Expert Committee on Weeds
Comité d'experts en malherbologie

Proceedings of the 1999 National Meeting

November 28 - December 1, 1999
Delta Ottawa
Ottawa, Ontario, Canada

Expert Committee on Weeds
Comité d'experts en malherbologie

Proceedings of the 1999 National Meeting

November 28 - December 1, 1999
Delta Ottawa
Ottawa, Ontario, Canada

Compiled, assembled and produced October 19, 2000 by

Wendy Asbil[1] and Daniel Cloutier[2]
[1] Kemptville College, University of Guelph, Kemptville, ON K0G 1J0
[2] ECW-CEM, P.O. Box 222, Sainte-Anne-de-Bellevue, QC H9X 3R9

Disclaimer

The contents of these proceedings are preliminary or completed research results that are the property of the authors. The contents have not been peer-reviewed and may not be used or quoted without expressed permission of the authors. It remains the responsibility of the readers to follow product information contained on the product label. While every effort has been made to ensure accuracy, ECW-CEM, its executive, committee members and contractors do not accept responsibility for any publication errors or any consequences resulting from the use of this publication.

Each annual meeting registrant receives a copy of the proceedings. Additional copies of the proceedings of the 1997, 1998 and 1999 annual meetings can be purchased for $20.00 per copy for members and $ 30 per copy for institutions or non-members. The 1999 proceedings are only available electronically. Please forward orders and payment to the Expert Committee on Weeds at the address below.

Expert Committee on Weeds
Comité d'experts en malherbologie
(ECW-CEM)

P.O. Box 222
Sainte-Anne-de-Bellevue
(Québec) H9X 3R9
Phone: (514) 630-4658
Fax: (514) 695-2365
E-mail:assistant@ecw-cem.org

Table of contents

Introduction

Expert Committee on Weeds 1999 National Meeting
Ottawa, Ontario

The 1999 annual meeting was held in Ottawa from November 29-December 1 and was attended by over 200 people. This is a further indication of the continuing interest in the activities of the ECW/CEM. The plenary session theme of Weeds and Regulations was well received, especially given the venue, the many changes affecting the resource base for agriculture and the environment, and the impact of regulations that govern regional, domestic and global control of plants and plant products. Topics presented in the plenary session were: the current status of weed control in Europe; the impact of weeds on international trade; the regulation of plants with novel traits; risk assessment for biocontrol organisms; risk assessment herbicide buffer zones; and, design and implementation of weed control acts. The presentations stimulated much discussion and debate on biodiversity, genetically modified crops, reduction in herbicide use, usefulness of regulations and the impact of these issues on production efficiency. The opportunity to share information and and participate in the various working groups continues to be a highlight of the ECW/CEM annual meeting. Many of the working group chairs had arranged speakers for their meetings and the sessions were well attended. If the high caliber of the ten student papers presented at the meeting are an indication, then the future of weed science in Canada is bright. Paper topics included herbicide resistance, chemical, biological, mechanical and cultural weed management strategies, critical period of weed control, and site specific weed management. Enthusiasm to share and promote research was evident from the twenty six volunteer posters presented at the meeting. The eight commercial displays also provided information on useful products and services. The tour of the herbarium and insect quarantine facilities at Agriculture and Agri-Food Canada attracted several participants and tied in well with the theme of the plenary session. The meetings would be almost impossible to run without the support of industry sponsors. We are grateful to AgrEvo, Cyanamid, Dow AgroSciences, Zeneca, BASF, Bayer, DuPont, Monsanto and Novartis for their contributions to the tremendous CPI reception and to Harold Wright for organizing it. Coffee breaks were generously sponsored by Vaughn Agricultural Research, Monsanto, Dow AgroSciences, Bayer, BASF and AgrEvo. Travel awards and scholarships graciously provided by Monsanto, Dow AgroSciences and Zeneca gave several students the opportunity to attend the meeting. Prizes for the photo contest were donated by AgrEvo and DuPont supplied the awards for the poster winners. Special thanks is extended to Judy McCarthy and Susan Flood - Graphic Designers at AAFC Ottawa - for their patience and artistry in creating the beautiful, foxtail enhanced forms and banners for the meeting.

The committee members and their responsibilities were:

Wendy Asbil - Chair; Graduate Student Papers; Working Groups liaison
Kemptville College - University of Guelph
Kemptville, ON K0G 1J0
Tel. (613) 258-8336 x 340
Fax (613) 258-8401
E-mail: wasbil@kemptvillec.uoguelph.ca

Scott Couture - Photography contest
Plant Science Department
Macdonald Campus of McGill University
21111 Lakeshore Rd.
Ste-Anne-de-Bellevue, QC H9X 3V9
Tel: (514) 398-7851 x 7874
Fax (514) 398-7869
E-mail: scoutu3@po-box.mcgill.ca

Stephen Darbyshire - Registration Coordinator and Plenary Session
Eastern Cereal and Oilseeds Research Centre
William Saunders Building # 49
Agriculture and Agri-Food Canada
Ottawa, ON K1A 0C6
Tel. (613) 759-1389
Fax (613) 759-1599
E-mail: darbyshires@em.agr.ca

David Jones -Audio-Visual Arrangements and CPI Reception liaison
Senior Coordination Officer, Product Coordination (Herbicides)
Pest Management Regulatory Agency, Room E638
Sir Charles Tupper Building, 2250 Riverside Dr.
Ottawa, ON
Tel. (613) 736-3627
Fax (613) 736-3770
E-mail: djones@pmra.hwc.ca

Len MacGregor - Planning Assistant
Kemptville College - University of Guelph
Kemptville, ON K0G 1J0
Tel. (613) 258-8336 X 680
Fax (613) 258-8401
E-mail: lmacgreg@kemptvillec.uoguelph.ca

François Montambault - Commercial Display Manager
Cyanamid Crop Protection Division
Tel: (450) 770-7944
Fax: (450) 770-7945
E-mail: francois_montambault@py.cyanamid.com

Margo Murray - Planning Assistant
Eastern Cereal and Oilseeds Research Centre
William Saunders Building # 49
Agriculture and Agri-Food Canada
Ottawa, ON K1A 0C6
Tel. (613) 759-1362
Fax (613) 759-1599
E-mail: murraym@em.agr.ca

Derek Oudit - Plenary Sessions
Grains and Field Crops Section
Canadian Food Inspection Agency
59 Camelot Drive
Nepean, ON K1A 0Y9
Tel: (613) 225-2342 x 4332
Fax: (613) 228-6626

Carole Portelance - Poster Session; Delta Hotel liaison
5486 West River Dr.
Manotick, ON
K4M 1G8
Tel: (613) 692-8224
E-mail: carolep@magma.ca

Gilles Quesnel - Sponsorship Coordinator
Ontario Ministry of Agriculture and Food
Box 97, Centennial Dr.
Avonmore, ON K0C 1C0
Tel.: (613) 346-2143
Fax: (613) 346-2689
E-mail: gquesnel@omafra.gov.on.ca

Agenda
1999 Meeting

Expert Committee on Weeds
Comité d'experts en malherbologie
1999 National Meeting,
The Delta Hotel, Ottawa, Ontario
Agenda

Sunday / dimanche, 28 Nov. / nov.

10:00 -17:30h	Executive Board Meeting /*Réunion du conseil exécutif*
15:00 - 21:00h	Registration /*Inscription*
15:00 - 21:00h	Poster and Commercial Display setup /*Montage des affiches de recherches et affiches commerciaux*

Monday / lundi, 29 Nov. / nov.

08:00 - 10:00h	Registration/ *Inscription*
08:00 - 12:00h	Poster and Commercial Display setup/*Montage des affiches de recherches et d'affiches commerciaux*
08:30 - 09:00h	ECW / CEM 1999 opening remarks/*Mots d'ouverture*
09:00 - 10:00h	Opening Plenary Session/ *Scéance plénière*
	★ Jim Orson, Weed Regulations: An International Perspective Morley Research Centre, UK
10:00 - 10:30h	coffee break / *pause café*

10:30 - 12:00h	Plenary Session continued / *continuation de la scéance plénière*

★ Doreen Watler, Weed Regulations: Canadian Perspective - Impact of Weeds on Iternational Trade
CFIA / ACIA, Ottawa. Plant Quarantine

★ Doug Parker, Guidelines for Importation and Releases of Biocontrol Organisms in Canada
CFIA / ACIA, Ottawa. Biocontrol

★ Mireille Prud'homme, Regulations of Plants with Novel Traits
CFIA / ACIA, Ottawa. GMOs

12:00 - 13:00h	Luncheon Buffet / *Dîner style buffet*
13:00 - 14:00h	Plenary Session continued / *continuation de la scéance plénière*

★ Doug Doohan, Provincial Weed Control Acts
Ohio State

★ Ted Kuchnicki, Herbicide Risk Asessment: Buffer Zones
PMRA/ARLA, Ottawa

14:00 - 14:30h	coffee break/*pause café*
14:30 - 17:00h	Student Papers/ *Présentations des articles d' étudiant(e)s*
17:00 - 18:00h	Computerization Committee Meeting/ *Committée sur des donnes électronique*
18:00 - 24:00h	CPI Reception/*Banquet de l'Institut pour la protection des cultures*

Tuesday / mardi, 30 Nov. / nov.

08:00 - 10:00h	Poster Session (authors in attendance), Commercial Displays and coffee /*Scéance d'affiches de recherches et d'affiches commerciaux (les auteurs y-seront présent) et pause café*
10:00 - 11: 30h	Working Groups /*Ateliers* :

★ Forestry; industrial vegetation management/*Foresterie; gestion de végétation industrielle*

★ Site Specific Weed Management/ *Gestion des mauvaises herbes en lieux spécifiques*

★ Product Profiles/*Profiles de produits*

11:30 - 13:30h	Awards Banquet / *Banquet des prix et bourses*

13:30 - 15:00h Working Groups /*Ateliers* :

★ Integrated Weed Management/*Lutte intégrée des mauvaises herbes*

★ Extension and Teaching/ *Vulgarisation et enseignement*

15:00 - 15:30h coffee break/*pause café*

15:30 - 17:00h Working Groups/ *Ateliers* :

★ Application Technology/T*echnologies de pulvérisation*

★ Noxious Weeds/*mauvaises herbes nuisibles*

17:00 - 18:00h GLP Information Session/*Scéance d'information sur les Bonnes pratiques de laboratoire (BPL)*

Wednesday / mercredi 1 Dec. / dec.

08:00 - 09:30h Working Groups / *Ateliers* :

★ Biological Control/ *Lutte biologique*

★ Herbicide Resistance/ *Résistance aux herbicides*

09:30 - 10:00h coffee break/ *pause café*

10:00 - 11:00h Student Papers /*Présentations par les étudiants*

11:00 - 12:00h Business Meeting and Adjournment / *Réunion d'affaires et levée de la scéance*

12:00 - 17:00h Executive Board Meeting / *Réunion du conseil exécutif*

Plenary Session Presentations

List of presentations

Speaker	Topic
Jim Orson	Weed Regulations: An International Perspective Morley Research Centre, Norfolk, U.K.
Doreen Watler	Weed regulations: Canadian Perspective - Impact of Weeds Plant Health Risk on International Trade Assessment Canadian Food Inspection Agency
Doug Parker	Guidelines for Importation and Release of Biocontrol Centre for Plant Quarantine Organisms in Canada Pests Canadian Food Inspection Agency
Mireille Prud'Homme	Regulation of Plants With Novel Traits Canadian Food Inspection Agency
Doug Doohan	Provincial Weed Control Acts Ohio State University
Ted Kuchnicki	Herbicide Risk Assessment: Buffer Zones Pest Management Regulatory Agency

Current status of weed control in Europe

Jim Orson
Morley Research Centre, Norfolk, U.K.

Background

New support measures in Europe (Agenda 2000) are further exposing their farmers to world markets. There is now going to be a common area payment (around £250/ha) for all the supported combinable crops. This will result in world prices influencing cropping patterns rather than level of area payment for individual crop types and other support measures having a profound influence.

North European farmers have become competitive in world wheat markets by wisely investing in inputs that allow them to exploit soils and a climate that can sustain high yields. This has spread the costs of production enabling a competitive production cost/tonne. However, annual grass weeds, notably black-grass (*Alopecurus myosuroides)*, are a major restraint in adopting continuous winter wheat on clay soils that often cannot grow other crops competitively. Black-grass also limits sowing dates and the adoption of non-plough tillage and has developed resistance in most instances to all the effective herbicides used in cereals. However, the most common resistance mechanism is enhanced metabolism and control with herbicides is usually possible but may be expensive.

In much of Northern Europe, farmland accounts for 60-80% of the land area whilst in North America, it represents less than 30%. This fact, together with the intensity of population and cropping in the major arable areas of Europe and the associated reliance on pesticides and fertilisers, has led to concerns over the impact of arable cropping on the environment. Pesticides and nitrates in water and reductions in biodiversity, particularly farmland birds, are having a significant effect on consumer and political attitudes. There is legislation and various voluntary initiatives to limit these impacts. Hence, whilst legislators encourage European farmers to become competitive in world markets and consumers want cheap and wholesome food, they also wish to limit the technologies that enables these objectives to be achieved. This is the scenario into which Monsanto and Agrevo have attempted to introduce GM herbicide tolerant crops. However, many agricultural technologists argue that it is knowledge and the further adoption of technology, including GMOs, which will achieve the twin objectives of a competitive agriculture and an increase in the environmental value of arable land.

