Cropping Diversity and Input Use Affect Weed Competition

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Abstract

Of the various pests affecting crop growth weeds are among the most visible and potentially the most damaging. Changing markets, higher input costs and technological change are having a profound impact on weed management decisions in Western Canada. While the decision to change management practices can be immediate the long term agronomic consequences of adopting a farm management system are not well understood. One objective of a long term study, established at Scott in 1995, was to investigate the impact of 3 levels of inputs and 3 levels of cropping diversity on in-crop weed competition. Weed biomass used as an indicator of weed competition, was found to be largely a function of input level decisions and the interaction of weed control operations with precipitation timing. Greater weed biomass in an Organic input system could be linked to a limited number of early season tillage operations occurring over a short window of opportunity near the time of seeding. Herbicides applied later in the growing season in the Reduced and High input system effectively delayed weed growth and reduced weed biomass. Weeds in the Organic input system tended to respond to June-July precipitation while weed growth in the Reduced and High input system increased as July precipitation increased. Differences between cropping diversities were less pronounced showing similar weed biomass trends over time.

Introduction

Production practices have changed dramatically over the last 20 years with the adoption of minimum or zero tillage cropping systems and the introduction of pulse and specialty crops. In recent years increased consumer demand and higher prices for organically grown produce has spurred a move back to a tillage-only based system by organic producers. For conventional producers low commodity prices and higher input costs has forced many farmers to look for ways to reduce weed control inputs to remain economically viable. These forces have resulted in various farm management systems that can be categorized on the basis of input level decisions and cropping diversity. To better understand the combined affects of input level decisions and cropping diversity a long term multi-disciplinary study was established. One objective of that study is to determine the impact of three levels of inputs and three levels of cropping diversity on in-crop weed biomass, evaluate the effectiveness of weed control strategies, and determine how climate interacts with management decisions to affect weed biomass

Materials and Methods

A long term alternative crops study was initiated at Scott in 1995 with input level as main plots and cropping diversity as the split plot.

Input levels were defined as Organic, Reduced, and High. In the Organic input system management of pests and nutrients was based on non chemical means in an attempt to mimic what an organic producer might do. In the Reduced input system integrated long term management of pests, nutrients, and reduced tillage were used to reduce non-renewable inputs while chemicals were used to supplement management practices. In the High input system management was based on pest thresholds and soil tests as in a conventional system with chemical inputs used to compliment conventional tillage practices.

Levels of cropping diversity were LOW, diversified annual grains (DAG), and diversified annual and perennial (DAP). All three cropping diversities were based on a six year rotation cycle. LOW represented a traditional wheat based rotation of fallow-wheat-wheat-fallow-canola-wheat. Fallow phases in the LOW diversity were managed differently for each level of input. Indian Head lentils were green manured in each fallow phase in the Organic input system. In the Reduced input system the initial fallow phase was green manured using Indian Head lentil followed by chemical fallow in the 4^{th} phase of the rotation. In the High input system all fallow phases were tillage based. The DAG diversity consisted of a mix of cereal, oilseed and pulse grains. In the Reduced and High input system the DAG diversity was; canola-fall rye-pea-barley-flax-wheat. The ORG-DAG system was altered to include two nitrogen fixing green manure fallow phases to provide much needed nitrogen to the system and enhance weed control. The ORG-DAG diversity consisted of lentil green manure fallow-wheat-pea-barley under seeded to sweet clover- sweet clover green manure fallow-canola. The DAP diversity consisted of 3 annual crops harvested for grain along with one annual forage crop and two perennial forage crops. The DAP diversity was consistent across all three levels of input with canola-wheat-barley-oat under seeded to brome alfalfa-brome alfalfa-brome alfalfa. B. rapa canola was grown in the Organic input system and B. napus in the Reduced and High input system.

Weed biomass was measured in annual crops near the time of crop maturity as an indicator of weed competition from 1996 to 2000. Two above ground biomass samples from 1 m^2 areas at diagonal corners of each plot were taken and bulked. Weeds were separated from the crop and a dry weight obtained to determine weed biomass yield.

Calculations of weed control operation intensities were based on the following criteria;

- Tillage performed primarily for weed control where the soil was not disturbed for at least 3 days prior was counted as a full tillage operation [eg. Most cultivations and in-crop harrowing].

- Tillage for soil finishing, seedbed preparation or to enhance weed control was counted as 0.5 operations if done simultaneously to a weed control tillage [eg. Mounted tine harrows, trailed rod weeder] or 0.75 operations if done separately [eg harrows, packers or harrow packers].

