Fertility Effects on Weed & Crop Competition

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Summary
A field study was conducted at three locations across western Canada to determine the combined effects of fertilizer timing (fall- or spring-applied), seeding date (late April or late May), seeding rate (recommended or 150% of recommended), and in-crop herbicide rate (50 or 100% of recommended) on weed growth and crop yield. The factorial set of treatments was applied in four consecutive years within a wheat-canola-wheat-canola rotation (Lethbridge, AB and Scott, SK) or a barley-field pea-barley-field pea rotation (Lacombe, AB) in a zero-tillage production system. Spring-banded fertilizer (mid-row or side-band) frequently reduced weed biomass compared with fall-banded fertilizer, and resulted in a 20% decrease in the weed seedbank at the end of the study at two of the three sites. Spring-applied fertilizer combined with early seeding and greater crop seeding rates provides the most competitive cropping system, which allows greater flexibility in herbicide use, such as reduced rates or fewer applications.

Background
Weeds are endemic in most crops and their importance is reflected in the amount of time and money used to control them. Herbicides account for 20 to 30% of input costs in North American cropping systems (Derksen et al. 2002). Farmers are keenly aware of weed control costs and thus are becoming increasingly interested in more comprehensive weed management programs that will reduce weed populations over time and reduce their dependence on herbicides. The escalating problem of herbicide-resistant weeds, herbicide persistence in soil and injury to succeeding crops, and general unease regarding pesticide effects on the environment and human health also are issues driving farmers to reconsider how they control weeds.

Integrated weed management systems have the potential to reduce herbicide use (and associated costs) and to provide more robust and long-term management of weeds. Numerous agronomic factors such as crop rotation, crop variety, seeding date, seeding rate, row spacing, and fertilizer management have been evaluated for their potential to manage weeds (Gill et al. 1997). However, these agronomic practices do not work with all crops or with all weeds, and many research studies have only looked at one or two of these practices in isolation.

A field study was conducted at three locations (Scott, SK; Lethbridge, AB; Lacombe, AB) to determine the combined effects of seeding date, seeding rate, fertilizer timing, and in-crop herbicide rate on weed growth and crop yield within a wheat-canola-wheat-canola rotation or a barley-field pea-barley-field pea rotation in a zero-tillage production system (Blackshaw et al. 2004a). This factorial set of treatments was applied in four consecutive years to assess both annual and cumulative effects over time. Results are presented only for fertilizer timing effects or interactions with other factors. Previous research (e.g., Kirkland and Beckie 1998; Blackshaw et al. 2004b) has concluded that precision fertilizer placement (banding, point injection, etc.) in zero-tillage systems generally results in enhanced crop competitiveness and yields with reduced weed density, biomass, and seed return to the soil seedbank compared with broadcast-applied fertilizer.

Methods

Experimental treatments

A field study was conducted from 1998 through 2001 at Lethbridge and Lacombe, and from 1999 through 2002 at Scott. The soils at all three sites are a loam, with pH ranging from 6.0 (Scott) to 7.8 (Lethbridge), and organic matter content of 3.2 (Lethbridge), 4.5 (Scott) and 8.0% (Lacombe).

Precipitation received at Lethbridge was near normal in 1998 and 1999, but was 42 and 60% less than the long-term mean in 2000, and 2001, respectively. At Lacombe, precipitation was near normal in 2001, but was 17, 29, and 33% greater than normal in 1998, 1999, and 2000, respectively. At Scott, precipitation was near normal in 1999 and 2000, but was 38 and 22% less than the long-term mean in 2001 and 2002, respectively.