Some EU countries, such as Denmark and Holland, have set targets for a reduction in the use of pesticides. In Denmark, the inability to meet these targets has resulted in the introduction of a pesticide tax.

Environmental impacts have a very high priority when pesticide registration is sought. In addition, reviews of existing pesticides are reducing the number of active ingredients on the market. The relative importance of impacts on various aspects of the environment varies from country to country. For instance, reduction of pesticide contamination of water has a very high priority in Holland.

Legislation specific to weed control

There is European legislation to prevent the spread of weeds in crop seeds. Under the European Union (EU) seed regulations, there are rigorous standards for some weeds; for example *Avena fatua*, *Avena ludoviciana*, *Avena sterilis*, *Lolium temulentum*, *Raphanus raphanistrum*, *Agrostemma githago*, *Agropyron repens* and *Bromus sterilis* in cereal seed. This is done by crop inspection and by imposing limits on the weed seed content of the seed sample. Some EU countries also have higher voluntary standards. Seed crops usually have a higher standard of weed control, particularly for wild-oats (*Avena fatua* and *Avena ludoviciana* spp. *ludoviciana)*, than commercial crops.

In addition, some European countries have adopted other measures to limit the spread of weed seeds. In the past, public shaming of farmers who had high levels of wild-oats in their crops has been adopted in some parts of Scandinavia and in this part of Europe powers to compel farmers to control high populations of this weed still exist. In the UK the Weeds Act of 1959 is still on the statute books: this is to prevent the spread of five species, ragwort (*Senecio jacobaea*), spear thistle (*Cirsium vulgare*), creeping thistle (*Cirsium arvense*), curled dock (*Rumex crispus*) and broad-leaved dock (*Rumex obtusifolius*). While some landowners have been warned, there has never been a prosecution under this Act.

There are limits on the weed seed content of grain sold into intervention and similar standards are adopted for all traded grain. Limits in traded grain are of a commercial nature and not a result of legislation. In cereals, the standards for traded grain are usually a limit of around a total of 2% by weight of other seeds (i.e. weeds), other cereal species, chaff and stones. The intervention standards for wheat, barley and rye also stipulate a maximum of 0.1% by weight of noxious seeds (in the UK, *Agrostemma lithago*, *Allium ursinum*, *Allium vineale*, *Melilotus officinalis*). These trading and intervention standards rarely impact directly on the level of weed control because weed populations to produce such levels of seed in the harvested sample would significantly reduce yields and also impair harvesting in damp conditions. In addition, such a content of small seeded weeds would limit airflow in grain stores. Other countries outside the EU will, on occasions, also state a zero tolerance for certain weed species in grain exported from the EU; the only common UK weed stipulated is black-grass for exports to Slovakia, the other stipulated species tending to be natives of Southern Europe or the Americas.

There are no phytosanitory (quarantine) standards for weed seeds in commercial produce imported into the EU with the exception of a mention of a rare semi-parasitic weed. There are many quarantine restrictions for pests and diseases.

Indirect effects of weed control

Effective herbicides, along with chemical fertilisers, have largely replaced the need to grow crops to 'feed and weed' the rotation. The consequent concentration of crops onto the land most suited to their production has resulted in less diversity of cropping and hence the destruction of habitats of some farmland species. The increased adoption of autumn-sown crops to achieve high yields, made possible by herbicides, has also reduced the area of unploughed over-wintered stubbles, which are a valuable food source for some species of mammals and birds.

In addition, the high level of weed control that is now possible is attributed to have resulted in a decline in the number of farmland birds by disrupting their food chain. Research is identifying the weed species that are the most important in producing seed for birds and also those that act as hosts to insects which are an integral part of the food chain of some bird species. Some farmers are voluntarily not controlling non-competitive populations of these species close to crop edges by not treating with a herbicide or by using a herbicide which allows the desired weed species to survive. In addition, the UK government is financially supporting the sowing of narrow grass strips around fields, although adoption is limited by the funds available.

Reduction in the contamination of water with pesticides

The EU has set a limit of 0.1 ppb of an individual pesticide in drinking water (after treatment): pesticides in total should be less than 0.5 ppb. These levels were, at the time of the introduction of the directive, the limits of detection and were not based on possible impacts on human health or on the environment. These standards are very rigorous and causing problems for some herbicides, particularly those which are less active (i.e. high doses are required) and are commonly used. It has resulted, in many European countries, in the withdrawal of some herbicides or specific uses of herbicides, particularly the triazines when used on hard (e.g. paved) surfaces for total weed control. Despite this, drinking water is often treated by ozone and/or carbon filtration to reduce the pesticide content to meet the EU standards. It is estimated that the operational costs of these processes to the UK water industry amount to around £50-100 million/annum.

The level of pesticides in groundwater is falling in the UK, again due to the restrictions imposed on the use of triazines. There are also special measures to protect groundwater; these involve licensing the on-farm method of disposal of pesticides if this does not take place in the crop.

Research is now indicating that a very significant proportion of pesticide movement to water is due to the operations of filling and cleaning sprayers and personal protective equipment. This message is now being promulgated to farmers.

In addition, application of pesticides close to watercourses may be limited in order to maintain biodiversity in the aquatic environment. Several approaches are being adopted in the individual EU countries, including designating the status of the watercourse, identifying which pesticides reduce aquatic biodiversity and the use of no-spray strips adjacent to watercourses. In the UK, a risk assessment system has been introduced that enables the width of the no-spray zone to be calculated according to the likely impact of the pesticide, the dose of the pesticide, the method of its application and the size of the watercourse.

The role of new 'weed' technology

Increasing production efficiency

Clay soils represent around 33% of the arable area of the UK but their extent in Europe has been impossible to estimate, although there are very large areas in most countries. Winter crops dominate these soils because of unreliable and poor crop establishment in the spring. Currently, winter oilseed rape (*Brassica napus*) and, in some parts of Europe, winter or spring field beans (*Vicia faba*) are of importance on clay soils as they are often the sole non-winter wheat crops. They offer the opportunity to control black-grass, an annual grass weed which shares the same growth cycle as winter crops, with herbicides whose efficacy is not affected by the enhanced metabolism form of herbicide resistance. Herbicide resistance in black-grass has been recorded in many parts of Northern Europe, particularly in the UK: such resistance has been confirmed on at least 750 farms in England and can result in extreme financial penalties. There is also herbicide resistance to some herbicides used in combinable crops in wild-oats (*Avena fatua* and *Avena ludoviciana* spp. *ludoviciana*) and Italian rye-grass (*Lolium multiflorum*) in Northern Europe. There is also widespread resistance to the sulfonylureas in common poppy (*Papaver rhoeas*) in Southern Europe.

It is evident that on clay soils, where winter wheat dominates cropping, the threat from annual grass weeds and particularly the presence or threat of herbicide resistance in black-grass is preventing approaches, such as earlier drilling and non-plough tillage, that might further reduce production costs. Hence, improvements in annual grass weed control, within a sound anti-resistance strategy, are an essential key to the future competitiveness of North European systems that rely solely or heavily on winter wheat production. Whilst increased knowledge of these weeds may provide improved cultural control measures, there is little doubt that there is the need for better selective herbicides and/or the adoption of herbicide-tolerant crops. This will be so particularly if the production of oilseed rape and field beans continues to be financially unattractive, resulting in the economic need to expand the area of winter wheat on clay soils.

The introduction of GM herbicide-tolerant rape has been delayed in Europe, due to consumer concerns, and its impact on the environment is being evaluated in the UK. From a technical point of view, this delay must be seen as a retrograde step. These crops would introduce new and effective modes of action for grass weed control in winter wheat/oilseed rape rotations.

To increase the efficiency of labour and machinery, approaches also need to be developed whereby the same herbicide mixture can be applied to many fields: the doses will be adjusted by changing spray volume according to parameters such as weed species, population and resistance status. This approach is already possible for fungicides in winter wheat but may require the introduction of more effective herbicides for the control of black-grass. Currently, the control of weeds on many farms often results in having to use specific herbicide mixtures in individual fields. This applies in particular to the control of black-grass, where the status of herbicide resistance (either target site and/or enhanced metabolism mechanisms) and weed population and growth stage can vary from field to field.

An alternative approach is to use a direct injection sprayer in order that herbicide mixtures can be changed with little or no reduction in work rates. These sprayers may be more generally adopted when spatial application of herbicides becomes feasible. However, there still remains the need to reduce the potential number of herbicides required between fields or parts of fields. In time, sensor technology allied to spatial application may enable populations of weeds that will not affect current and future crops to be left unsprayed.

Particular care needs to be taken with resistance management where the same product mixtures are adopted over the whole farm in the same year. Different basic programmes need to be developed both for annual grass and annual broad-leaved weed control in order that these can be rotated on an annual basis. Simple decision structures and improved information systems will support such an approach.

Reducing the impact on the environment

Agenda 2000 provides no opportunity to increase the diversity of cropping; quite the opposite. However, greater knowledge of the impact of modern arable systems on the environment along with new technology should result in increased biodiversity. For instance, it may be possible to drill GM herbicide-tolerant sugar beet in strips of cultivated soil, retaining much of the cereal stubble which research has proved is an important food source for farmland birds. This may be impossible with conventional herbicides because they may not provide effective weed control in the stubble.

The agronomic value of GM herbicide-tolerance has to be judged on a case-by-case basis. However, there are other approaches that can be adopted with these crops to increase the environmental value of land, such as enabling weeds to be controlled at more advanced growth stages, resulting not only in more biodiversity but also in the increased predation of crop pests. In addition, herbicide-tolerance will give farmers the confidence to leave narrow unsprayed strips within the crop knowing that the plants from the resulting shed seed can easily be controlled in future crops. Also, by enabling easy and cheap weed control in broad-leaved crops, farmers will be less zealous in their approach to the control of broad-leaved weeds in cereals that are an important part of the food chain for birds. Similarly, herbicide-tolerant crops will also increase the confidence of farmers to adopt spatial application.

Many of the objections to GM herbicide-tolerant crops are based around their ability to achieve consistently very high levels of weed control, thus reducing biodiversity. The use of selective herbicides also normally results in weed free crops, the impact of which can be partially offset by not controlling the less pernicious weeds close to the crop edge. In the future, the adoption of spatial application will have a significant positive impact on in-field biodiversity.

The increasing impact of weeds on international trade

Doreen Watler
Canadian Food Inspection Agency

ABSTRACT

The introduction of weeds into new areas by means of international trade in commodities is coming under increasing scrutiny. Our trading partners are adopting risk assessment procedures to justify the exclusion of commodities contaminated with weed seeds. Canada is moving in the same direction and is involved in cooperative efforts on the regulation of weeds among the three countries of North America. The presence of weeds is already affecting the acceptability of Canadian commodities in foreign markets. What will Canada have to do to adapt to the evolving international situation?

INTRODUCTION

North America began to be invaded by plant species from other parts of the world as soon as non-indigenous settlers began to arrive. Settlers brought the crops they wanted to grow from their countries of origin, and the weeds which were associated with the crops came with them, and were planted at the same time. Thus, in North America, we have always had the situation that the most important crops have been afflicted with alien weeds, but since the crops themselves are mostly alien species, this situation, though accidental, was no surprise (It is estimated that introduced species now provide more than 98% of the US food system, and it is probable that the Canadian system is little different.) We have also deliberately introduced many alien plant species for landscaping and decorative purposes, and many of them have been able to get out of gardens and other controlled settings into natural environments. Alien plant species have been troublesome and aggressive weeds in North America since early days. Most (though not all) native species are less problematic as weeds. The number of species which we have imported historically is unknown, but the Canada Botanical Conservation Network Invasive Plant List includes a total of 84 species which are characterized as invasive. Invasive weed species can be trees, shrubs or vines as well as herbaceous species (although these are the majority, with 53 species). They can flourish in all sorts of habitat all across Canada, and they crowd out native plants, as well as impeding production of all sorts of crops. Some of these species are threatening the existence of endangered native species. Garlic mustard (*Alliara petiolata*) is listed as a threat to the endangered wood poppy (*Stylophorum diphyllum*) and also to white wood aster (*Aster dicaricatus*) in Ontario, and slender mouse-ear-cress (*Halimolobos virgata*) is threatened by crested wheat grass (*Agropyron pectiniforme*).

The Crop Protection Institute 1998 Sales Survey of Pest Control Products showed that herbicides accounted for 85% of the total $1.4 billion in sales, or $1.2 billion. This giant figure of 85% of the total dwarfs insecticide sales, at 4%, $58 million, and fungicides at 7%, most of both of which were applied to oilseeds and potatoes. Field crop uses represented 96% of the total sales of herbicides. Thus alien invasive weed species are responsible for a substantial part of production costs in many crops, and the costs are climbing. The 1998 proportion of 85% is 4% higher than the previous year , which was 81%. In eastern Canada, it is estimated that 50% of the losses are from hay crops, and 33% in field crops, while in the west 84% is from field crops.

