spring seeded canola plants to be slightly taller than dormant seeded canola plants ($P = 0.07$).

Growing conditions generally favored canola seed production until July in 2003 (data not presented). Hot and dry conditions developed in July and persisted through August. These weather data suggested a possible advantage for dormant seeding compared with spring seeding since plants matured earlier when dormant seeded and may have produced more seed prior to the development of hot and dry conditions. However, no differences in seed yield were detected between dormant seeded treatments and the spring seeded treatment ($P = 0.3$; Table 1). Differences in seed test weight were not detected, nor were there differences in other seed traits that were considered (data not presented).

Seed yield was low and averaged only 746 lb/acre across seeding treatments (Table 1). Concentrations of N and P in canola plants also were low and below what is considered sufficient for optimum seed yield (Table 2). The low concentrations of N and P in canola plant tissues were surprising since adequate amounts of N and P were supplied for a 2000 lb/acre yield, based on soil test results. The presence of N and P deficiencies in canola plant biomass prior to seed harvest suggests that current canola fertilizer recommendations may not be applicable to canola production in NT systems in southwestern North Dakota in some years.

Develop tillage strategies for optimum economic returns of canola produced in southwestern North Dakota, and develop tillage strategies for optimum economic returns of canola produced in southwestern North Dakota, and (iii) determine the impact of canola on wheat in a wheat-canola rotation compared with continuous wheat.

Fewer than 5 plants/ft^2 occurred after seeding in April in 2002 (Table 3). As a result, plots were reseeded in late May. The seed yields that resulted were low and averaged only around 300 lb/acre across treatments. Differences were not detected between tillage treatments for seed yield ($P = 0.27$). Seed oil concentration averaged 38% and did not differ between tillage treatments (data not presented).

No differences were detected between grain yield of wheat following canola and in a continuous wheat monoculture (data not presented). Grain yield averaged 26 bu/acre across wheat production systems in 2002 and 32 bu/acre in 2003. No differences were detected in other grain traits (data not presented). Results of these field experiments failed to indicate advantages in grain yield or quality of wheat when rotated with canola compared with a continuous wheat monoculture.

Discussion

Results of this project failed to identify early seeding and tillage reduction strategies that optimized canola production in southwestern North Dakota. Dormant seeding failed to enhance canola production compared with early spring seeding. No advantages were demonstrated when using a polymer coated seed when dormant seeding compared with bare seed. Similarly, no advantages to tillage reduction systems were demonstrated compared with a conventional tillage system for growing canola. Seed yields were low regardless of the seeding strategy or tillage system used, in part because growing conditions did not favor optimum canola seed yield while this project was conducted. Regrettably, results of this project suggest that canola production may be a risky practices under some environmental conditions. A long-term project may be needed to determine if dormant seeding and tillage reduction strategies can enhance canola production across the range of environmental conditions that exist in southwestern North Dakota.

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Table 1. Plant stand, plant height, seed yield and test weight for fall-seeded and spring seeded canola in a no-tillage seedbed following wheat at Dickinson during 2003.

	Stand		Plant height		Seed	
Seed treatment	15 May	28 May	2-Jun	PM[†]	Yield	Test weight
	--- no./ft^2 ----		-- inches ---		-- lb/acre --	----- lb/bu -----
Coated and fall seeded	5	4	17	35	729	53
Non-coated and fall seeded	4	4	19	34	868	53
Non-coated and spring seeded	9	8	6	38	640	53
Mean	6	5	14	36	746	53
CV(%)	30	26	12	6	16	0.6
$LSD_{0.05}$	3	2	2	NS	NS	NS

[†]PM=Determined at physiological maturity.

Table 2. Nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), Manganese (Mn), copper (Cu), and boron (B) concentrations in mature, above-ground canola biomass under no-tillage management following wheat at Dickinson during 2003.

	Plant nutrient concentration										
	N	P	K	S	Ca	Mg	Zn	Fe	Mn	Cu	B
	ppm										
Mean	14,600	1,200	18,400	4,180	7,100	2,520	13	67	21	3	25
Standard deviation	4159	245	3362	691	903	482	7	24	6	0	2
Sufficiency lower limit†	25,000	2,500	15,000	2,500	5,000	2,000	16	21	16	3	30

†Sufficiency lower limit as reported by AgVise Laboratories, Northwood, ND

Table 3. Plant numbers and seed yield in conventional-tillage, reduced-tillage, and no-tillage seedbeds following wheat at Dickinson during 2002.