- Each pass with a sprayer was counted, even though more than one pesticide may have been applied as a tank mix.

- operations between harvest of the previous year and seeding were categorized as pre-seed. Operations between seeding and harvest in the current year were catagorized as in-crop.

Results and Discussion

Impact of Input Level Decisions and Cropping Diversity

Weed control operations between 1995 and 1996 were separated into pre-seed and in-crop weed control with in-crop weed control further subdivided into herbicide and tillage operations (Fig. 1). Less weed biomass in the Reduced and High input systems then in the Organic could be attributed in large part to an additional 1.4 in-crop weed control operations, the majority of which were herbicide applications. A comparison of combined pre-seed and in-crop operations indicated the High input system received on average 1.4 more weed control operations per year then either the Organic or Reduced input system. Little difference in weed biomass between the Reduced and High input systems (Fig. 2) of the DAG diversity suggests that the additional pre-seed operations, which were primarily pre-seed tillage operations did not reduce weed biomass in the DAG diversity. Greater weed biomass in the DAG diversity then either the LOW or DAP diversity occurred as a result of increased weed growth in barley, wheat, and canola crops in the Organic input system (Fig. 2). Greater weed growth in barley of the Organic-DAG system could be attributed to under seeding barley to sweet clover which precluded the use of post emerge tillage operations to control weeds. In 1998 dry conditions hindered the establishment of sweet clover and reduced crop competition leading to an average weed biomass of 1039 kg/ha compared to a mean of 196 kg/ha in 1996, 1997, 1999 and 2000. Weed growth increased dramatically in canola of the Organic-DAG system during wet years, and was high in peas in all years except 1998.

Interaction Between Precipitation Patterns and Management Decisions

Weed biomass like crop biomass was to a large degree dependent on the distribution of precipitation during the growing season. Not surprisingly June and July precipitation amounts appeared to have the greatest impact on pre-harvest weed biomass (Fig. 3). Years with above normal July precipitation were classified as wet years and those with below normal precipitation in July as dry years. The years 1996, 1999 and 2000 were characterized with below normal June precipitation but above normal July precipitation. In contrast 1997 and 1998 had above normal June precipitation but below normal July precipitation (Table 1). In wet years July precipitation was on average 42% greater then the long term mean and in dry years were 68% less.

In the Organic system weed control operations were confined to pre-seed and/or post seed tillage operations. Weed biomass in the Organic input system was generally greater and more variable then in the Reduced or High input system. A comparison of weed biomass between input levels between 1996 and 2000 showed the Organic input system produced more weed biomass then either the Reduced or High input system between 1996 and 1998 (P=0.05). In 1999 Organic weed biomass was greater then that produced by the High input system and in 2000 greater then weed biomass produced by the Reduced input system (P=0.05). With the exception of 1999 weed biomass in the Organic system increased as June-July levels of precipitation increased (Fig 3). Results in 1999 indicated the effectiveness of tillage operations in the Organic input system near the time of seeding was highly dependent on precipitation before and after seeding. Lower then expected weed biomass in 1999 could be attributed to moist conditions encouraging weed growth prior to seeding and dry conditions that delayed weed growth after seeding. This greatly enhanced the effectiveness of pre-seed tillage and post-seed harrow operations and reduced weed biomass. In the Reduced and High input system in-crop herbicides minimised the risk associated with precipitation patterns. Herbicides were effective in negating weed growth encouraged by June rains and limited weed response to late June and July precipitation by delaying weed growth and allowing the crop to become more competitive. Weed growth in the High and Reduced input system however continued to be greater in years with greater July precipitation amounts.

A comparison of weed biomass production between 1996 and 2000 for each of the three cropping diversities showed generally greater weed biomass production in the DAG diversity but similar weed biomass trends over time among diversities.

Conclusions

Weed biomass collected between 1996 and 200 for three levels of inputs and 3 levels of cropping diversity indicates;

1) In-crop herbicide application in Reduced and High input systems produced less in-crop weed biomass then pre- or post-seed tillage operations in the Organic system by delaying weed growth and reducing the risk associated with precipitation timing.

2) Three different levels of cropping diversity showed similar weed biomass trends over time. Greater weed biomass in the diversified annual grains system could be attributed to weed control problems in the Organic input system and to a lesser extent in the High input system.