In the US, it is estimated that 500 introduced plant species have become weeds, and there are many examples of competition with foreign weeds resulting in decline of native species. It is estimated that alien weeds are invading approximately 700,000 ha/year of the US wild life habitat, or nearly 2,000 ha each day, as well as causing forage losses of about $1 billion a year. Weeds cause a crop reduction of about 12% overall, representing a loss of around $33 billion US. About $4 billion US is spent on herbicide in the US.

REGULATION

Thus, alien weeds are numerous and costly and likely to become more so. Is it too late for governments to worry about trying to keep weeds out of their countries? Oh, no, many weeds may have become cosmopolitan, but there are still plenty of them which have not got spread around yet, and regulation is not in decline. Quite the reverse, in fact, the focus on invasive plants is becoming sharper. As many of you may know, the US started this year on a new initiative, under the auspices of an executive order from the President, dated February 3rd, “to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological and human health impacts that invasive species cause”. A federal Interagency Weed Committee has been set up as one of the initiatives and has produced a National Strategy for Invasive Plant Management. The National Goals are Prevention, Control and Restoration. The plan is available on the Internet at the Interagency Weed Committee Web site. How this plan will translate into action, including regulatory action, remains to be seen, but the overall aim of coordinating activities among many agencies, using the Internet to share information, is an interesting and challenging idea. There are already many organizations with ongoing programs, but the US executive order will have the effect of pooling information and giving a better overall picture of the situation.. It is bound to influence international thinking, in Canada as well as in other countries.

Concern about weeds is not new in the US, of course. The USDA already has a long list of weed species which are regulated under the authority of the quarantine agency of the country. Many other countries are similarly equipped. Australia and New Zealand are prime examples in this regard, but so are many others, such as Russia. Some other countries, such as India, require freedom from weeds without specifying which ones. Canada exports large quantities of seeds and grains to many countries, both for planting and for consumption. Up to the present, quarantine standards have been applied strictly usually only to seed for planting. Seed for production has been usually treated differently, for example, in New Zealand where the handling of grain which arrives for processing takes into account the level of infestation with weeds. However, there are some new trends. There is a move in several countries to expand the enforcement of quarantine regulations to cover seeds and grains for consumption and processing. For example, Chile and Mexico have started along that path, although so far they have not implemented any new regulations. We are working with both countries to see what measures could be implemented to meet their concerns. For seeds for planting, purity standards are met by analyzing samples taking at the rate of 1 kg/25 tons. If you scale that rate of sampling up for a shipment of 25,000 tons of grain for processing, you would require 100 kg of samples , a daunting and expensive prospect! Also, currently, there is no system of field inspection during the growing season for grain for consumption, as there is for seed for planting.

RISK ANALYSIS

Would the Chilean and Mexican governments, or any government, have the right to impose such new regulations? Under the provisions of the World Trade Organization (WTO), phytosanitary regulations must be supported and justified by a scientifically-based analysis of the risk posed by allowing the regulated organisms (in this case, weeds) into the country. One hears a lot about risk analysis these days, and methods of carrying risk analyses out have been developed in many disciplines. For organisms associated with plants, accepted international guidelines have been developed under the auspices of the International Plant Protection Commission (IPPC). The aim of the risk analysis is to determine which of the organisms assessed meet the definition of a quarantine pest.

Usually risk analysis is split into two parts, risk assessment and risk management. The first part contains the biological data which affects the level of risk and the second part contains the factors which influence the practical decisions about how the risk can best be addressed. Under risk assessment, we consider two types of factors, one set relating to how an organism could get into a country and the other set relating to how well it is adapted to the new environment. In the first set, it is necessary to determine how many ways of getting into the country exist for the organism. Which commodities it could travel with, and any other pathways, which for weeds would include such means as soil with plants, dirty vehicles and containers etc. In the second come all of the biological attributes which contribute to its likelihood of success, including its adaptation to the climate, soil, and other environmental factors and its adaptations for propagation, spread and establishing itself in the new place. Under international law, a country is not justified in regulating any organism under quarantine laws unless it could establish in the country and cause economic damage.

Several countries have developed a risk analysis format adapted to weeds, notably Australia and the United States. The USDA format for weed assessment is available on the Internet, and you can visit the site and see how the assessment part of the analysis is carried out in an 8-step qualitative process. It is a straight-forward approach which has considerable value. Although qualitative, scores are given for each factor, leading to a final evaluation of high, medium or low risk.. The US developed this approach in 1997, which is about the same time as the Australians. The guidelines there look rather different , but are still concerned with the same type of factors. The IPPC Guidelines do not specify exactly how the factors in a risk assessment are to be combined, whether they are all to have the same weighting, or whether the assessment is to be qualitative or quantitative. The idea is to provide a framework for explaining why an organism is treated in the regulations as it is. The method has to be fully transparent so that if the regulation is challenged under the WHO, the basis of the regulations can be understood, and if necessary, challenged by another country.

CANADIAN SITUATION

How does Canada stand in relation to the regulation of weeds? Not at the forefront at the present, actually. Canada has very few weeds regulated under the Plant Protection regulations, only some parasitic plants and some aquatic weeds. Canada <u>does</u> have regulations under the Seeds Act which completely prohibit the presence of 29 species of weeds in seed for planting. Our regulations are rather similar to those which the previous speaker talked about for Great Britain, and include lists of primary and secondary noxious weeds as well as the prohibited noxious species, and the grading system is based on the maximum number of seeds of the primary and secondary noxious weed seeds in a one kilogram sample. Samples are evaluated in specialized laboratories in Ottawa and Saskatoon. The existence of a list of prohibited noxious weeds under the seeds act is not the same as having a list of prohibited quarantine weeds for Canada. The list refers only to seeds for planting and not does not apply just to seeds imported from other countries. Many of the weeds named on the list would not meet the definition of a quarantine species, that is that it is either absent from Canada, or present in a restricted area and under official control. Under the quarantine regulations of many other countries, quarantine weeds are not allowed to be in any commodity, so that plants, soil etc are also under the regulations.

Individual provinces of Canada are free to establish their own quarantine laws preventing movement of weeds inside their own boundaries, and they have done so, but they cannot regulate the importation of weeds into Canada as a whole, or effectively control movement from one province to another. Why is the Canadian situation as it is? The regulation of weeds was not, historically, clearly under the Plant Quarantine laws in Canada, and it is only with the new, well, fairly new, Plant Protection Act (1992) that we have had the definite mandate to regulate weeds.

It is clearly to our advantage to establish a list of regulated quarantine weeds for Canada. There is no crop production system which needs to be burdened with the control of more weed species. Also, the establishment of a new weed species may make meeting the requirements of a trading partner more costly, impeding access for Canadian products to that market. Even weeds which are marginal in our climate, and which do not cause much direct economic damage may have major consequences for trade if they are of importance to a trading partner with a warmer climate. We are already involved in the international regulation of weeds within North America, by participation in various panels of the North American Plant Protection Organization, seeking to bring harmonization into the way that weeds are regulated in North America, even though we do not yet have actually our own list of regulated weeds. We have been doing risk assessments for insects, diseases and even nematodes for more than ten years now, but we do not yet do assessments for weeds.

In order to develop a good list of quarantine weeds, it is necessary to carry out Canadian risk assessments for weed species in order to determine their level of risk for us. We may adopt or adapt a format developed elsewhere, but the actual assessments must be done with regard to our own climate and environment. Which weeds are important to keep out? For example, we do not have black-grass (*Alopecurus myosuroides)*, mentioned by Dr. Orson, in Canada. We need to assess if it could be an important weed for Canada, and we need to do the same for many other species. The database of the Ottawa and Saskatoon Seed Labs contains a list of 159 species which come into the category of "other weeds". That is, species which are not listed in the Seeds Regulations, and not classified as noxious in Canada. We need to take a look at that list and see what is coming in. (I did notice that *Alopecurus* was on the list). A list of potential quarantine species is also in existence from a few years back, and that too needs to be reviewed. For all this work of review and assessment we need at least one weed expert devoted to the task, and probably that person would need to set up cooperative relationships with other experts within Canada. We have identified this need within the agency in requests for additional resources and we have hopes that we may be given the possibility of hiring a biologist with this expertise in the reasonably near future. We cannot be sure what resources we may get and what we will be able to do with them. But the changes in international trade mean that we must move to defend the Canadian environment and Canadian trade.

Once we have begun to conduct our own risk assessments on weeds, it will make it easier to review the proposed quarantine lists of other countries to determine if their assessments of the risks associated with the weeds which they list are reasonable. That is another important function of a risk assessor for weeds, defending Canadian exporters from unjustified regulations. It is important to be able to challenge another government if we need to do so.

Guidelines for Importation and Release of Biocontrol Organisms in Canada

Doug Parker
Canadian Food Inspection Agency

I would like to thank the Organizing Committee for inviting me to speak to such a distinguished group of weed experts. My name is Douglas Parker and I will be talking about the procedures and guidelines for the Importation and Release of Phytophagous Biocontrol Organisms in Canada. I will preface my talk with some general information on our mandate and duties within the Canadian Food Inspection Agency.

We work in the Entomology Unit of the Center for Plant Quarantine Pests. We maintain a laboratory in the K.W. Neatby Building on the Central Experimental Farm where we provide an identification service for our field inspectors across Canada. My colleague, Dr. Bruce Gill, and I are responsible for identifying insects, mites and terrestrial molluscs intercepted on imported, exported and domestically-moved plants and plant products. This service is provided in support of the Plant Protection Act - "an Act to prevent the importation, exportation and spread of pests injurious to plants and to provide for their control and eradication and for the certification of plants and other things." The purpose of the Act is "to protect plant life and the agricultural and forestry sectors of the Canadian economy by preventing the importation, exportation and spread of pests...". The Act defines a pest as "any thing that is injurious or potentially injurious, whether directly or indirectly, to plants or to products or by-products of plants, and includes any plant prescribed as a pest..". When our inspectors intercept an organism on a plant or plant product, the sample is submitted to our laboratory for identification. With the help of the Canadian National Collection of Insects (a reference collection of 12 million pinned specimens), the finest entomology library in Canada and the taxonomic support of scientists and technicians in Research Branch of Agriculture and Forestry, we then advise the regulatory officers of the Plant Production Division on a course of action depending on the seriousness of the pest. These actions may include destruction, treatment or return to origin of the commodity.

Along with our identification service, Dr. Gill and I provide biological risk assessments for all permit applications for the importation of live insects, mites and terrestrial molluscs. Presently, permits are required for the importation into Canada of almost all live insects, mites and terrestrial molluscs including phytophagous, predaceous and parasitic biocontrol agents. We assess approximately 200 to 400 permit requests per year.

Generally, there are very few introductions of non-indigenous biocontrol agents into Canada each year. While other organizations within the Federal and Provincial Governments have shown interest in the area of biocontrol, the regulatory responsibility still resides within the Plant Health and Production Division of the CFIA. Provincial governments may promulgate supplementary regulations and in fact, the governments of Ontario and Quebec have done so, which means that anyone who wishes to release such agents in Ontario or Quebec must obtain permission from both federal and provincial authorities.

The Agency is not in the business of promoting biocontrol. While biocontrol may be an important component of sustainable agriculture, we just assess the risks of the introduction and try to ensure that the introduced organism does not itself become a pest. Biological pollution is and will continue to be a very important issue. The intentional and accidental introductions of non-indigenous species have caused enormous losses of biodiversity and disrupted natural habitats throughout the world. However, we are not purists in demanding an end to the introduction of all exotic organisms. As an extremely invasive species ourselves, we have a moral responsibility to ensure that before the introduction of any organism into an area where it does not already occur, there should be a thorough risk assessment. It is only common sense.

Many countries and regions have tried to establish rules for the importation and release of classical biocontrol agents. Generally speaking, there are few international published guidelines for the import and release of classical biocontrol agents. Difficulties arise when regulators try to include all biocontrol agents from microbials to invertebrates under one set of guidelines. This cannot be done. In Canada, there are two different procedures for assessing classical agents-phytophagous agents are assessed differently that predators and parasites. Our guidelines have been developed in collaboration with the North American Plant Protection Organization Biocontrol Panel and have been agreed upon by the regulatory agencies in Canada, the United States and Mexico. As already stated, the Plant Protection Act is in place to prevent the introduction of exotic plant pests; non-indigenous classical biocontrol agents for weed suppression are indeed plant pests.

Most introduction of agents into Canada for classical biological control purposes have been conducted by a smaller number of federal research scientists, working in the Research Branch of Agriculture Agri-food Canada (AAFC). There are also a few introductions by scientists who work for provincial governments or universities, usually in collaboration with federal scientists.

Firstly, petitions are received by the Chairperson of the Agriculture Canada Biological Control of Weeds Review Committee, a committee within the Research Branch of Agriculture and Agri-food Canada. These petitions contain screening reports and other biological data on the phytophagous agent to be imported. According to the NAPPO Standard (attached), all petitions must conform to the outline and address the issues raised in the guidelines. The completed petitions are circulated and assessed within the AAFC review committee as well as sent to USDA-APHIS, Biological Control of Weeds Technical Advisory Group (TAG). Our Research Branch Review Committee is composed of taxonomists in entomology and botany and other scientists within the Federal Government. Once the comments have been received from the reviewers within Canada and the United States by the Secretary of the Committee, they are collated and circulated again. If questions are raised concerning the introduction, the Chairperson of the Committee may ask the petitioner to provide more information or even carry out further testing.

