From High Herbicide/No Tillage to No Herbicide/High Tillage: How do Crops Respond?

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Abstract

Yield, Quality & Weed biomass

In general, zero-till systems resulted in higher yields and yields declined as the intensity of tillage was increased. The High Herbicide/Zero Tillage system always resulted in the highest yield. The Medium Herbicide/Zero Tillage, Low Herbicide/Zero Tillage and Medium Herbicide/Medium Tillage systems always resulted in similar yields just slightly lower than the HH/ZT system.

Canola yields declined the most and barley and pea yields the least when herbicide inputs were reduced. Management system had little or no effect on crop quality characteristics and weed biomass tended to be greatest when herbicides were not used. As herbicide intensity decreased, weed biomass increased and yield decreased in all crops.

Application of fungicide generally increased seed yield of barley, wheat and field pea with the greatest increases occurring in barley. In most cases where yield responses were significant, the magnitude of the increase was relatively small and so the economic impact of fungicide application was often not positive. The greatest response to fungicide occurred in the wetter years of 1999 and 2000. Fungicide application increased seed weight of all crops except for canola, tended to reduce protein concentration of cereals and field pea and increased barley plumpness.

Introduction

This study was initiated to investigate the effect of various crop and weed management systems on grain yield and quality and on the weed population and density over time in a wheat – canola – barley – pea rotation. A secondary objective was to determine the effect of these practices on insect populations and disease severity. A final objective was to measure the impact of annual fungicide applications on the yield and quality of the four crops grown in rotation. This portion of the report will focus on the effect of the crop management systems and fungicide treatment on crop yield, crop quality and weed biomass.

Materials and Methods

The trial was conducted over 4 years from 1997 through 2000 at the Kernen Crop Research Farm (KCRF) near Saskatoon and at the Saskatchewan Wheat Pool Research Farm at Watrous. The KCRF is located on a Sutherland Clay soil with 60% clay, 28% silt, and 12% sand. The soil

organic matter is 4.5% and the soil pH is 7.2. The Watrous site was located on an Elstow clay loam soil that has 4.5% organic matter and a pH of 7.0. The experimental design was a randomized split-split plot replicated 4 times. Crops were the main plots, management systems were the sub-plots and fungicide treatments were the sub, sub-plots. The plots were 4 by 20 metres.

The experiment included four crops in rotation (wheat – canola – barley – pea). Within each rotation there were 6 cropping systems; #1 - High Herbicide / Zero till (HH/ZT), #2 - Medium Herbicide / Zero Till (MH/ZT), #3 - Low Herbicide / Zero Till (LH/ZT), #4 - Low Herbicide / Low Till (LH/LT), #5 - Medium Herbicide / Medium Till (MH/MT) and #6 - No Herbicide / High Till (NH/HT). Within each of these systems there were differences in seeding rate, fall weed control, pre-seeding weed control, in-crop herbicide rate and seeding date. The systems are summarized in Table 1.1 below. Half of each plot was sprayed with a fungicide and the other half was left untreated. Every crop was grown each year in each of the cropping systems.

Saskatoon:
The experiment was established in an area that had been in a minimum tillage, continuous wheat rotation for several years. All the crops were seeded with a Versatile hoe drill that has 20 cm. (8 in.) row spacing and a 5 cm. (2 in.) seed row spread, with on row packing. Each treatment was fertilized according to soil test recommendations and all the fertilizer was banded at the time of seeding 2.5 cm. (1 in.) below the seed row.

Watrous:
The experiment was established in an area that had been used for other research plots in the past, maintained in a conventional tillage system and the first year was seeded into wheat stubble. All crops were seeded with a Fabro direct seed drill. In 1997 seed was planted with a disc opener at 20 cm. (8 in.) row spacing. In 1998 – 2000 the openers were changed to the Atom Jet 2.5 cm (1 in.) knife openers at 25 cm. (10 in.) spacing. Phosphate fertilizer was usually seed placed and the nitrogen and sulphur was side banded to the side and below the seed row at seeding.