	Plant numbers				
Tillage treatment	21 May	5 June	11 June	20 June	Seed yield
	-------------- no./ft^2 ---------------				----- lb/acre -----
Conventional	2	3	5	5	92
Reduced	2	3	6	7	188
No-till	1	3	4	5	640
Mean	2	3	5	6	307
CV(%)	63	68	21	30	110
$LSD_{0.05}$	NS	NS	NS	NS	NS

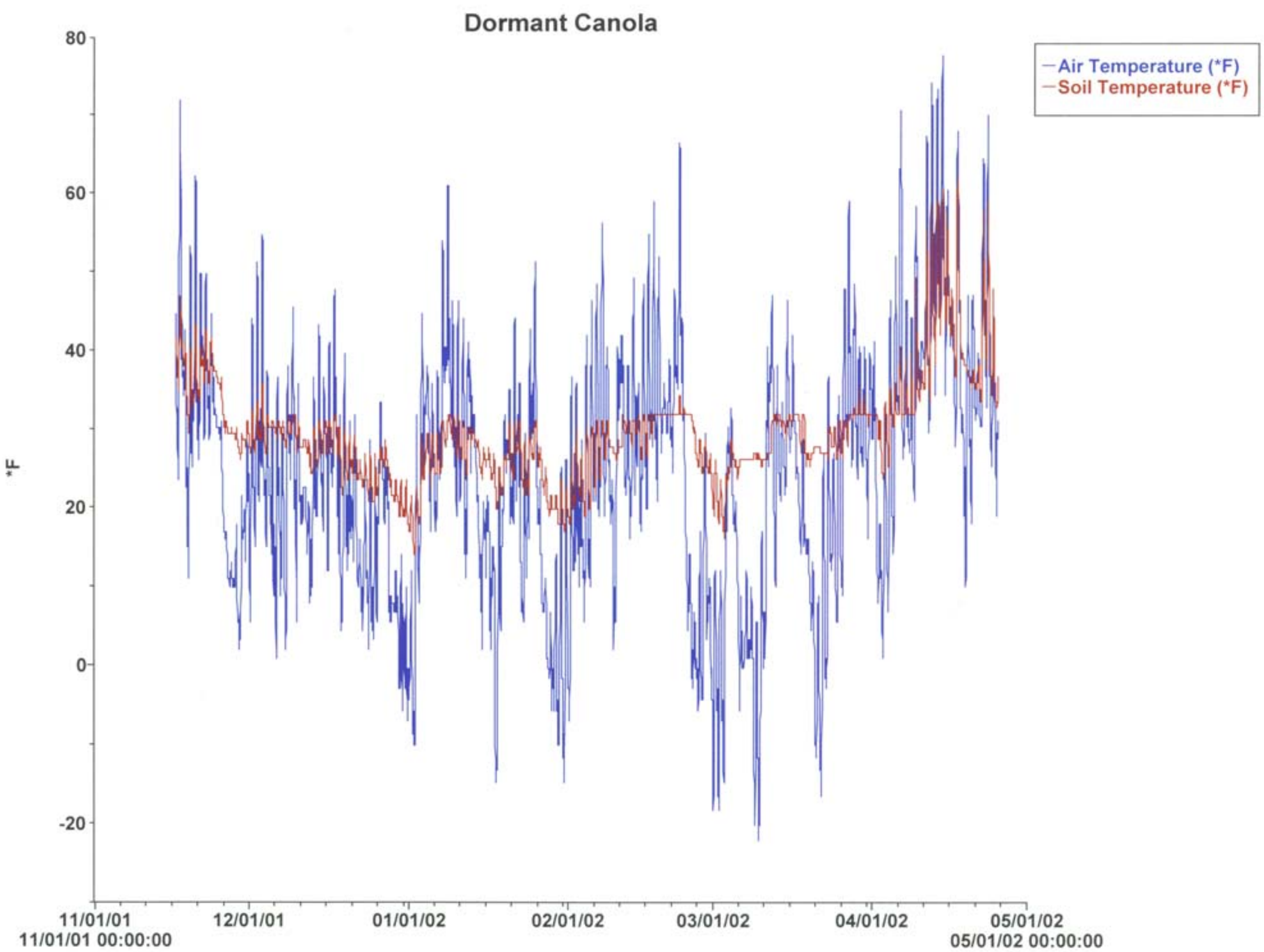

Figure 1. Air and soil temperatures during 2001-2002.