Once the chairperson is satisfied with the petition, he makes a recommendation to the Director of the Plant Health and Production Division and provides all parts of the petition and the reviewer's comments. The petition is then reviewed by the regulatory entomologists of the Center for Plant Quarantine Pests. On the basis of our recommendations, a letter will be issued by the director of the Plant Health and Production Division either authorizing or denying the release of the agent in Canada. With approval, the organisms can be imported through a quarantine facility, their taxonomy and health confirmed and then, released into the environment.

There are certain problems with this review process for phytophagous agents. The internal review committee because of its membership may not be qualified enough to assess all the risks associated with an introduction. There is also a need to broaden the membership of the review to include representatives of Environment Canada, provincial governments and citizen groups. Moreover, we do not know all the answers to our questions concerning an introduction. It is best to be conservative in regards to introductions. Which brings us to the creed of quarantine - "when in doubt, keep it out" and the corollory, "guilty until proven innocent".

Probably the most distressing problem with the review process is that the number of taxonomists in botany and entomology is in serious decline. Without this type of knowledge, biological control will become far too risky. The taxonomy, identification and collection records of the organism and its hosts are central to the assessment of the risk. The number of insect taxonomists at BRD has dropped from 40 scientists in the 1960's to about 16 today. How can we hope to continue effective, safe introductions in biocontrol without this foundation of sound knowledge? We are at a crisis point in taxonomic support, and scientific support in general.

The system seems to work quite well at assessing the risks of non-indigenous introductions. We have the co-operation of both ARS (Agricultural Research Service) and APHIS (Animal and Plant Health Inspection Service) in the United States. Through NAPPO, we have standardized the information requirements and procedures for all three countries in North America. This will result in a continental approach to exotic biocontrol introductions which has been sadly lacking in the past.

Within the larger picture of the introduction of all non-indigenous organisms, the assessment of biocontrol agents is almost as rigorous as novel or transgenic organisms. What about the introduction of the other taxa that fall through regulatory oversight - algae, diatoms, plants, spiders, scorpions, mammals, birds and fishes? These organisms are usually only assessed, if at all, on their risk as carriers of other pathogens and pests, not as potentially-invasive species themselves. When you consider what we are doing in context of the regulation of other non-indigenous organisms, we at least have systems and guidelines in place that help us assess the risks of these releases. However, the introduction of non-indigenous organisms is still essentially a dangerous endeavor. We must always keep in mind that nature is not static; all organisms, including nature's success story the insects, have the ability to adapt to new situations. Few introduced organisms behave the way they do in their native habitats. And in the final analogy, no matter how confident or uncomfortable we may feel, nature bats last.

NAPPO STANDARDS FOR PHYTOSANITARY MEASURES
GUIDELINES FOR PETITION FOR RELEASE OF NON-NATIVE
PHYTOPHAGOUS AGENTS OF THE BIOLOGICAL CONTROL OF WEEDS

GENERAL REQUIREMENTS

Each petition should be preceded by a summary or abstract. A petition to request the release of exotic phytophagous organisms for biological control of weeds in NAPPA member countries should include the following information:

1. Proposed Action
   - S Purpose of the release .
   - S Need for the release.
   - S Reasons for choice of the agent.
   - S Specific location of rearing/quarantine facility.
   - S Timing of the release.
   - S Methods to be used (rearing, multiplication, release etc.).
   - S Disposal of any host material, parasites/pathogens accompanying import shipment.
   - S Agencies and/or individuals that will be involved in the release and monitoring.

9. Target Weed Information
   - S Taxonomy: scientific name, full classification, synonymy, common names (if any), and sufficient characterization to allow unambiguous recognition.
   - S Regulatory and/or noxious status of the target weed in state, provincial or federal law and pest status.
   - S Economically and environmentally important plants (introduced and native) related to the target weed.
   - S Distribution of target weed (in probable area of origin and in North America).
   - S Economic impact of target weed.
   - S Knowledge of status of other biological control organisms that have been introduced against the target weed.

16. Biological Control Agent Information
   - S Taxonomy scientific name, synonymy, common names.
   - S Methods used to identify the agent.
   - S Location of voucher specimens.
   - S Natural geographic range, other areas of introduction, and expected attainable range in North America (also habitat preference and eliminate requirements of the organisms).
   - S Source of the culture/agent in nature.

- S Life history (including dispersal capability and damage inflicted on host plant).
- S Field host range based on valid literature records, host data from museum specimens, and unpublished records (from the place of origin).
- S Pathogens/parasites/hyper parasites of agent and how to climate them from a culture of the agent.
- S SOP stating how agent will be handled in quarantine.
- S Other closely related genera, sibling species or closely-similar species in North America.

27. Host-Specificity Testing
    - S Selection of test plants: subspecies, species, subgenera, genera and other closely-related plants and plants recorded as hosts in the literature, museum labels or other unpublished collection records, agriculture pest reports, etc; hosts of close relatives (i.e. in the same genus) of the candidate agent, unrelated plants having physical and chemical similarities to the weed.
    - S Laboratory tests (multiple and no-choice feeding tests, oviposition tests, development tests).
    - S Field tests (in country of origin).

31. Environmental & Economic Impacts of the Proposed Release
    - S Known impact on vertebrates including humans.
    - S Direct impact of the organism (e.g. intended effects on targets, direct effects on non-targets).
    - S Effects on physical environment.
    - S Indirect effects (e.g. potential impacts on organisms that depend on target or non-target species).
    - S Possible direct or indirect effects on threatened and endangered species.
    - S Proposed methods to prevent undesired environmental effects.

NOTE:

Voucher specimens must be deposited in a National Collection in advance of approval for release. (The specimens must be labeled clearly indicating collection locality, latitude and longitude of the site, date of collection, name of collector and any other pertinent information). Researchers must also provide exact location of release(s) to regulatory officials.

Regulations of Plants with Novel Traits in Canada

Mireille Prud'homme
Plant Health Risk Assessment Unit, Canadian Food Inspection Agency,
59 Camelot Drive, Nepean, Ontario K1A 0Y9

Abstract

The environmental issues relevant to new plant varieties include the potential for the novel plant or its related species to become weeds of agriculture, to become invasive of natural habitats, and the potential impact of the novel plant or its gene products on non-target species and biodiversity.

In Canada, the importation and field release of plants with novel traits (PNTS) have been regulated since 1988. Plants with novel traits (PNTs) include products of both recombinant DNA technology and plants derived through traditional plant breeding. To date over 4700 confined field trials have been authorized in Canada and 33 PNTs have been authorized for unconfined release. In addition, the importation of 9 commodities derived from PNTs has been authorized.

This presentation is intended to provide an overview of the Canadian system for regulating plants with novel traits and provide insights on how the Canadian Food Inspection Agency addresses the relevant issues before authorizing the importation, field testing and unconfined environmental release of a PNT in Canada.

Introduction

The Canadian Food Inspection Agency, along with other federal departments, including Environment Canada and Health Canada, regulate products of biotechnology in order to protect human health, animal health, and the environment.

This presentation will provide an overview of the regulation of the importation, research trials under confined conditions and unconfined environmental releases of plants with novel traits (PNTs) in Canada.

Regulations of plants with novel traits (PNTs)

PNTs are defined as a plant variety/genotype possessing characteristics that demonstrate neither familiarity nor substantial equivalence to those present in a distinct, stable population of a cultivated species of seed in Canada and that have been intentionally selected, created or introduced into a population of that species through a specific genetic changes. PNTs include products of both recombinant DNA technology and plants derived through traditional plant breeding - the primary trigger for assessment being the novelty of the product rather than the method used to produce it.

This is consistent with the approach adopted in Canada for regulating biotechnology products - that is to regulate the final product (e.g. a novel seed, feed, food or a novel fertilizer). The philosophy of the regulatory framework is that genetically engineered organisms are not fundamentally different from traditionally bred organisms and can be assessed using well-defined and understood principles of risk assessment. Each new product is therefore evaluated on its own merits and characteristics, while at the same time the processes used to develop the organisms are carefully considered.

Determination of whether a plant is a PNT or not relies on the application of two concepts borrowed from the OECD's approach to food safety assessment: familiarity and substantial equivalence. Familiarity is the knowledge of the characteristics of a plant species and the Canadian experience with the use of that plant species. The concept of substantial equivalence is that of comparing new products with existing familiar products. Substantial equivalence embodies the concept that if a plant is found to be substantially equivalent to a plant already grown and thus considered as safe in Canada, in terms of its potential impact on the environment and human health, it can be treated in the same manner as its traditional counterparts.

Importation

The importation of PNT and derived products capable of propagating into Canada, such as grain and fruits, is subject to regulatory requirements under the *Plant Protection Act* and *Regulations* to prevent the importation, exportation and spread of pests injurious to plants. Importers must obtain an import permit prior to the entry of the PNT into Canada. The import permits are issued with specific conditions that only allow the PNT to be used in contained facilities (e.g. research lab, greenhouse, etc.) and specify that measures must be taken to prevent inadvertent mixture and spillage during transit and storage. The importers are also notified of domestic regulatory requirements prior to the release of the PNT outside of the contained facility (e.g., for field testing or commercial planting) or its use as feed or food.

The requirement for a permit is in addition to the importation and phytosanitary requirements that generally apply for the importation of specific commodities based on the country of origin and the intended use. Plants and derived products that are exempt from permit requirements are those where the CFIA has determined that they not pose a plant pest risk. These can include PNTs that have been authorized for unconfined release following an environmental assessment.

Environmental releases

The release of PNTs into the environment is regulated under the *Seeds Act* and *Regulations* to prevent or mitigate potential negative impacts to the environment. The release of PNTs into the environment are regulated according to whether they are released:

(a) under conditions of confinement, such as for research trials, to minimize the establishment or spread of the PNT in the environment and also to minimize interactions with other organisms, or

(b) with no or reduced conditions

a. Confined research field trials

Regulated research field trials are authorized to be conducted under conditions of confinement where the PNTs are grown under reproductive isolation, and include restrictions on post-harvest land use, and disposal of seed and plant residues. In addition, sites are inspected by CFIA personnel both during and following the trials. The authorizations take into consideration potential risks and, subsequently conditions are imposed on the trials based on the reproductive characteristics of the plant species and the novel trait introduced.

b. Unconfined releases

A PNT may be authorized for general unconfined release into the environment following a thorough environmental safety assessment. The environmental assessment requires the applicant to meet the regulatory criteria which include information on the following:

- description of the PNT and its modification
- the novel trait
- the biology and interactions of the PNT including information pertaining to the potential of the PNT to become a weed of agriculture or be invasive of natural habitats, potential for gene-flow to wild relative whose hybrid offspring may become more weedy or more invasive, potential for the PNT to become a plant pest, potential impact of the PNT or its gene products on non-target species, including humans, and potential impact on biodiversity.

Assessments are done on a case-by case basis. After an environmental assessment has been completed, authorization may be granted with or without conditions. An example of a conditional authorization is that granted for herbicide tolerant polish canola (*B. rapa*). Unconfined release of these *B. rapa* canola is only authorized for western Canada. This decision took into consideration the presence of populations of wild bird rape (also *B. rapa*) in Quebec, and the Atlantic provinces of Canada (and to a lesser extent in the Southern part of Ontario); and the undesirable movement of the herbicide tolerance trait into these weedy populations where these specific herbicides are used for weed control. Other examples of conditional authorizations are those granted for BT corn and

BT potatoes, where the authorizations require the applicants to develop and implement an insect resistance management plan.

The development of this regulatory regime for PNTs over the last 10 years has involved extensive consultation with plant breeders, weed scientists, and agronomists in academia, provincial government services, industry, and environmental interest groups.

A summary of each environmental safety assessment is published as a Decision Document along with the species specific biology document. These documents as well as other related information is available on the Plant Biotechnology Office website at http://www.cfia-acia.agr.ca/english/plant/pbo/home_ e.html.

The Role of Provincial Weed Control Acts

D. J. Doohan [1], John Cardina [1] and Rick Hoeg[2]
[1]Department of Horticulture and Crop Science, OARDC,
1680 Madison Ave., Wooster, Ohio 44691
[2]Production Technology Branch, NSDAM, Truro, NS B2N 3E3

Several years ago the senior author participated on a team dealing with invasive, parasitic mites of honeybee. Nova Scotia was 'mite-free' and the beekeepers of the province wanted to keep it that way. The provincial Department of Agriculture and Marketing erected a sign at the border with New Brunswick emblazoned with the image of a giant honeybee and the warning "Importation of honeybees prohibited". The problem with the sign according to a local businessman, who was opposed to the regulations, was "Bees can't read".

This story illustrates the difficulties in regulating invasive plants and animals. In the first place we are attempting to disrupt biological processes that we usually do not understand adequately. Secondly, human behaviour (ignorance, motivation, greed, fear, pride etc.) is a far more important feature of biological invasions than mere plant biology.

We suggest that regulators consider the following four observations if activities aimed at preventing and controlling noxious weeds are to be effective. Our comments are framed within the context of Canada, s geography even though political boundaries alone, are probably never an appropriate scale for decision making about invasive plants.

1. Regulatory activity must have a national perspective and be coordinated across the country.
2. Regulatory activity is not a substitute for research and education.
3. Prioritize! Regulators cannot do everything.
4. Focus should be on risk assessment and prevention.