The herbicides used on each treatment were selected just prior to application to control the weed species that were present. The rates were determined by the system treatment list. (Table 1.1) In 1997 all the wheat plots were sprayed with chlorpyrifos (Lorsban) for control of the orange wheat blossom midge. In 1998 all the canola was sprayed with carbonfuran (Furadan) for control of flea beetles.

Growing Conditions

Saskatoon:
The weather conditions over the 4 years were very variable. The 1997 growing season was favourable for crop growth. April was wetter than normal with adequate rainfall throughout the growing season and there were no prolonged heat waves to limit crop growth.

The 1998 growing season presented some challenges, as the spring and early summer were quite dry. Early season drought resulted in extremely poor canola stands so this crop was reseeded in

late June after significant rain fell. The resulting crop was extremely weedy and was destroyed prior to harvest. Following the dry start to the season, rainfall amounts were adequate for the remainder of the summer and yields of the other crops did not suffer.

Table 1. Management System Variables

	Seeding Rate				Fall				Burn off				Incrop				Seeding Date			
	W	C	B	P	W	C	B	P	W	C	B	P	W	C	B	P	W	C	B	P
HH/ZT	1	1	1	1	2,4-D	2,4-D	2,4-D	2,4-D	yes	yes	yes	yes	yes	yes	yes	yes	mid	mid	early	early
MH/ZT	1	1	1	1	2,4-D	no	2,4-D	no	no	yes	no	yes	(2/3)	(2/3)	(1/2)	yes	early	mid	early	early
LH/ZT	1.5	1.5	1.5	1.3	2,4-D	no	2,4-D	no	no	yes	no	yes	(2/3)	no	no	yes	early	late	early	early
LH/LT	1.5	1	1.5	1	till	no	till	till	no	till	no	no	(2/3)	(2/3)	no	yes	early	mid	early	early
MH/MT	1	1	1	1	til	till	till	till	till	yes	till	yes	(2/3)	(2/3)	(1/2)	yes	mid	mid	early	early
NH/HT	1.5	1.5	1	1.3	till	till	till	till	till	till	till	till	p-e till	no	p-e till	p-e till	mid	late	early	early

The 1999 growing season was cool and wet, with a dry fall. This resulted in some of the highest yields recorded over the 4 years of this trial.

The 2000 growing season started with a very dry soil surface. This was followed by below normal rainfall in May and June. However, above normal rainfall in July helped to improve crop yields.

Watrous:

The 1997 growing season started off with plenty of soil moisture, April May and June were above average for temperature and slightly below average for moisture. July was both cooler and drier than normal. Thus towards the end of the season crops were suffering from moisture stress.

The 1998 growing season started off with plenty of soil moisture. April, May and June were above average for temperature and received close to normal precipitation. Rainfall for July and August was below normal while temperatures for July were normal but August was warmer than normal.

In 1999, April, May, June and July saw above average rainfall and August and September were below average. A 2 week wet spell in May delayed seeding. The temperatures were above average for April but equal or below average for the rest of the summer. A hailstorm occurred at this site on July 12 causing damage that ranged from 30 to 83% according to hail adjusters.

In 2000, April, May, June and July received above normal precipitation and August, September and October received below normal precipitation. The temperatures in April were below normal but the rest of the summer was warmer than normal. For the second year in a row this site received hail. The damage was not as severe as from the storm in 1999 but still great enough to reduce yields and possibly mask treatment effects.