Treatments were applied to the same plots for four consecutive years within a wheat-canola-wheat-canola rotation (Lethbridge and Scott) or a barley-field pea-barley-field pea rotation (Lacombe) in a zero-tillage production system: knife openers with 20-23 cm (Lethbridge and Scott) or 30 cm (Lacombe) row spacing. The factorial set of treatments was arranged within a randomized complete block design with four replications. Individual plot sizes were 2.5 by 15 m at Lethbridge, 4 by 10 m at Scott, or 4 by 15 m at Lacombe. The factorial set of treatments consisted of (1) early and late seeding date: last week in April and third to fourth week in May; (2) seeding rate - recommended: wheat (var. Katepwa at Lethbridge and AC Barrie at Scott) = 80, canola (var. 45A51RR at Lethbridge and 45A50RR at Scott) =6, barley (var. AC Harper) =110, field pea (var. Swing) =225 kg/ha, or 150% of recommended; (3) in-crop herbicide rate (50 or 100% of recommended): wheat=Horizon plus Refine Extra, canola=glyphosate; barley=Achieve plus Prestige; field pea=Odyssey; glyphosate alone or mixed with 2,4-D was applied 3 to 5 days before seeding; and (4) fertilizer timing (fall- or spring-applied). Fertilizer was banded 10 cm deep in October or mid-row banded or side-banded during the spring seeding operation. N and P rates at Lethbridge in all years were 75 and 15 kg/ha, respectively; N, P, and S applied at Scott in all years were 70, 15, and 10 kg/ha, respectively; N and P were applied in barley at Lacombe at 30 and 15 kg/ha, respectively, in all years, whereas field pea was inoculated with a granular *Rhizobium* inoculant at 6 kg/ha and P was applied at 15 kg/ha in all years.

Data collection

Weed density was determined immediately before in-crop herbicide application. Dry conditions prevented collection of some weed biomass and crop yield data at Scott in 2002. Weed shoot biomass was determined before crop maturity by cutting plants at ground level in three 0.5-m^2 quadrats per plot at Lethbridge and Lacombe, or in three 0.25-m^2 quadrats per plot at Scott, and oven-drying. Crop seed yield was determined at maturity. Wheat grain protein content and canola seed protein and oil content were determined at Lethbridge and Scott. The viable fraction of the weed seed in the soil seedbank was determined at the conclusion of the study at all sites.

Results: Summary of seeding rate, seeding date, and herbicide rate effects
Increased crop seeding rates had the most consistent positive effect on reducing weed growth and the weed seedbank and increasing crop yields. Weed biomass was often less with May than with April seeding because of more weeds being controlled with preseeding glyphosate. Despite fewer weeds with May than April seeding, crop yields were not usually greater when seeded later. Crop yield, weed biomass, and the weed seedbank were often similar between the 50 and 100% herbicide rates when high crop seeding rates were used.

Results: Fertility effects or interactions
Weed density
The dominant weed community at Lacombe included wild oat, cleavers, hemp-nettle, and stork's-bill; dominant weeds at Lethbridge included wild oat, green foxtail, redroot pigweed, lamb's-quarters, stork's-bill, and wild mustard; weeds at Scott included wild oat, redroot pigweed, lamb's-quarters, wild buckwheat, shepherd's-purse, and wild mustard. Fertilizer timing did not affect weed density at any site.

Weed biomass
Spring-applied fertilizer reduced weed biomass in wheat in 1 of 4 years at Lethbridge and in 3 of 4 years at Scott compared with fall-applied fertilizer (Table 1). Similarly, weed biomass in canola was reduced in 2 of 4 years at Lethbridge and in 2 of 3 years at Scott with spring- compared with fall-applied fertilizer. Spring-applied fertilizer increased weed biomass in barley in 1 of 4 years compared with fall-applied fertilizer (Table 2). In contrast, spring-applied fertilizer (primarily P) reduced weed biomass in field pea in 2 of 4 years compared with fall-applied fertilizer.

Seeding date and fertilizer timing interacted to affect weed biomass in some cases. Weed biomass was greater (44 vs. 20 g/m^2) with fall- than with spring-applied fertilizer with April but not with May seeding in wheat at Scott in 2000. Similarly, weed biomass was greater (52 vs. 38 g/m^2) with fall- than with spring-applied fertilizer with April but not with May seeding in canola over the four years at Lethbridge. These results suggest that fertilizer timing effects increase as weed densities increase.

Table 1. Fertilizer timing effects on weed biomass (g/m^2) in wheat and canola

	Lethbridge				Scott			
	1998	1999	2000	2001	1999	2000	2001	2002
Wheat:								
Fall	44a	11a	18a	15a	50a	28a	5a	20a
Spring	66a	10a	10b	11a	48a	17b	2b	7b
Canola:								

Fall	59a	28a	33a	39a	99a	143a	15a	-
Spring	46a	12b	28a	27b	66b	124a	7b	-

Numbers within a column (for a crop) followed by the same letter are not significantly different at the 5% significance level.