<u>Regulatory activity must have a national perspective and be coordinated across the country.</u> The problem with provincial weed control acts is that weeds do not respect political boundaries. We are traders and merchants so inter-provincial commerce is a fact of life. If borders don't matter, what does? Historically, landscape features (probably at a continental or at least regional level) formed effective barriers through which certain species could not spread, or could do so only slowly. Nova Scotia's geographical isolation exemplifies this. The isthmus of Chignecto is a 12 mile sea of grass and tidal marsh that is believed to have impeded the migration of wild grape, arbor vitae, and butternut into the province (Roland and Smith 1969). Similarly, prairies, mountains, and bodies of water are natural barriers to migration.

While landscape features probably continue to retard natural migration processes, modem transportation provides rapid and highly effective corridors for invasive species through these natural barriers. The Maritime provinces have been recipients of new weeds from central and western

Canada for many years. Imported western feed grains for livestock have brought with them wild oats, velvet leaf and round-leaved mallow. Containerized ornamentals imported from Ontario have frequently been infested with yellow nutsedge.

Land-use patterns and environmental susceptibility are also important. Agricultural weeds tend not to naturalize in non-agricultural areas. Wild oats are widely spread throughout the Maritimes but are rarely a serious problem (Thomas et al. 1994, Thomas and Ivany, 1990); in contrast, round leaved mallow infestations are localized but are usually very detrimental (Fisher 1997). At the local scale land use patterns and environmental conditions are probably more important than landscape features and inoculum, and probably function to limit or unleash the invasive potential of particular species. Wild oat infestations in the Maritimes rarely reach serious proportions because grain is mostly grown only one year in a rotation, which often includes potatoes. Mild fall weather may also contribute to lethal germination in the fall under eastern conditions. In contrast, establishment of forage grass, which is the most common crop in the region, provides ideal conditions for colonization by round leaved mallow (Fisher 1997). Careful consideration of landscape sensitivity, local environmental conditions, and land-use patterns are important in a risk assessment scenario.

How would we distinguish migration within the continent from outside invasion? In the case of migration, historical pollen records are available which show that species followed advancing and receding ice ages (Livingstone 1968.). Invasion may have more in common with repetitive inundation by human activity, as was the case in the Maritimes with round-leaved mallow, but this is not necessarily so. Point-source infestations of invasive weeds, which have since colonized entire landscapes, are well documented (Smith et al. 1999). It has been suggested that the approximately 20 infestations of yellow nutsedge in Nova Scotia may have all originated from one initial infestation in Somerset, Kings County. Invasion also has ecological and biological components that are probably functions of landscape and community sensitivity, breeding system, and demographic characteristics of the invader.

<u>Regulatory activity is no substitute for research and education.</u> While there surely are many examples of wise regulatory decisions across provincial weed control acts, there are also a number of questionable quality, at least in the Nova Scotia experience. Money invested in regulating certain species might have been better spent on educating farmers and other property owners on the detrimental effects and best management practices for those weeds. The Nova Scotia Weed Control Act (WCA) was a response to a group of livestock farmers from Pictou County who were concerned about the ongoing spread of tansy ragwort from eastern Nova Scotia in a westerly direction. For over 20 years the department employed weed inspectors, who not only badgered and threatened property owners but who also sprayed, cut, and grubbed tansy ragwort themselves. The department reimbursed 50% of the cost of attaining and maintaining control. In the meantime, ragwort spread from east to west, following the river valleys in which livestock watered. Ragwort is now established in every county of the province east of Annapolis and is common around the south shore of Nova Scotia as well. How much more could have been accomplished, and at what savings to the taxpayer if those resources had been directed to training farmers to spray their pastures with 2,4-D every 3 to 5 years? When the "cat is out of the bag7 so to speak as was undoubtedly the case with tansy

ragwort, it makes more sense to instil individual responsibility in property owners, train them in the best techniques available and forget about regulating. An exception to this might be when the land is publicly owned and the government is prepared to pay all of the costs on an ongoing basis.

In contrast containing the spread of velvetleaf was one of the most successful programs in the history of the Nova Scotia WCA (LeBlanc and Doohan, 199 1). Prior to the last 3 summers ('97 - '99), 1990 was one of the warmest of recent memory. In that year, infestations of velvetleaf went from sporadic to approximately 120 documented sites. County weed inspectors were deployed with instructions to 'seek and destroy'. The WCA mounted a major awareness and educational campaign, which continues today. Farmers took responsibility for velvetleaf control on their properties, adjusting herbicide programs if necessary, but more often resorting to hand-pulling as a means to clean up the point-sources on their farms. Along with this, some pressure was put on the feed industry to access corn that had less contamination of velvetleaf seed. While velvetleaf has not been eliminated, farmers are very aware of its potential impacts and most practice regular cleanup programs.

While tansy ragwort was the catalyst for a weed control act for Nova Scotia, it was not the only species of interest to weed regulators in the Nova Scotia. When the act and regulations became law in 1967, the scope covered 24 species including yellow nutsedge. Yellow nutsedge is one of the most invasive plants of agriculture (Holm et al. 1977). Its unique biology and tolerance of control methods sets it apart as both an invasive and noxious weed. Over the 32 years that the Act has existed, only a couple of very small infestations have been eradicated, while the number of known sites has expanded from a half dozen to over 20. However, prior to 1995 not a single experiment was conducted to determine any aspect of the biology or control of the species under Nova Scotia conditions.

Nutsedge also illustrates a conundrum experienced by Nova Scotia within the Canadian regulatory climate. While the species has been considered the most important noxious weed in the province since inception of the WCA, it was not quarantinable under the Plant Protection Act, despite its rarity, documented importation in nursery plants and the recognized importance of point-source infestation. In the mid-1990s we requested scheduling of nutsedge as a quarantinable species under the federal act. We provided documentation confirming that all known sites were under strict phytosanitary control and that continual introduction through interprovincial trade threatened the provinces food production systems. A risk assessment was to be conducted by Agriculture and AgriFood Canada; however, the province has not been provided with the outcome of that assessment and nutsedge is still a non-quarantinable species under the Plant Protection Act.

Financial assistance provided by the Nova Scotia WCA was never well thought out. In the case of nutsedge the Act provided reimbursement of up to 75% of the cost of attaining and maintaining control. if anything, it may have made nutsedge an almost attractive species to have on the farm!

Prioritize! Regulators cannot do everything. When the senior author joined the Nova Scotia Department of Agriculture and Marketing in 1987, 37 species were scheduled as noxious weeds, an increase from 24 in 1968 (Anonymous 1989). At best we were able to do some work on several of these, with little or no real success and mounting costs to taxpayers. It is difficult to understand why new species were added, while no efforts were made to control several weeds already scheduled, such as Canada thistle and bull thistle. Over the next two years Japanese knotweed, elephant ears, blueweed and wild chervil were also scheduled Risk assessments generally consisted of testimonials which could be paraphrased as 'all were large and hairy weeds'. An expectation by a county farm organization to have St. John's wort scheduled was averted when it was demonstrated (Jensen et al. 1995) that infestation density and the levels of hypericin present in local populations were inadequate to explain photo sensitization observed in livestock. This example illustrates the importance of research and scientific knowledge in making decisions about noxious and invasive plants.

We realized our only hope was to "whittle" down the listed species to a number we could work with and to species that we could justify spending tax payers money on. Crudely but with some effectiveness we endeavored to determine what constituted a noxious weed and to conduct risk assessments on all scheduled species.

For our purposes plants were considered noxious if they met the following criteria:
- Highly detrimental impact upon natural and agricultural ecosystems.
- Difficult to control by readily available methods.
- Rare *(not present)* or localized infestations.

By this definition a plant might be regulated even if it did not display particularly invasive characteristics.

Risk assessment consisted of a synthesis of observations made by staff, local botanists, weed specialists and farmers and by reviewing the literature. For several species the literature review was scant; for instance, there are very few studies dealing with the competitiveness of marsh hedge nettle in crops. Based upon this review, Schedule A - Class Number One Noxious Weeds, those "capable of spreading from the source to cultivated or pasture lands" was reduced from 29 to 11 species. Schedule B - Class Number Two Noxious Weeds weed "those capable of inflicting economic loss or ill health on people within the Province" was reduced from 8 to 4 species (Anonymous 1995). In the past year a proposal to de-regulate coltsfoot,
stinging nettle, ragweed, poison ivy, and blue weed has been approved by the Nova Scotia Federation of Agriculture.

It is important to consider carefully all costs of scheduling a new species. In 1995 two of our inspectors won the "Idiot of the Month Award' from Frank Magazine in recognition of the efforts to control angel's trumpet and other *Daturas.* Jimson weed *(Datura stramonium* L.) was scheduled, as a Class Number Two Noxious Weed in 1971 and was found occasionally over the years. However, in the early 1990's one of our inspectors found her local garden club was distributing seed of 'angels trumpet' which turned out to be an ornamental variety of *Datura.* Quickly the *Datura stramonium* classification was changed to *Datura spp.* and our inspectors proceeded along their merry way, visiting all the garden centers and nurseries in the province with confiscated and destroyed plants in their wake. Apparently a few garden center and nursery folk objected to our science and 'common-sense' and the loss they incurred from having their assets wiped out. No doubt, amongst those few were the nominators of the coveted award Once again hind-site is 20:20 and one has to question the long-arm of government protecting helpless Nova Scotians from the 'deadly' angel's trumpet.

Sixty-five percent of the 2 100 species that have been classified by the Weed Science Society of America as weeds in Canada and the United States are non-native (Westbrooks 1998). Considering that Holm et al. (1977) identified 6,741 species of weeds world-wide, of which 2,063 are already present in the United States one must wonder if it is not now time to close the door to invasion. Resources are so limited and the work to be done so extremely important that every regulatory decision should be made with utmost care.

<u>Focus on risk assessment and prevention</u> The easiest weeds to regulate are those not already present. The most important activity conducted would be to predict which species are likely to be introduced, and to evaluate their invasiveness. It is important to recognise that the success of plant invasions depends on land use and management practices that make sites vulnerable to establishment and colonization by adapted species. In other words, the invader and the invaded are part of the same process. Therefore, a greater understanding of specific characteristics that allow various plant species to become invasive, and that make sites susceptible to invasion, will help us develop education programs that support a preventive approach to plant invaders rather than relying on costly regulation after the infestation has reached a menacing level.
At the more local level it would make sense to conduct research to determine the degree of invasiveness of recently introduced species at sites with different levels of disturbance (and hence susceptibility to invasion), while taking action to prevent spread in the short term, until a knowledge-based decision can be made. However, part of the difficulty in trying to limit plant invasion is that we do not have good data on the state of affairs today. That is, we don't have a good baseline for judging progress. As good as satellite technology is, it is unlikely that it will ever be good enough to detect initial colonies of invasive plants. Therefore, continued effort is needed to survey and monitor weed populations, especially at highly vulnerable sites.

Protocols for monitoring sensitive sites and conducting general surveys with emphasis upon corridors and ports of entry are available (Zamora et al. 1989, Prather and Callihan 1993). Survey data should be collected on an ongoing basis. Unfortunately, there are as yet no validated risk assessment models, with wide applicability. It has not been possible to establish clear relationships between processes of invasion that occur in agricultural settings from those that occur in natural environments beyond commonalties of invader aggressiveness and site disturbance (Cronk and Fullcr 1995). Until the science of risk assessment advances considerably the best we currently can do is adhere to "Rules of thumb” which could be used as hypothesis in assessing invasive potential. The following invader and site characteristics should raise a red flag and lead the way to more detailed risk assessment and regulation when appropriate.

Rules of thumb - watch out for these characteristics

- ♦ Prodigious seed production.
- ♦ Early reproductive potential.
- ♦ Small seed size.
- ♦ Self-compatibility. Seed dormancy
- ♦ Early position in succession.
- ♦ Long- and short-distance dispersal mechanisms.
- ♦ Similarity between origin and invaded site.
- ♦ Be aware of potential invasiveness of naturalized weeds of current minor importance. They too can become major weed problems as farming systems change.

We would propose regulating species that are not yet present as the foundational step. Secondly, launch extension programs to educate land owners on the hazards associated with invaders and noxious weeds and on methods of control. Finally, use regulatory power to collect data, eliminate point source infestations and to prevent spread We also suggest that provincial weed control acts cooperate with agencies and organizations interested in controlling spread of invasive plants of natural areas. All of these steps require national and interprovincial cooperation if they are to be successful.

In conclusion, real and effective regulation of noxious weeds requires
1) identifying characteristics of plants that contribute to their 'weediness' as well as their potential benefits (to the environment, to the plant community, to humans).
2) understanding why these plants are present on the landscape and means by which they arrive and persist there.
3) balancing benefits of human activity that result in the presence or persistence of the weed with the costs of their negative effects on health and commerce.
4) understanding the values implicit in the objection of members of the community to those weeds.
5)%. understanding the legal instruments necessary to implement the desired balance between costs and benefits.
6) developing a coordinated approach that spans the country and ideally is linked with similar programs in the United States.