Results and Discussion

Fig 1 - Wheat Yield

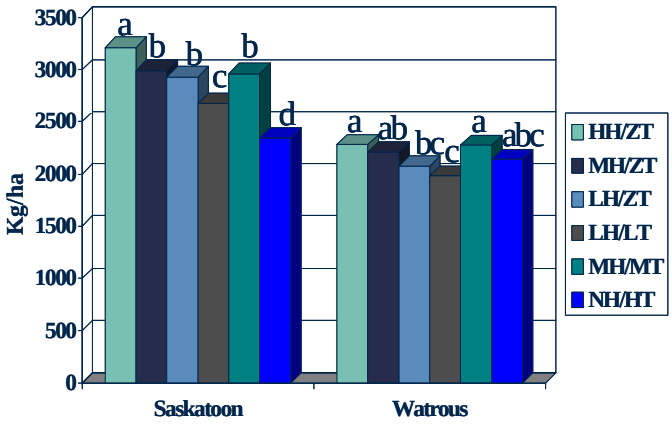


Fig 2 - Barley Yield

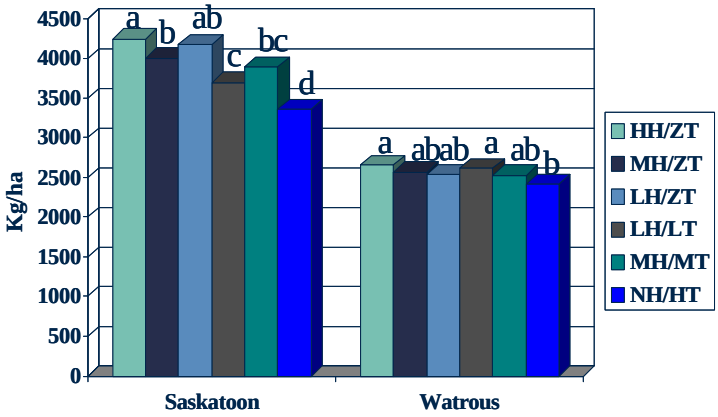


Fig 3 - Canola Yield

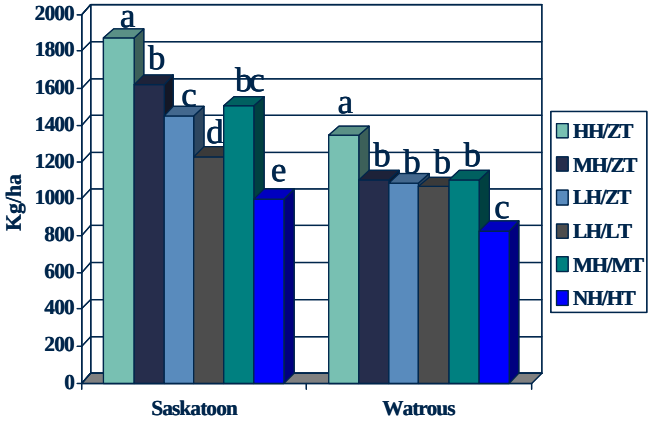
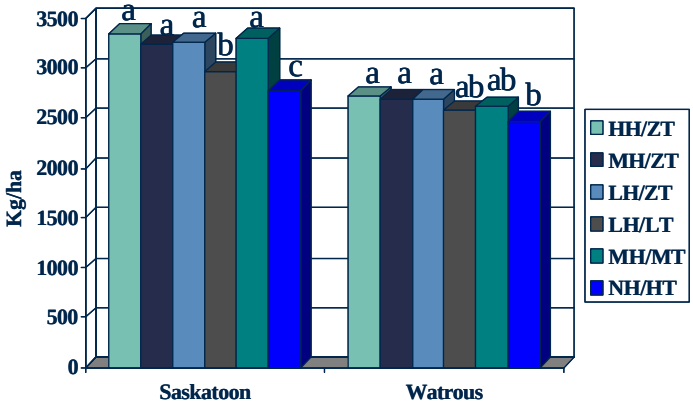


Fig 4 – Pea Yield



Crop Yield (Figs. 1-4)

Crop Quality Characteristics

Seed Weight

System had no effect on wheat kernel weight
System had no consistent effect on seed weight in canola, barley or peas

Seed Protein Concentration

System had no consistent effect on seed protein
No correlation between yield and protein when compared across systems

Barley Plumpness

System did not affect barley plumpness

Canola Seed Oil Concentration

No relationship between system and oil concentration

Response to Fungicide:

Seed Yield:

The application of fungicide increased the yield of pea and cereal crops, especially barley, when yields were averaged across cropping systems and years. Fungicide increased barley yield in all systems except System 4 at both Saskatoon and Watrous. In wheat, fungicide application increased the yield in Systems 1, 2, 5 and 6 at Saskatoon and in Systems 1, 2, 3 and 5 at Watrous.