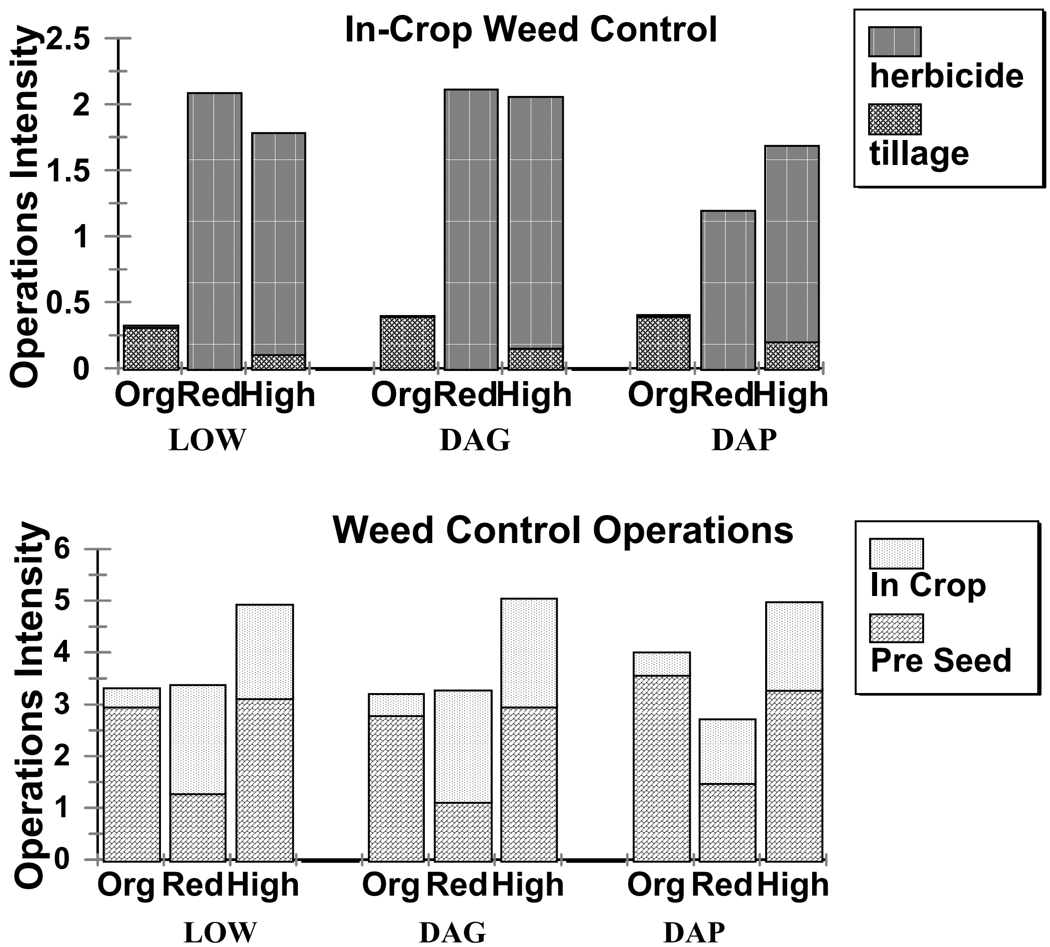

Figure 1. In-crop tillage and herbicide operations intensity and average weed control operations intensity per year and from 1996 and 2000 for three levels of inputs and three levels of cropping diversity.