Table 2. Fertilizer timing effects on weed biomass (g/m^2) in barley and field pea at Lacombe

	Barley				Field pea			
	1998	1999	2000	2001	1998	1999	2000	2001
Fall	241a	184a	178a	119b	161a	62a	21a	54a
Spring	193a	177a	175a	151a	106b	48a	19a	40b

Numbers within a column followed by the same letter are not significantly different at the 5% significance level.

Weed seedbank

Spring-applied fertilizer reduced the weed seedbank by 24 and 21% at Lethbridge and Scott, respectively compared with fall-applied fertilizer (Figure 1). However, fertilizer timing did not affect the weed seedbank at Lacombe.

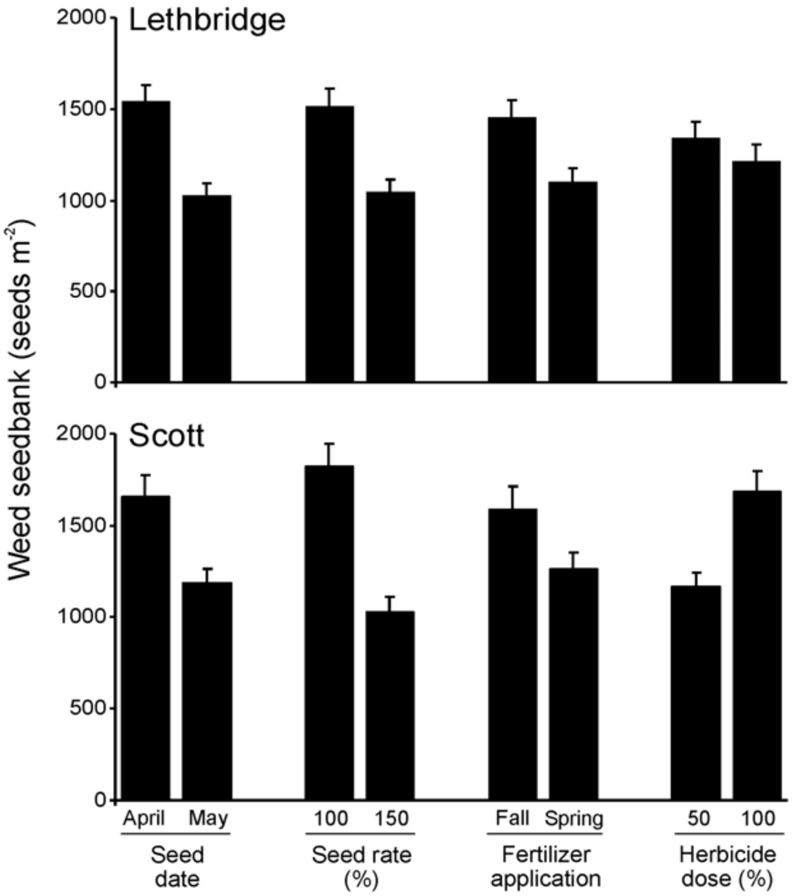

Figure 1. Effect of fertilizer timing, seeding date, seeding rate, and herbicide rate on the weed seedbank at the end of a four-year study at Lethbridge and Scott (bars represent standard errors)

Crop yield

Spring- compared with fall-applied fertilizer increased wheat yield in 1 of 4 years at Lethbridge and in 2 of 3 years at Scott (Table 3). Fertilizer timing never affected canola yield at Lethbridge, but spring- compared with fall-applied fertilizer increased canola yield in 1 of 3 years at Scott. Crop yield was never less with spring- than with fall-applied fertilizer, suggesting that this is the preferable fertilizer application timing. Fertilizer timing did not affect barley yield in any year (Table 4). However, field pea yield was greater with spring- than with fall-applied fertilizer (primarily P) in 2 of 4 years.

Seeding rate and fertilizer timing sometimes interacted in affecting crop yield. Wheat yield was greater (1440 vs. 1160 kg/ha) with spring- than with fall-applied fertilizer with the 150% of recommended but not with the recommended seeding rate in 2000 at Scott. Similarly, canola yield over the four years at Lethbridge was greater (1520 vs. 1320 kg/ha) with spring- than with fall-applied fertilizer with the 150% of recommended but not with the recommended seeding rate. Fertilizer timing became more important as seeding rates were increased in these situations.