Provincial weed control acts arc important and should be the focus of surveillance, rapid response and extension education programs. Programs arc currently floundering because provincial and federal efforts are not coordinated regionally or nationally. Because regulating invasive plants is always an issue of national importance, federal programming must ensure maximum coordination and cooperation nation- wide. Additionally, only federal government has the resources to fund the research that is necessary for effective regulatory decisions. Until a truly nation-wide program is instituted, there will be no consistent mechanism to protect our plant communities and invasion will continue unabated

LITERATURE CITED

Anonymous. 1989. Regulations - Weed Control Act. Registrar of Regulations. Halifax, NS.

Anonymous. 1995. Regulations - Weed Control Act. Registrar of Regulations. Halifax, NS.

Cronk Q.C.B. and J.L. Fuller. 1995. Plant Invaders. Chapman and Hall. London UK.

Fisher, T. 1997. Control of Round-leaved mallow *(Malva pusilla)* Sm. in Forage Fields. MS Thesis Proposal. The Nova Scotia Agricultural College, Truro.

Holm, L.G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1977. The World's Worst Weeds Distribution and Biology. The University of Hawaii. Honolulu.

Jensen, K.I.N., S.O. Gaul, E.G. Specht, and D.J. Doohan. 1995. Hypericin content of Nova Scotia biotypes of *Hypericum perforatum L.* Can J .Pl. Sci. 75:923-926.

LeBlanc, L. and D.J. Doohan. 1992. The introduction and spread of velvetleaf *(Abutilon theophrasti* L.) in Nova Scotia. WSSA Abstracts. 32: 111.

Livingstone, D.A. 1968. Some Interstadial and Postglacial Pollen Diagrams from Eastern Canada. Ecological Monongraphs. 38:87-125.

Prather, T. S. and R.H. Callihan. 1993. Weed eradication using geographic information systems. Weed Technol. 7: 265- 269.

Roland, A.E. and E.C. Smith. 1969. The Flora of Nova Scotia. The Nova Scotia Museum. Halifax.

Smith, AR, W.S. Johnson, J.S. Shonkwiler, and S.R. Swanson. 1999. The implications of variable or constant expansion rates in invasive weed communities. Wd. Sci. 47: 62-66.

Thomas, A.G., D.J. Doohan, and KV. McCully. .1994. Weed survey of spring cereals in New Brunswick. PHYTOPROTECTION. 75 (3):113-124.

Thomas, A.G. and J. A. Ivany. 1990. The weed flora of Prince Edward Island Cereal Fields. Weed. Sci. 38: 119-124.

Westbrooks, R.G. 1989. Invasive Plants - Changing the Landscape of America. Government Printing Office. Washington, DC.

Zamora, D.L., D.C. Thill, and R.E. Eplee. 1989. An eradication plan for plant invasions. Weed Technology 3: 2-12.

Herbicide Risk Assessment: Buffer Zones

Ted Kuchnicki
Pest Management Regulatory Agency

This presentation was originally in Microsoft Powerpoint.
It has been converted in Adobe Acrobat and is available separately.

Graduate Students Papers

Graduate Student Paper Presentations / Présentations des articles des étudiants gradués

Chair / Président: Dr. Diane Benoit — Agriculture and Agri-Food Canada/Agriculture et Agroalimentaire Canada - Saint-Jean-sur-Richelieu

Monday, 29 November / le lundi, 29 novembre		
Time / l'heure	Presenter / Présentateur	Paper Title / Titre de l'article
14:30	Cory Feschuk Univ. of Manitoba	Evaluating competitive differences among barley cultivars *C.J. Feschuk, D.A. Derksen, M. Therrien and R.C. Van Acker*
14:50	Robert Nurse Univ. of Guelph	Influence of pre-dispersal weed seed predation in soybeans. R.E. Nurse and C.J. Swanton
15:10	Hameed Baloch McGill Univ.	Effect of row spacing, seed size and fungal disease on velvetleaf height, hierarchy and development. H. A. Baloch, A. Di Tommaso and A.K. Watson
15:30	Shauna Humble Univ. of Manitoba	Weeds and ground beetles as influenced by crop rotation type and crop input management. S. Humble, M. Entz, N. Holliday and R. C. Van Acker
15:50	Heather Goudy Univ. of Guelph	Evaluation of site-specific weed control in a maize-soybean rotation. H.J. Goudy, R.B. Brown, K.A. Bennett and F.J. Tardif
16:10	Delaney Ross Univ. of Manitoba	Effect of fertilizer addition and weed density on spring wheat yield at two landscape positions. D.M. Ross and R.C. Van Acker
16:30	Robert Thomas Univ. of Guelph	Soil and weed management strategies for processing tomato *(Lycopersicon esculentum)* production in Ontario. R.J. Thomas, J. O'Sullivan, C.J. Swanton and A.S. Hamill
16:50	Steve Martin Univ. of Manitoba	The critical period of weed control in canola. S. Martin and R.C. Van Acker
Wednesday, 1 December / mercredi, 1er décembre		
09:30	Gabrielle Ferguson Univ. of Guelph	Characterization of imazethapyr and thifensulfuron-methyl resistance in populations of green pigweed *(Amaranthus powelill* S. Wats.) and redroot pigweed *(Amaranthus retroflexus* L.) in Ontario. G.M. Ferguson, A. Hamill, F. Tardif
09:50	Eric Johnson Univ. of Saskatchewan	Revisiting mechanical weed control. E.N. Johnson, F.A. Holm and K.J. Kirkland

The Role of Pre-dispersal Weed Seed Predation in Soybeans

R.E. Nurse and C.J. Swanton
Department of Plant Agriculture, University of Guelph, Guelph, Ontario

Introduction

The role of pre-dispersal weed seed predation on the population dynamics of weeds is unknown in an agricultural setting, and this study is the first of its kind in soybeans. The need for more sustainable agricultural practices continues to grow on a global basis, and with the increased frequency of herbicide resistance in many species of weeds, it is important to create a more diverse method of weed control. Pre and post dispersal seed predation has been shown to have significant effects on the viability of seeds (Louda *et al*. 1990) and the recruitment of plants into the next generation, with predation levels ranging from 0 to 95% (Andersen 1988, Andersen 1989a, Andersen 1989b, Anderson 1989c, Boe *et al*. 1988, Brust 1993, Brust and House 1988, Cromar *et al*. 1999, Inouye *et al* 1980, Janzen 1971, Lamp and McCarty 1982, Louda 1982, Louda *et al* 1990; Windus and Snow 1993). Thus, the inclusion of this form of control into an integrated weed management program should be beneficial, without excluding any of the current forms of weed control such as herbicides. The hypothesis of this study is that alterations to the soybean microclimate will enhance pre-dispersal weed seed predation. Common Lambsquarters (*Chenopodium album* L.) and Pigweed spp (*Amaranthus* spp.) were used to obtain predation percentages since they have hard seed coats that readily show signs of seed predation.

The main objective of this study was to quantify that pre-dispersal weed seed predation was occurring in an agricultural setting. Soybean planting strategies that enhance predation levels may then be incorporated into a weed management program. This study was designed to determine which strategy enhanced predation levels without sacrificing crop yield.

Materials and Methods

Row width and tillage were used as variables to modify the microclimatic conditions. Field experiments were conducted at the Woodstock Research Station, Ontario, University of Guelph in 1998 and 1999. The study was conducted in a no-till field previously planted with corn. The soybean row widths were 19cm, 76cm, and no crop and the treatments were arranged as a Randomized Complete Block Design (RCBD) with 9x9m plots and four replications.

Chenopodium album and *Amaranthus* spp. were grown in a growth room facility until seed head formation prior to being transferred into the field environment. The test weeds were arranged in a 'W' formation with eighteen individuals of each species being planting within each plot. Three sub-treatments were then applied with six individuals of each species assigned to a treatment. The first two treatments were designed to eliminate insect predation. The first treatment used no-seem nylon mesh to completely cover the inflorescence and the second treatment eliminated predation through spraying the terminal inflorescence with the antifeedant insecticide Admire. The remaining weeds were left naturally exposed to the insects to comprise the third treatment.

Environmental measurements were made throughout the growing season. Photosynthetic Photon Flux Density (PPFD), soil moisture, air temperature, and relative humidity were all used to try and quantify the habitats that were created within the various soybean canopies.

Finally, prior to soybean harvest the terminal inflorescence of each test weed was harvested and brought back to the lab for examination. The seeds were examined for signs of seed predation denoted by damage to the seed coat, resulting from the entrance made by the micro- moth larvae.

Preliminary Results

The insect responsible for seed predation in pigweed was identified as *Choleophora lineapuvella* (Lepitodoptera) during the summer of 1998. This micro-moth is known to consume the seeds of *Amaranthus* spp. and then builds a case and overwinters in the inflorescence. In 1998, we confirmed that pre-dispersal seed predation occurs in soybeans. Seed predation levels ranged from 0 to 7% for pigweed and 0 to 2% for lambsquarters. Seed predation of Pigweed spp. in soybeans was highest in the wide row no-till plantings and lowest in narrow row no-till plantings in 1998. No effect of row width or soil tillage on seed predation of Common Lambsquarters in soybeans was identified. Microclimatic differences were observed between wide and narrow rows in both tillage treatments. Results for 1999 have yet to be analyzed.

Conclusions

Pre-dispersal weed seed predation brings an exciting new angle to weed management. Results show that predation is occurring and may provide an additional biological solution, without increasing other inputs. Seeds being consumed by these insects are in addition to seeds being naturally aborted by the parent plant and those dying through desiccation. Other studies are also looking at the effects of post-dispersal seed predation by another subset of organisms. Through the combination of pre- and post-dispersal seed predation in addition to other IWM practices, a reduction in the number of viable seeds reaching the soil seed bank may be achieved. If seed predation reduces the distribution of a weed species even by 2-10% it has still provided another form of control in an agricultural setting, and thus is important to research further. Crop management strategies that enhance pre-dispersal weed seed predation may prove to be an important weed management tool and may add another dimension to integrated weed management.

References

Andersen, A.N. 1988. Insect seed predators may cause far greater losses than they appear to. Oikos **52**:337-340.

Andersen, A.N. 1989a. How important is seed predation to recruitment in stable populations of long-lived perennials? Oecologia **81**: 310-315.

Andersen, A.N. 1989b. Impact of insect predation on ovule survivorship in *Eucalyptus baxteri*. Journal of Ecology **77**: 62-69.

Andersen, A.N. 1989c. Pre-dispersal seed losses to insects in species of *Leptospermum* (Myrtaceae). Australian Journal of Ecology. **14**:13-18.

Boe, A., B. McDaniel and K. Robbins, 1988. Patterns of American licorice seed predation by *Acanthoscelides aurcolus* (Horn) (Coleoptera: Bruchidae) in South Dakota. Journal of Range Management, **41**: 342-345.

Brust, G.E. 1993. Seed-predators reduce broadleaf weed growth and competitive ability. Agriculture Ecosystems and Environment **48**:27-34.

Brust, G.E., and G.J. House. 1988. Weed seed destruction by arthropods and rodents in low-input soybean agroecosystems. American Journal of Alternative Agriculture **3**(1):19-25.

Cromar, H.E., S.D. Murphy, and C.J. Swanton. 1999. Influence of tillage and crop residue on postdispersal predation of weed seeds. Weed Science **47**:184-194.

Inouye, R.S., G.S. Byers, and J.H. Brown. 1980. Effects of predation and competition on survivorship, fecundity, and community structure of desert annuals. Ecology **61**(6):1344-1351.

Janzen D.H., 1971. Seed Predation by Animals. Annual Review of Ecological Systems. **2**:465-492.

Lamp, W.O., and M.K. McCarty. 1982. Predispersal seed predation of a native thistle, *Cirsium canescens*. Environmental Entomology **11**:847-851.

Louda S. M., 1982. Limitations of the recruitment of the shrub *Haplopappus squarrosus* (Asteraceae) by flower- and seed- feeding insects. Journal of Ecology **70**: 43-53

Louda S.M., M.A. Potvin, and S.K. Collinge. 1990. Predispersal seed predation, postdispersal seed predation and competition in the recruitment of seedlings of a native thistle in sandhills prairie. American Midland Naturalist **124**: 105-113.

Windus, S.D. and A.A. Snow, 1993. Fruit set and seed predation in an Ohio population of *Genitiana saponaria*. American Midland Naturalist 129: 346-351.

Effect of the fungal pathogen *Colletotrichum coccodes* on velvetleaf (*Abutilon theophrasti*) height hierarchy development in soybean

Hameed A. Baloch, A. DiTommaso, and Alan K. Watson
Department of Plant Science Macdonald Campus, McGill University
Ste-Anne-de-Bellevue PQ, Canada.

Abstract

Velvetleaf (*Abutilon theophrasti*) (Malvaceae) is a serious weed in the corn belt of North America. A. theophrasti is a strong competitor because of its rapid growth rate and architecture which provides an advantage by overtopping neighboring plants and competing for light. Effect of a fungal pathogen *Colletotrichum coccodes* and a competing crop on velvetleaf height and biomass were studied in the field during summers of 1998 and 1999. Velvetleaf were harvested twice, a mid-season harvest (85 days after seeding (DAS)) and a final harvest (118 DAS). At each harvest, velvetleaf height, above ground biomass, and stem diameter were measured. Fungal infection and presence of soybean resulted in significant reduction (60-70%) in velvetleaf aboveground biomass and plant height. Effect of different treatments were significant ($P<0.05$) both in 1998 and 1999. Height frequency distribution in control and inoculated velvetleaf were generally positively skewed (L-shaped) in presence of soybean and negatively skewed (J-shaped) in monoculture (velvetleaf alone). The Gini coefficient value of velvetleaf height increased in presence of *C. coccodes* and soybean compared with velvetleaf monoculture.

