Integrated Pest Management Systems: Rationale, Objectives and Design

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Abstract

The objective of the project was to develop integrated crop management systems for weed, insect and disease populations and evaluate the efficacy and cost/benefit of the various management practices. The strategy of integrated management of crop pests seeks to understand the factors that influence changes in pest populations and to utilize these factors to regulate population levels. Field experiments were established in the fall of 1996 on the Kernen Crop Research Farm at the University of Saskatchewan and on the Agricultural Research and Development Farm of Saskatchewan Wheat Pool at Watrous. Six systems were based on combinations of tillage and herbicide inputs. A four-year crop rotation of wheat, canola, barley and field pea was used from 1997 to 2000. Agronomic and pest population data were collected yearly. The economics and energy efficiency of the six systems were compared. Carabid beetle diversity was used as an assessment of soil health.

Introduction

The purpose of this paper is to describe a field experiment that was established at two sites in the fall 1996 to investigate the impact of six management systems on weed, insect and disease pest populations. This paper is meant to serve as an introduction to the four papers (Leeson et al. 2002; Olfert et al. 2002; Sapsford et al. 2002; Zentner et al. 2002) and three posters (Blomert et al. 2002; Leeson et al. 2002; Olfert et al. 2002) in this proceedings that discuss various aspects of the project.

This project was part of the Sustainable Farming Systems Program of the Canada-Saskatchewan Agri-Food Innovation Agreement. The objective of the program was “to research and develop sustainable farming systems and increase the adoption of emerging sustainable farming practices to support diversified Saskatchewan farm enterprises.” The specific objective for our field experiment was to compare the impact of the of six management systems on weed, insect and disease populations and assess the environmental and economic sustainability of these systems.

Management Systems

The six management systems used in the project are based on variations in herbicide and tillage inputs (Table 1a-f). Herbicide use was a maximum in the HH/ZT system where no tillage was used and herbicide applications were allowed in 14 of 16 weed management windows (based on four crops and four herbicide application times). In contrast, no herbicide was applied in the NH/HT system and tillage operations were used in 11 of 12 weed management windows (based on four crops and three tillage times). Four other systems were designed to fall between these two extremes with various combinations of medium or low number of tillage operations and medium or low number of herbicide applications. Herbicide use was reduced in these four systems by both decreasing the number of applications and by decreasing the application rate to on-half or two-thirds of recommended. Seeding date and rate were adjusted where appropriate to compensate for reduced tillage or herbicide inputs.

The number of tillage operations and herbicide applications actually used from 1997 to 2000 is summarized in Figure 1. The combined number of inputs in the HH/ZT, MH/MT, and NH/HT systems is approximately 13 per system per year (total for the four crops in the rotation). The LH/ZT system had the lowest number of inputs at 6 per year. This method of summarization does not take into account the use of reduced herbicide rates or the impact of the tillage operations on residue cover. Figure 2 illustrates the effect of weighting the reduced rates and tillage intensity on the comparison of the six systems. Herbicide intensity is based on kilograms of active ingredient per hectare per year in a system. Tillage intensity measures the amount of crop residue present in a system each year. The value for residue is based on residue type (fragile or non-fragile), type of tillage operation, and crop production and was estimated for the six management systems using a residue tillage decision support system (Moulin and Beimuts 1996). Data for both herbicide and tillage intensity are presented as relative values. The position of any particular system is not the same for both sites because of lower crop production and hence less residue at Watrous.

Experimental Sites

The management systems were established near Saskatoon at the Kernen Crop Research Farm of the University of Saskatchewan and near Watrous at the Agricultural Research and Development Farm of the Saskatchewan Wheat Pool. The soil at Saskatoon is a Sutherland clay with soil organic matter of 4.5% and a pH of 7.2. The soil at the Watrous site is a Elstow clay loam with soil organic matter of 4.5% and a pH of 7.0.

The sites were prepared in the fall of 1996 in preparation for starting the management systems in the spring of 1997. The experimental site at Watrous was established in an area that had been partially or wholly cropped to wheat the previous five years. The experimental site at Saskatoon was established in an area that had been continuously cropped to wheat for several years using minimum tillage management.