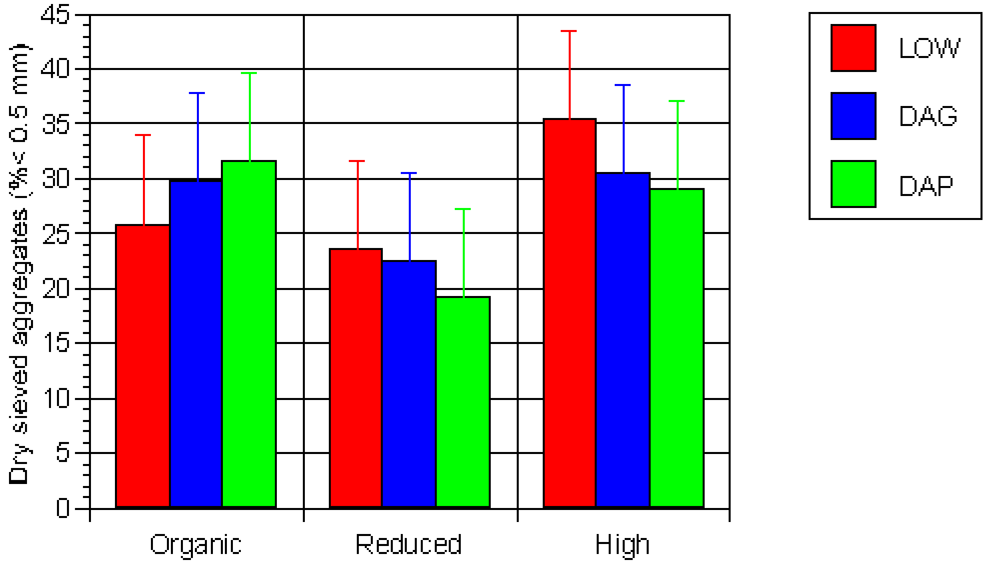

Figure 2. Average annual weed biomass yield for different input systems and cropping diversities between 1996 and 2000 and relative contribution by crop.

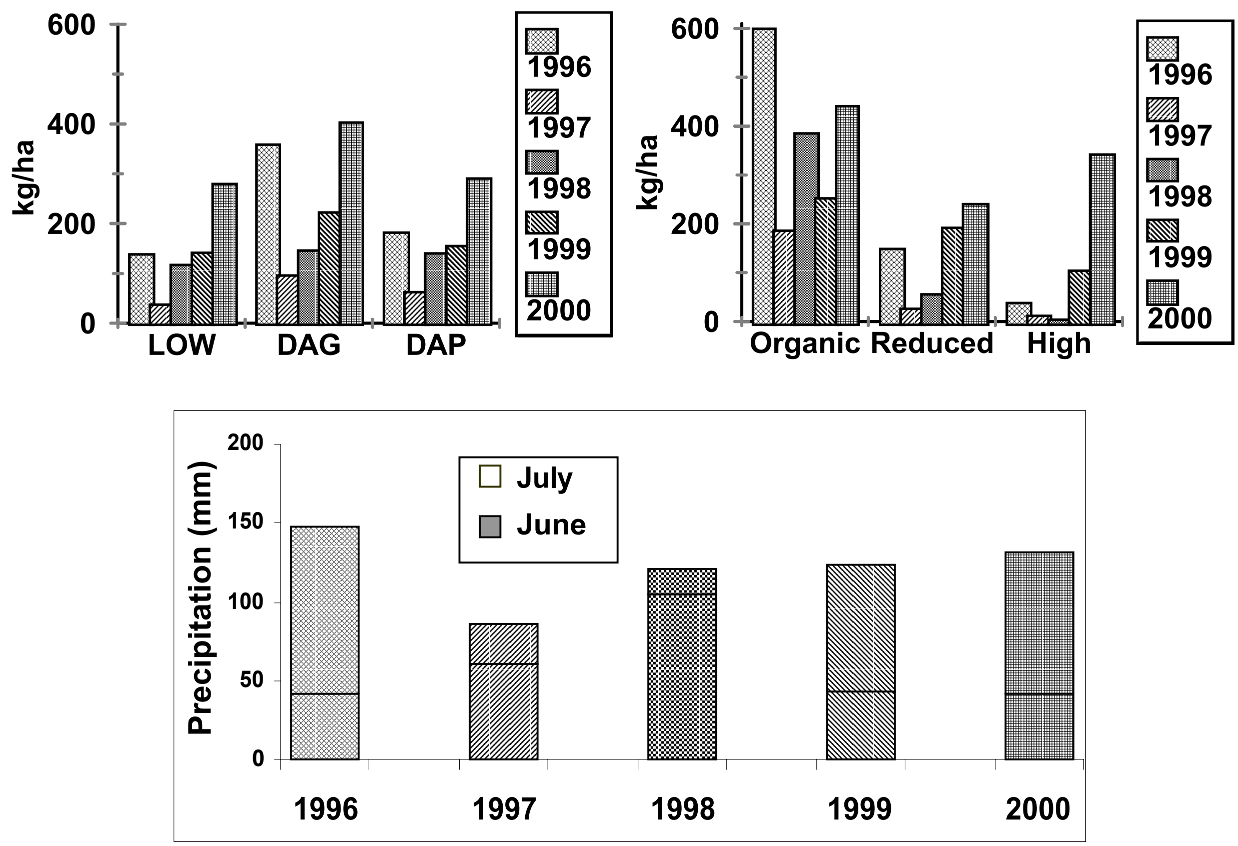

Figure 3. Average annual weed biomass for input systems and cropping diversities and June-July precipitation between 1996 and 2000.