Weed and Ground Beetles (Coleoptera: Carabidae) as Influenced by Crop Rotation Type and Crop Input Management: The Glenlea Crop Rotation Study

S.M. Humble, M.H. Entz, N.J. Holliday and R. VanAcker.
Department of Plant Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2

Introduction

Ecological biodiversity refers to all species of plants, animals and microorganisms existing and interacting within an ecosystem. Agriculture often reduces biodiversity by replacing native diversity with a small number of cultivated plants and domesticated animals. The result is an artificial ecosystem requiring constant human intervention in the form of agrochemical inputs, which may have undesirable environmental effects and social costs (Altieri, 1994). In addition, reduction of plant diversity has seriously affected the abundance, diversity and efficiency of predator arthropods (i.e. ground beetles) closely linked to local habitats (Lys et al., 1994; Purvis et al., 1984). Ground beetles (*Coleoptera: Carabidae*) are excellent bio indicators of habitat perturbation, such as nutrient enrichment, as some are sensitive to pollutants and the majority are highly selective of their habitat (Larsen et al., 1996). The structural diversity of ground cover in agroecosystems can influence a habitat and thus affect activity of ground predation (Carcamo et al., 1994).

Sustainable agriculture refers to a mode of farming that attempts to provide long term sustainable yields through the use of ecologically sound management technology (Altieri, 1994). The goal of sustainable agriculture is to stress natural physical, biological and ecological processes (Paoletti et al., 1989). If the concept of sustainable agriculture is to be applied it must be put into practical alternative systems for the specific needs of farmers (Altieri, 1994). Thus, there is a need to assess the biological performance of various cropping systems and to study the effects of external fertilizer and herbicide inputs on a system's sustainability.

The objectives of this research are to determine how cropping system diversity and input use affect populations of weeds and ground beetles and to identify relationships between insect and weed populations.

Materials and Methods

In 1992, a long term cropping systems study was initiated near Winnipeg, Manitoba to address concerns surrounding the sustainability of commercial agriculture. The experiment is a split plot design with main plots of rotation and subplots of management inputs being a randomized complete block design. Rotations under investigation were established on a rego black chernozem soil (9-26-66 % sand, silt and clay, respectively) over 24 acres at the Glenlea Research Station. The three rotations are:

Rotation one (annual crops only): wheat-pea-wheat-flax

Rotation two (annuals plus one green manure crop): wheat-sweet clover-wheat-flax

Rotation three (annuals plus alfalfa hay crop): wheat-alfalfa-alfalfa-flax.

Rotations were subdivided into four subplots based on fertilizer (f) and herbicide (h) use (all four combinations: +f+h, +f-h, -f+h, -f-h in each rotation type). Fertilizer is added according to soil test recommendations. Phosphorus is seed placed. Nitrogen is applied with the seed (to upper limit for the respective crops) and the remainder is broadcast (ammonium nitrate; ammonium sulfate when S required) immediately after crop row closure. In this way, the broadcast N has minimal effect on weed competitiveness. Typically, in-crop herbicides are applied in all the +h subplots. A restored native prairie grass control plot is included in each of 3 replicates. A common test crop (flax) is seeded in all plots at the end of each rotation cycle (1995; 1999).

Assessment of total dry matter production has been conducted for all experimental units each year. Dry matter was assessed by hand clipping 3 randomly placed 1 m^{-2} quadrats within each subplot. Crop and weed plants were separated before drying. In 1999, individual weed species were separated for drying.

Weed seedling density and community composition was assessed immediately prior to in-crop herbicide use in the early summer of each year. This was assessed by identifying and counting seedlings within randomly placed quadrats . In 1999, weed assessment was conducted prior to seeding, prior in-crop herbicide and prior to grain harvest operations by identifying and counting seedlings within 10 randomly placed 0.1 m^{-2} quadrats.

Pitfall traps have been used to trap insects each year since 1992. Two traps are placed in the north and south end of each subplot of each rotation and emptied every 7 to 10 days. In 1992 to 1996, and 1998 to 1999 sampling took place over an 8 to 10 week period beginning in early June and ending in mid August. In 1997, sampling took place over a 3 week period in mid July. Insects are stored in 70% ethanol in a cold room until they can be separated into families and orders. Ground beetles are stored in 70% ethanol in a cold room until they are separated into species.

Grain and herbage yield has been determined each year. In 1999, yield was determined by randomly hand clipping 5, 1m rows at 4 locations within each subplot. Plant growth, weed and insect populations, and crop yield data are used to determine how cropping system diversity and input use affect populations of weeds and beneficial insects, and whether insect populations are related to changes in weed populations.

Preliminary Results and Discussion

1995 Flax test crop

In 1995, weed dry matter was highest in +f-h treatments and lowest in -f+h treatments for all rotations. Weed community composition was more consistently affected by crop rotation than by input treatment; herbicides significantly affected weed density but not weed community composition. Diversity and total population of ground beetles were significantly influenced by herbicide, with unsprayed plots having the highest levels. No significant effect of rotation or fertilizer use on ground beetles was observed. Crop biomass production and seed yield were influenced by both crop rotation and input management. When alfalfa was included in a rotation, the need for chemical inputs was reduced. This was demonstrated by herbicide and fertilizer inputs having the greatest influence on yields in rotations that did not include alfalfa. The annual crop rotation selected for both annual and perennial weeds. The green manure rotation was associated with Canada thistle and stinkweed. The alfalfa containing rotation was associated with wild mustard. In addition, there were significantly fewer Canada thistle plants in the alfalfa containing rotations when compared with the annual crop and green manure rotations.

1999 Flax test crop

In 1999, the annual crop rotation had a significantly higher total weed population compared to the legume forage containing rotations. Canada thistle and stinkweed appear to be most closely associated with the green manure rotation. Wild buckwheat has become problematic in the alfalfa containing rotation in the fertilized subplots.

Agroecosystems had a significantly higher ground beetle population than the natural prairie ecosystem. Crop rotation significantly influenced ground beetle populations. Ground beetle numbers were higher in the annual crop rotation compared with the other two rotations. This may be due to the higher number of weeds. As well, significantly more ground beetles were found in the green manure rotation compared with the alfalfa containing rotation.

Crop input significantly influenced ground beetle population with +f-h subplots consisting of the highest numbers. Vegetation is thought to influence the population size of carabids through humidity of the habitat (Rivard, 1966) due to differing canopy structures altering the microclimate. The structural diversity and increased population of weeds in the agroecosystems can influence a habitat favorably and thus affect activity of ground predation (Carcamo et al., 1994). As well, an increase in weed diversity broadens the food source range, allowing more species of ground beetles in a community.

Conclusion

Based on 8 years of observations the following conclusions can be made:

1- the use of herbicides for weed management in an annual crop rotation is critical compared with a four year rotation containing two years of alfalfa

2- ground beetles are significantly influenced by the structural diversity of the cropping system, which is influenced by crop input management.

References

Altieri, M. A. 1994. Biodiversity and Pest Management in Agroecosystems. Food Products Press. New York. p. 1-16, 39, 131-138.

Carcamo, H. A. and J. R. Spence. 1994. Crop type effects on the activity and distribution of ground beetles (Coleoptera: Carabidae). Environmental Entomology. 23: 684-692.

Larsen, K. J.; F. F. Purrington; S. R. Brewer and D. H. Taylor. 1996. Influence of sewage sludge and fertilizer on the ground beetle (Coleoptera: Carabidae) fauna of an old field community. Environmental Entomology. 25: 452-459.

Lys, J.; M. Zimmermann and W. Nentwig. 1994. Increase in activity, density and species number of carabid beetles in cereals as a result of strip management. Ent. Exp. Et App. 73:1-9.

Paoletti, M. G.; B. R. Stinner; G. Lorenzoni. 1989. Agriculture Ecosystems and Environment 27:1-4.

Purvis, G. and Curry, J.P. 1984. Influence of weeds and farmyard manure on the activity of carabids and other ground dwelling arthropods in a sugar beat crop. Journal of Applied Ecology. 21:271-283.

Rivard, I. 1966. Ground Beetles (Coleoptera: Carabidae) in relation to agricultural crops. The Canadian Entomologist. 98:189-195.

Evaluation of site-specific weed control in a corn-soybean rotational system.

Heather J. Goudy[1], Kenneth A. Bennett[2], R. B. Brown[2] and F. J. Tardif.[1]
[1] Department of Plant Agriculture; [2] School of Engineering, University of Guelph, Guelph, Ontario, N1G 2W1

Abstract

Site-specific herbicide applications target weed patches for herbicide application. This potentially represents cost savings for operators, reduction in environmental herbicide impacts and increased efficiency. An experiment was initiated in a no-till corn field near Woodstock, Ontario, in 1998 and continued in rotation with no-till soybeans in 1999. Weeds were intensively scouted and distribution maps were generated for both years. A prescription map for each plot was made using the weed density maps. Treatment decision were based on a threshold value of 1 shoot m^{-2}. Four herbicide treatments were compared, a conventional broadcast, a site specific application over weed patches only, and two combinations of broadcast and site specific applications. Treatments were applied using a direct injection sprayer. Efficacy of weed control and yield were compared between treatment. In 1998 and 1999 there was no difference in the level of weed control or yield between treatments. The average percent area sprayed in the site-specific treatments was reduced as much as 26 in the site-specific treatment and up to 59% in the site-specific and broadcast combination treatments.

Introduction

In traditional agricultural weed management situations herbicides are sprayed on the entire field with the assumption that weed distribution is random or uniform throughout the field. However, in most cases weeds are patchy or clustered in distribution (Mortensen & Dieleman, 1997; Cousens & Woolcock, 1997). The concept of site-specific herbicide applications offers the opportunity to reduce the environmental impacts of herbicide use in farming while maintaining efficacy and profitability. In theory, site-specific herbicide applications would only target the areas in the field that have weed patches at densities that would impact on the yield of the crop. Stafford & Miller (1996) have suggested that there would be a 40 to 60% reduction in the amount of herbicide inputs into the environment if site-specific applications were utilised. As well as the potential environmental benefits, site-specific applications would economically optimise the use of herbicides and thus result in a cost reduction for the farmer.

As of yet, there has been very little research done examining if site specific herbicide applications would perform as effectively, in regards to weed control, compared to broadcast herbicide applications. Another important issue relating to site-specific applications that has not been adequately investigated is the effect of targeting weed patches for herbicide applications on patch stability. If patches remained relatively stable in a field from year to year then farmers could use the same weed maps for several years without having to have their fields re-mapped yearly.

The objectives of this research are to monitor the efficacy of site-specific herbicide applications compared to broadcast herbicide applications for weed control and yield, and to monitor the dynamics of weed patches and weed free areas over time.

Materials and Methods

A commercial no-till field site in a corn-soybean-wheat rotation was chosen for the study. In the spring of 1998, a 100 x 400m portion of the field was flagged on a 6 x 6m grid. Flags were geo-referenced using a GPS and left as semi-permanent markers in the field throughout the summer. In 1998 the field was planted into corn and in 1999 was planted into soybeans. Just prior to the 5^{th} leaf stage of the corn and the 2^{nd} trifoliate stage of the soybeans weed counts were conducted. At each flagged intersection point a 1 x 1m quadrat was laid down on the ground and weeds within the quadrat were identified and counted. From the weed counts, weed contour maps were developed for the most prevalent species using the GIS program Surfer. Simple point kriging was used as the interpolation method based on the variograms developed in Gstat for each species.

The field was further divided into 16 plot areas of 28 x 85m. The experiment was laid out according to a randomized complete block design with 4 replications and 4 treatments. The same randomization was used from year to year. Each weed contour plot map was divided into management units of 3 x 5m that the sprayer was capable of targeting. Decisions on whether to spray or not were based on the presence of targeted weed species above the threshold density of 1 shoot m^{-2} in any portion of each decision unit. For each plot there were 136 decision units. The broadcast treatment plots were not assessed and the whole plot area was targeted for herbicide application. Depending on the treatment, two or three of the weed density contour maps were overlaid. Once the decisions about what units would be sprayed had been made, prescription maps were created that could be read by the on-sprayer computer.

The direct injection sprayer system (Bennett & Brown, 1999) is equipped with a water tank and a separate container of the herbicide that is to be injected according to the prescription map. The sprayer constantly sprays the carrier and injects the herbicide only for those decision units that have been prescribed for application. Therefore two types of site-specific applications were possible, 1) injection of herbicide for targeted areas only or 2) injection of herbicide for the targeted areas and simultaneous blanket coverage over the entire plot area with another herbicide mixed into the carrier tank.

In 1998 the herbicides sprayed were nicosulfuron/rimsulfuron, flumetsulam/clopyralid/2,4-D and atrazine at 0.10 kg ai ha^{-1}, 0.28 kg ai ha^{-1} and 1.15 kg ai ha^{-1}, respectively. In 1999 the herbicides sprayed were chlorimuron ethyl at 0.009 kg ai ha^{-1} and acifluorfen at 0.6 kg ai ha^{-1}. Applications were made at the 6th leaf stage of the corn in 1998 and the 2nd trifoliate stage of the soybeans in 1999 according to the treatment lists in tables 1 and 2.