Table 1a. High Herbicide / Zero Tillage (HH/ZT) Management System

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	herbicide (±)	herbicide (±)	no	no
Fall weed control	herbicide	herbicide	herbicide	herbicide
Pre-seeding weed control	herbicide	herbicide	herbicide	herbicide
In-crop weed control	herbicide	herbicide	herbicide	herbicide
Seeding date	mid	mid	early	early
Seeding rate	normal	normal	normal	normal

Table 1b. Medium Herbicide / Zero Tillage (MH/ZT) Management System

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	herbicide (±)	herbicide (±)	no	herbicide (±)
Fall weed control	herbicide	herbicide	herbicide	no
Pre-seeding weed control	no	herbicide	no	herbicide
In-crop weed control	0.7 herbicide	0.7 herbicide	0.5 herbicide	herbicide
Seeding date	early	mid	early	early
Seeding rate	normal	normal	normal	normal

Table 1c. Low Herbicide / Zero Tillage (LH/ZT) Management System

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	no	no	no	no
Fall weed control	herbicide	no	herbicide	no
Pre-seeding weed control	no	herbicide	no	herbicide
In-crop weed control	0.7 herbicide	no	no	herbicide
Seeding date	early	late	early	early
Seeding rate	1.5 normal	1.5 normal	1.5 normal	1.3 normal

Table 1d. Low Herbicide / Low Tillage (LH/LT) Management System

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	no	no	no	no
Fall weed control	tillage	no	tillage	tillage
Pre-seeding weed control	no	tillage	no	no
In-crop weed control	0.7 herbicide	0.7 herbicide	no	herbicide
Seeding date	early	medium	early	early
Seeding rate	1.5 normal	normal	1.5 normal	normal

Table 1e. Medium herbicide / medium tillage (MH/MT) management system

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	no	herbicide (±)	no	no
Fall weed control	tillage	tillage	tillage	tillage
Pre-seeding weed control	tillage	herbicide	tillage	herbicide
In-crop weed control	0.7 herbicide	0.7 herbicide	0.5 herbicide	herbicide
Seeding date	medium	medium	early	early
Seeding rate	normal	normal	normal	normal

Table 1f. No Herbicide / High Tillage (NH/HT) Management System

Management Practice	Wheat	Canola	Barley	Field Pea
Pre-harvest weed control	no	no	no	no
Fall weed control	tillage	tillage	tillage	tillage
Pre-seeding weed control	tillage	tillage	tillage	tillage
In-crop weed control	tillage	no	tillage	tillage
Seeding date	medium	late	early	early
Seeding rate	1.5 normal	1.5 normal	1.5 normal	1.3 normal

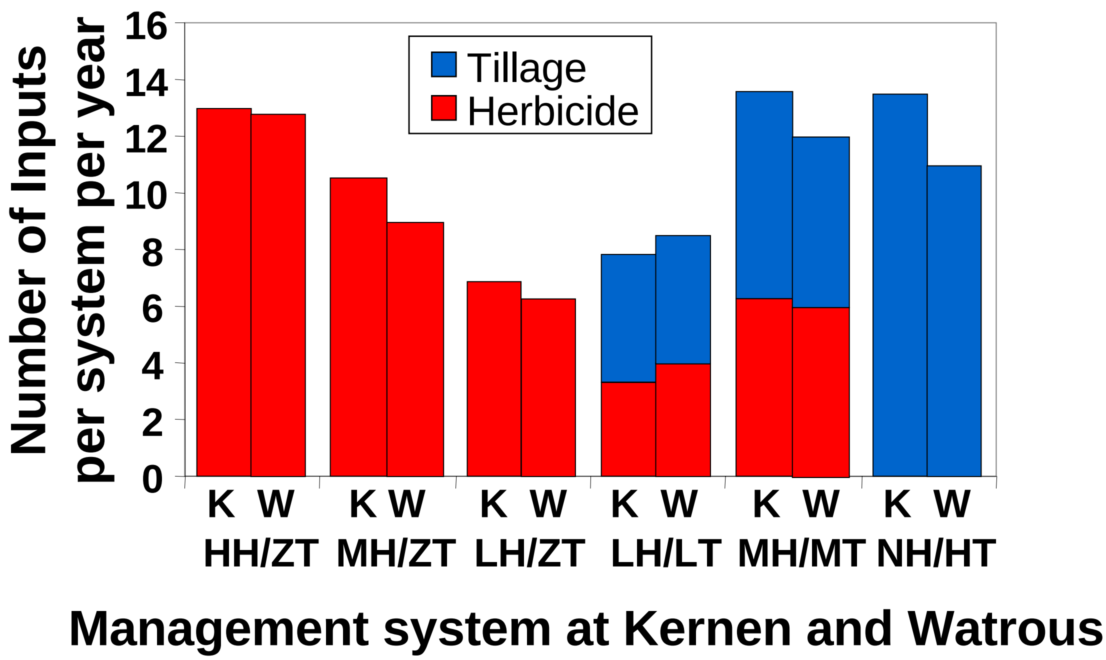

Figure 1. Summary of the mean number of herbicide applications and tillage operations used for each of the six management systems at the Kernen Crop Research Farm and the Watrous Research and Development Farm from 1997 to 2000.