Table 3. Fertilizer timing effects on wheat and canola yields (kg/ha)

	Lethbridge				Scott			
	1998	1999	2000	2001	1999	2000	2001	2002
Wheat:								
Fall	2570a	3300a	2010b	2000a	2310a	1100b	550b	-
Spring	2430a	3010a	2230a	2030a	2500a	1440a	800a	-
Canola:								
Fall	1580a	1920a	1110a	800a	1560a	730a	130b	-
Spring	1390a	2000a	1130a	850a	1660a	820a	200a	-

Numbers within a column (for a crop) followed by the same letter are not significantly different at the 5% significance level.

Table 4. Fertilizer timing effects on barley and field pea yields (kg/ha) at Lacombe

	Barley				Field pea			
	1998	1999	2000	2001	1998	1999	2000	2001
Fall	2630a	3360a	3390a	2180a	2980b	3720a	2800a	1600b
Spring	2910a	3570a	3580a	2100a	3280a	3830a	2980a	1750a

Numbers within a column followed by the same letter are not significantly different at the 5% significance level.

Wheat and canola quality

Spring-applied fertilizer gave greater oil levels in canola seed in 1999 and 2000 at Scott compared with fall-applied fertilizer (Figure 2). Although fertilizer timing did not affect yield in either year, spring-applied fertilizer was still beneficial in terms of greater oil content.

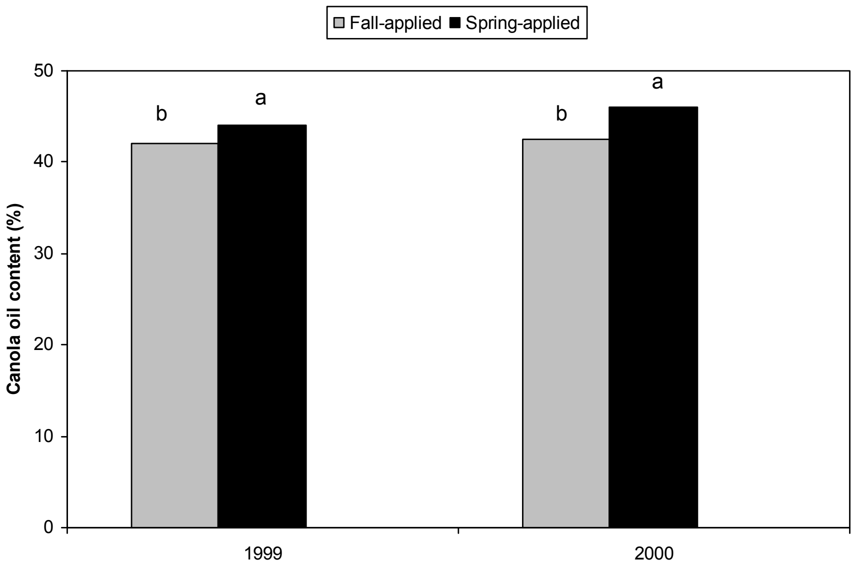

Figure 2. Fertilizer timing effects on seed oil content of canola at Scott, SK

Discussion

Fertilizer application at seeding in the spring in the wheat-canola-wheat-canola rotation reduced weed biomass in 8 of 15 cases by an average of 48% compared with a previous fall fertilizer application and reduced the weed seedbank after four years by more than 20%. Crop yield was only greater in 4 of 14 cases by an average of 35% with spring- compared with fall-applied fertilizer but it was never less. In the barley-field pea-barley-field pea rotation at Lacombe, weed biomass was reduced by 30% and yield increased by 10% in 2 of 4 years in field pea with spring-applied fertilizer than with fall-applied. Fertilizer timing, however, had little effect on weed competition in barley. Thus, spring-applied fertilizer was frequently positive and rarely negative in terms of managing weeds and optimizing crop yield. A previous study conducted at Lethbridge in spring wheat found that density and biomass of wild oat, green foxtail, wild mustard, and lamb's-quarters were sometimes less with spring- than with fall-applied N (Blackshaw et al. 2004b). In that study, wheat yield was never less and was greater in 50% of the cases, when N was spring- rather than fall-applied; four consecutive years of spring- compared with fall-applied fertilizer reduced the seedbank of wild oat and lamb's-quarters, but not that of green foxtail or wild mustard. Other research indicates that fertilizer-use efficiency of spring-planted crops is often greater with spring- than fall-applied fertilizer (Grant et al. 2002), indicating that spring is likely the preferred timing for fertilizer application for both weed management and crop production.

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