In most cases where yield responses were significant, the magnitude of the increase was relatively small and so the economic impact of fungicide application was often not positive.

In general, field pea yield did not respond to fungicide application when averaged over years. At Watrous, positive responses to fungicide application occurred in Systems 2, 3 and 5 but not in the other systems. The response of cereals and field pea often varied among years. Fungicide application had little or no effect on crop yield in 1997 at both locations and had no effect on wheat and pea yield at Watrous in 1998. The greatest response to fungicide occurred in the wetter years of 1999 and 2000. In general, pea yield response to fungicide was less than that of wheat, which was less than that of barley. This may be the result of using Harrington barley, a disease susceptible malting variety, in the trial.

Canola yield did not respond to fungicide application regardless of location or year.

There were significant year x fungicide interactions for yield in barley wheat and pea. There was also a system x fungicide interaction for yield of wheat at Saskatoon but not at Watrous.

Seed Weight

Increased seed weight in all crops except canola

Seed Protein

Reduced protein in all crops except canola

Barley Plumpness

Increased barley plumpness (no change in malt grade)

Canola Oil Concentration

No effect on Canola oil concentration

Weed Biomass

Except for barley and peas at Watrous, System 6 always resulted in the highest weed biomass. Although there were few significant differences in weed biomass among other systems, the general trend suggests that as herbicide intensity decreased weed biomass increased. At Watrous only System 6 resulted in significantly more weed biomass than any other system in both wheat

and canola. At Saskatoon, as herbicide intensity decreased, weed biomass increased and yield decreased in all crops.

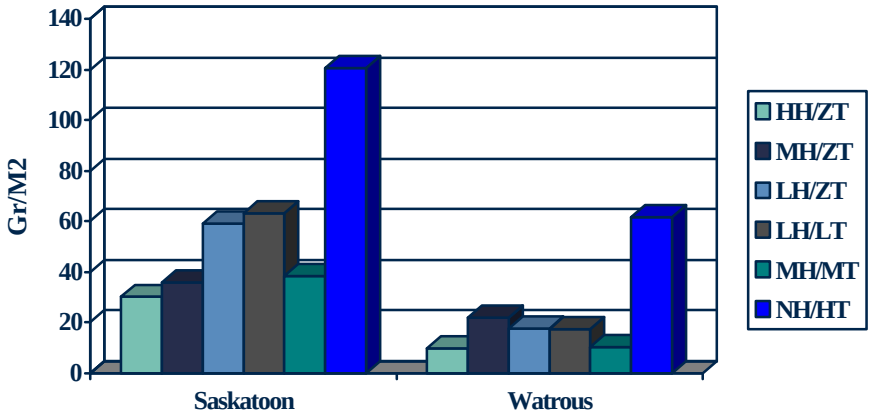


Fig. 5. Weed Biomass

Summary

Significant hail damage at Watrous in 1999 and 2000 likely masked some of the responses to management system and fungicide treatment. Management system had little effect on crop yield at Watrous, the only consistent trend being that the No Herbicide/High Tillage system resulted in the lowest yield. This system was also the lowest yielding at Saskatoon. The High Herbicide/Zero Till system consistently resulted in the highest yield. In general, zero-till systems resulted in higher yields and yields declined as the intensity of tillage was increased. Canola yields declined the most and barley and pea yields the least when herbicide inputs were reduced. Management system had little or no effect on crop quality characteristics and weed biomass tended to be greatest when herbicides were not used. Application of fungicide generally increased seed yield of barley, wheat and field pea with the greatest increases occurring in barley. In most cases where yield responses were significant, the magnitude of the increase was relatively small and so the economic impact of fungicide application was often not positive. The greatest response to fungicide occurred in the wetter years of 1999 and 2000. Fungicide application increased seed weight of all crops except for canola at Saskatoon, tended to reduce protein concentration of cereals and field pea and increased barley plumpness.