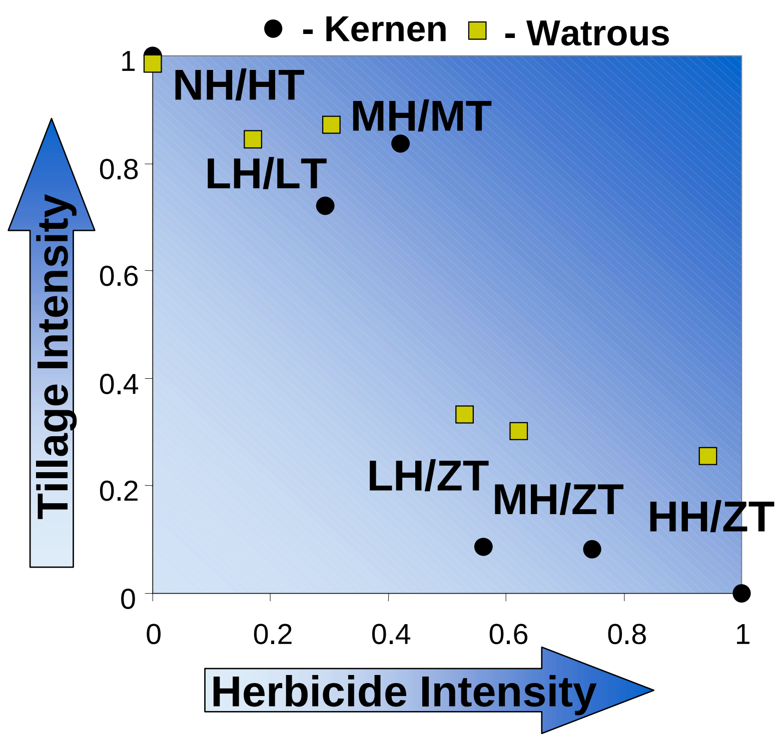

Figure 2. Summary of the relative amount of herbicide (kg ai) used and an estimate of the relative amount of residue removed for each of the six management systems at the Kernen Crop Research Farm and the Watrous Research and Development Farm from 1997 to 2000.

Experimental Design

A randomized split-split plot design with four replicates was used for the experiment. One crop rotation of wheat-canola-barley-pea was used in all six systems and at both sites. Crops were used as the main plots and all of the crops in the rotation were present each year. The six management systems were used as sub-plots. Each sub-plot was split into two sub-sub-plots, one of which received a fungicide application and the other plot was left untreated. Individual plot sizes were 4.0 m by 20.0 m at Saskatoon and 5.8 m by 15 m at Watrous.

Agronomic Inputs

The same crop varieties were used at both sites. AC Barrie wheat, Harrington barley and Grande pea were used in all systems each year. The herbicide-tolerant canola varieties Innovator (1997-1998) and Exceed (1999-2000) were used in the MH/ZT, LH/LT, and the MH/MT systems. Quantum canola was seeded in the remaining three systems. Appropriate seed treatments and inoculants were used for all crops. All the crops at Saskatoon were seeded with a Versatile hoe drill with 20 cm row spacing, a 5 cm seed row spread and on-row packing. At Watrous, crops were seeded with a Fabro direct seed drill. In 1997 the seed was placed with a disc opener at a 20 cm row spacing. From 1998 to 2000, the Atom Jet 2.5 cm knife opener with a spacing of 25 cm was used.

A heavy duty cultivator and a tine harrow were used for tillage operations in the fall and in the spring before seeding. Tine harrows were used for in-crop weed control.

Each crop was fertilized according to soil test recommendations. The crop in each of the six management systems received the same rate of fertilizer. All fertilizer was applied at the time of seeding. Fertilizer was placed 2.5 cm below the seed row at Saskatoon but at Watrous, the phosphate fertilizer was seed placed and the nitrogen and sulphur were placed 2.0 to 3.0 cm to the side of the seed row and 2.0 to 3.0 cm below the seed row. The amount of fertilizer required at Saskatoon was higher than at Watrous and all crops at Saskatoon required an application of sulphur (Table 2).

Table 2. Comparison of the Average Amounts of N, P and S Fertilizer Applied to Crops from 1997 to 2000 at the Saskatoon and Watrous Experiment Sites.

	Saskatoon			Watrous		
Crop	N	P	S	N	P	S
	...... kg/ha					
Wheat	64	27	7	47	24	0
Canola	88	24	14	66	22	12
Barley	59	27	7	50	24	0
Pea	17	23	7	9	20	0

Herbicides and the rate of application were selected just prior to application based on the weed species that were present. Glyphosate was used as the pre-harvest and pre-seeding herbicide and 2,4-D was used for fall weed control. Over the four years of the experiment at both sites, 18 different herbicide products were used for in-crop treatments. Herbicides were rotated among six different groups to delay the development of herbicide resistant weed populations.

In 1997 all the wheat plots at the Saskatoon site were sprayed with chlorpyrifos for control of wheat midge and in 1998 all the canola plots were sprayed with carbofuran for control of flea beetles. At Watrous, chlorpyrifos was used in 1997 for wheat midge control in the HH/ZT, MH/MT, and NH/HH systems where wheat had been seeded later than in the other three systems. Bertha armyworm, diamondback moths, and flea beetle populations were monitored at both sites in all years. Numbers were below economic thresholds in all years.

Growing Conditions

Temperature and rainfall were recorded at Saskatoon (Figure 3) and Watrous (Figure 4) during the four years of the project. The 1997 and 1998 growing seasons were drier and warmer than normal and the 1999 and 2000 growing seasons were cooler than normal with above normal rainfall, except at Saskatoon in 2000. The crops at Watrous were damaged by hail in 1999 and 2000. All canola plots at Saskatoon had to be reseeded in 1998 because of a very dry seedbed that resulted in poor emergence.

Project Participants and Advisors

Name	Agency	Role
A. Gordon Thomas	Agriculture and Agri-Food Canada	Project leader
Frederick A. Holm	University of Saskatchewan	Site manager
Aaron Miller	University of Saskatchewan	Assistant site manager
Ken Sapsford	University of Saskatchewan	Assistant site manager
Daryl Kratchmer	Saskatchewan Wheat Pool	Site manager
Julia Leeson	Agriculture and Agri-Food Canada	Weed community
Anne Légère	Agriculture and Agri-Food Canada	Weed biomass
Barbara Gradin	Agriculture and Agri-Food Canada	Weed populations
Randy Kutcher	Agriculture and Agri-Food Canada	Plant diseases
Bruce Gossen	Agriculture and Agri-Food Canada	Plant diseases
Bob Elliott	Agriculture and Agri-Food Canada	Wheat midge
Owen Olfert	Agriculture and Agri-Food Canada	Soil arthropods
Julie Soroka	Agriculture and Agri-Food Canada	Root maggots
Lori-Ann Kaminski	Agriculture and Agri-Food Canada	Insect pests
Ross Weiss	Agriculture and Agri-Food Canada	Ag-met
Hugh Beckie	Agriculture and Agri-Food Canada	Soil moisture
Robert Zentner	Agriculture and Agri-Food Canada	Economics / energy
Abdul Jahil	Saskatchewan Agriculture and Food	AFIF / ADF advisor
Desiree Jans	Saskatchewan Agriculture and Food	AFIF / ADF advisor
Zoheir Abouguendia	Saskatchewan Agriculture and Food	AFIF / ADF advisor
Clark Brenzil	Saskatchewan Agriculture and Food	Weed advisor
Scott Harley	Saskatchewan Agriculture and Food	Insect advisor
Penny Pearce	Saskatchewan Agriculture and Food	Disease advisor

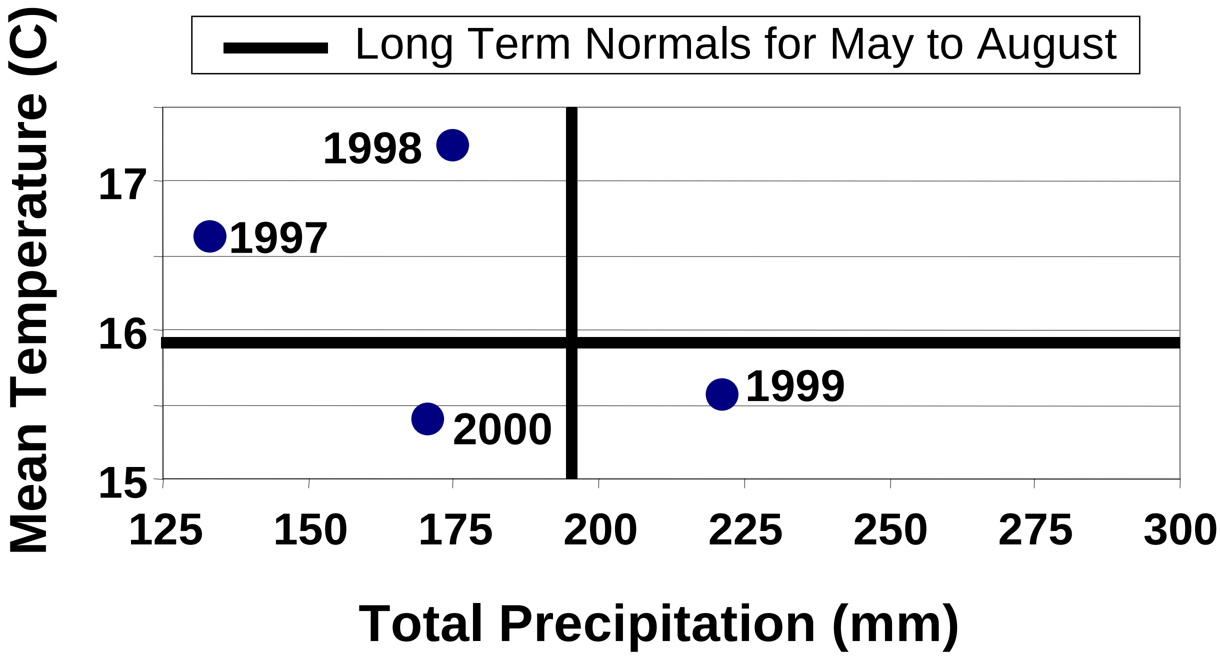

Figure 3. Growing season temperatures at 1.5 m height and precipitation for May through August at Saskatoon.

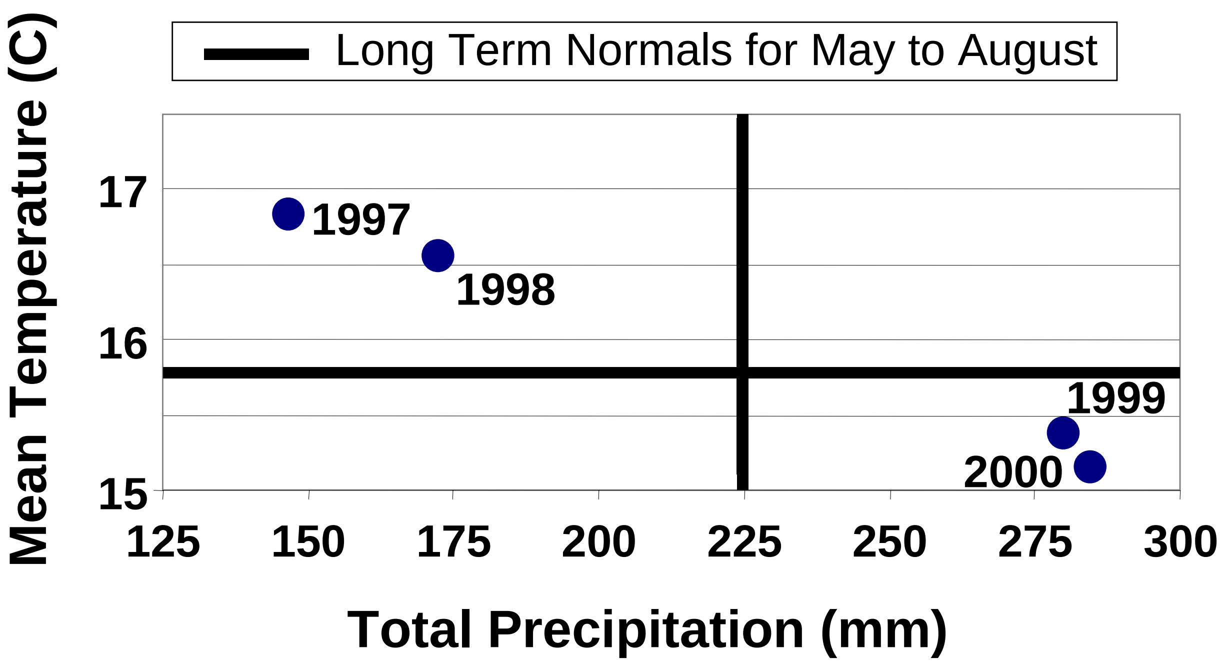

Figure 4. Growing season temperatures at 1.5 m height and precipitation for May through August at Watrous.

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