Three to four weeks after application, weed counts were conducted on the same 6 x 6m sampling grid. Yield was also collected in both years. Statistical analysis was performed using an Proc Mixed and means were compared using the Tukey test.

Table 1. Herbicides applied and weeds targeted in 1998

		Weeds targeted[a]		
Treatment no.	Herbicides	TAROF	SONAS	EQUIR
1	Flumetsulam/clopyralid/2,4-D	I[b]	I	I
	Atrazine + nicosulfuron rimsulfuron	I	I	I
2	Flumetsulam/clopyralid/2,4-D	BC	BC	BC
	Atrazine + nicosulfuron rimsulfuron	X	I	I
3	Flumetsulam/clopyralid/2,4-D	BC	BC	BC
	Atrazine + nicosulfuron rimsulfuron	I	I	I
4	Flumetsulam/clopyralid/2,4-D	BC	BC	BC
	Atrazine + nicosulfuron rimsulfuron	BC	BC	BC

[a] TAROF: *Taraxacum officinale*, SONAS: *Sonchus asper*, EQUIR: *Equisetum arvense*.
[b] I: herbicides injected for patches above threshold density, X: no injection even if density is above threshold; and BC: broadcast application of the herbicides to the whole plot area

Table 2. Herbicides applied and weeds targeted in 1999

		Weeds targeted[a]		
Treatment no.	Herbicides	CHEAL	SONAS	EQUIR
1	Chlorimuron +acifluorfen	I	I	I
2	Chlorimuron	BC	BC	BC
	Acifluorfen	I	X	I
3	Acifluorfen	BC	BC	BC
	Chlorimuron	X	I	X
4	Chlorimuron +acifluorfen	BC	BC	BC

[a] CHEAL: *Chenopodium album,* SONAS: *Sonchus asper,* EQUIR: *Equisetum arvense*.
[b] Symbols as per table 1.

Results and Discussion

The most prevalent weed species found over the two years were field horsetail (*Equisetum arvense*), spiny-annual sowthistle (*Sonchus asper*), common lambsquarters (*Chenopodium album*) and dandelion (*Taraxacum officinale*). Visually the field horsetail patch was quite localized and very dense and this was confirmed by the geostatical analysis. The variogram equation reflected the high spatial correlation with a nugget value of zero and the range of spatial dependence was of 61.54 m. The spiny-annual sowthistle patches ran lengthwise in the field following the direction of the implement traffic and this was reflected in the variogram equations with north/south (N/S) anisotropy. Both spiny-annual sowthistle and common lambsquarters had relatively low nugget values indicating that spatial correlation existed but random variation was also present. Common lambsquarters had a much shorter range of spatial dependence at 6.7m while spiny-annual sowthistle had a range of 14.33m. Common lambsquarters was not present at high densities in 1998 and was not targeted. However it was found to be very abundant in this field in 1999 and densities warranted its inclusion in the decision grid. Dandelion was targeted for herbicide application in 1998 but not in 1999. The variogram equation indicated that there was no spatial correlation and therefore was randomly distributed. A preplant application of glyphosate at 900 g ai ha^{-1} controlled dandelion in 1999. The variograms derived from counts of field horsetail and spiny-annual sowthistle in 1998 were very similar to those derived from 1999 observations. This suggests that the level of patchiness of a particular weed may remain stable within a field. However no conclusions can be drawn about relative field to field patchiness of a particular weed. As for the stability of a patch in a field over time it seemed to be dependent on the weed type. The field horsetail patch was almost in exactly the same location as the previous year (Figure 1). There was a greater year to year variation in patch location for spiny annual sowthistle (Figure 2).

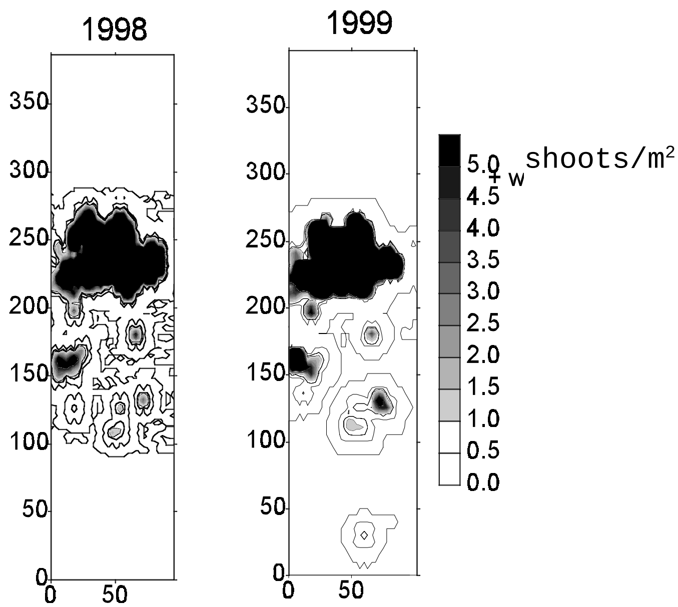


Figure 1. Initial field horsetail maps from 1998 and 1999 for the 4 ha field area. Axes represent distances are in meters.

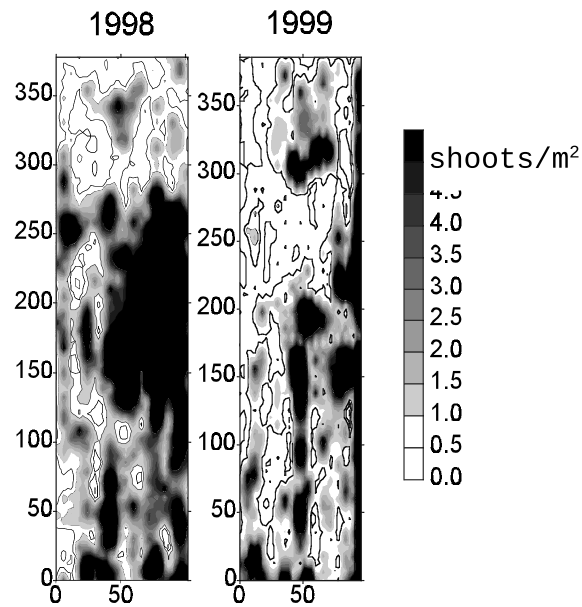


Figure 2. Initial sowthistle maps from 1998 and 1999 for the 4 ha field area. Axes represent distance in meters.

Weed control was assessed by comparing the initial weed counts in each quadrat with the counts for that same quadrat 3 to 4 weeks after application. Regardless of the year, there was no significant difference in weed control between any of the treatments for each species. In 1998, excellent control of spiny-annual sowthistle and field horsetail were obtained with values ranging between 76 to 92% and 86 to 99%, respectively. Control of dandelion ranged between 69 to 80%. In 1999, control of spiny-annual sowthistle ranged between 97 to 99%. Control of lambsquarters and field horsetail was lower which reflects the fact these species are difficult to control with the herbicides used in 1999. Levels of control ranged between 28 to 70% for lambsquarters and 10 to 41% with field horsetail. There were no differences in yield between any of the treatments in 1998 with values ranging from 9.0 to 9.5 tonnes ha^{-1}. There was, therefore, no yield advantage in applying herbicides to the whole field as compared to the site-specific applications. The absence of yield differences among the four treatments is in agreement with the fact that weed control levels were identical.

With these results in mind the next relevant question is whether the actual plot area sprayed was reduced in the site-specific treatments and to what magnitude. In 1998 the actual area sprayed in the site-specific treatment (1) was 26% less than the traditional broadcast treatment (4 in Figure 3). However, the combination site-specific/broadcast treatments (2 and 3) were not different from treatment 4. In 1999, there was no difference in the total area sprayed with site-specific treatment (1) as compared to treatment 4, but the combination site-specific/broadcast treatments (2 and 3) reduced the actual area sprayed by 59 and 50%, respectively. The reductions seen in the combination site-specific/broadcast treatments (2 and 3) are only representing the injection component of the application.

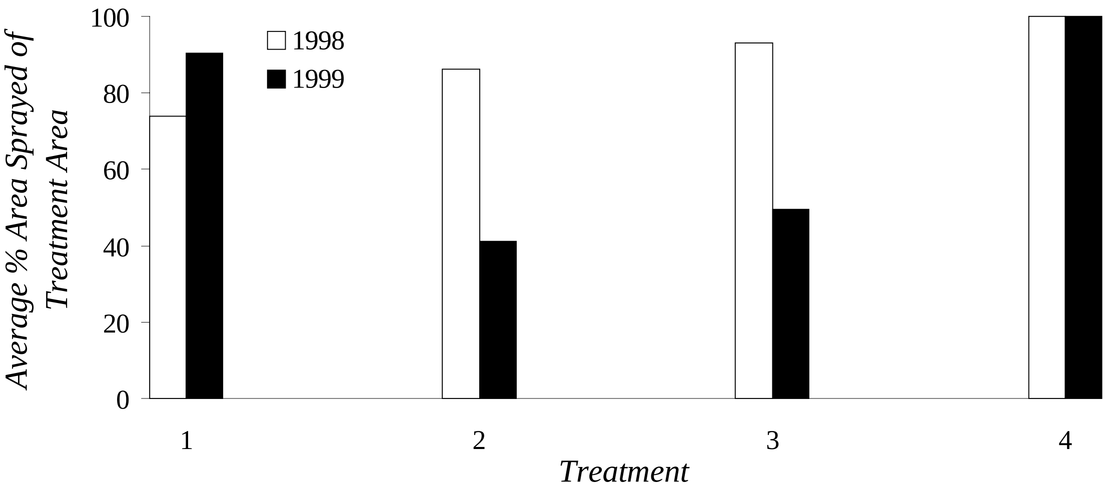


Figure 3. Reduction of area sprayed by using site-specific herbicide applications in both 1998 and 1999 as compared to broadcast.

Site-specific herbicide applications provided encouraging results in both years. The reduction in herbicide inputs would be meaningful economically to a farmer as well as environmentally to the public. However the entire process is in need of refinement. Obviously, in a large field scale situation the intensive sampling method that was used would be time consuming and costly. As technology progresses, better ways of accurately locating weed patches in the field when the weeds are small and within the herbicide application window will be developed. The direct injection sprayer restricted the size of our decision unit. Perhaps a flexible decision unit size would reduce the number of zones that were targeted where only a very small portion of the area was above the threshold density. Moreover, the decision whether to spray an area or not was based on a single criteria for all broadleaf weed species. Realistically, each weed species would have a different impact on the crop based on density, location in the patch (Mortensen & Dieleman) and time of emergence. Leaving an area unsprayed because it did not have weeds above threshold densities may impact the possibility of using the same weed maps over several years. For example in 1998 common lambsquarters was not targeted because it was not above the threshold but in 1999 it was one of the major species in this field. More research into the dynamics of weed patches as well as the impact of site-specific herbicide applications is required if precision weed management is to be a success.

References

Bennett K A; Brown R B (1999). Field Evaluation of a site specific direct injection herbicide sprayer. Presented at 1999 ASAE Annual International Meeting, Paper No. 99-1102. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659 USA.

Cousens R D; Woolcock J L (1997). Spatial dynamics of weeds: an overview. Brighton Crop Protection Conference - Weeds. **7B 7**,613-618.

Mortensen D A; Dieleman J A (1997). The biology underlying weed management treatment maps and maize. *The Brighton Crop Protection Conference - Weed.* **7B 9**, 645-648.

Stafford J V; Miller P C H (1996). Spatially variable treatment of weed patches. *Precision Agriculture* **3**, 465-473.

Effect of fertilizer addition and weed density on spring wheat yield at two landscape positions.

D.M. Ross and R.C. Van Acker
University of Manitoba, Winnipeg Canada.

Abstract

Site-specific fertilizer applications may have implications for weed population dynamics that have been largely ignored. The purpose of this study is to determine the effect of landscape specific nitrogen application on wild oat and wild buckwheat competitiveness in spring wheat. The experiment was conducted during 1998 and 1999 at sites near Birtle and Carman, Manitoba. The experimental design was split-split plot wherein the main plot was landscape position, the subplot was nitrogen rate, and the sub-subplot was target weed density. The main plots were replicated twice (three times at Carman, 1998). The experiment was repeated with wild oats (*Avena fatua* L.) and wild buckwheat (*Polygonum convulvulus* L.) at a range of target densities. Measurements used to determine weed competitiveness include wheat grain yield per plot (as percentage of average weed-free treatment), and dry matter weight (g/m^2) for wheat, wild oats, and wild buckwheat. Other measurements include soil fertility levels, gravimetric moisture levels, soil profile characterization, and site topographical characterization. Results from three site years indicate that under high nitrogen rates relative wild oat competitiveness may increase. Concave slope positions (footslope) may also increase competitiveness of wild oat, particularly on larger slopes (Birtle site). Results from three site years suggest that wild buckwheat caused no consistent decrease in wheat yield. Birtle 1999 plots and biomass data from all site-years have yet to be analyzed.

Introduction

With increased availability and decreasing cost of GPS and GIS technology there is intense interest in developing site-specific farming. One aspect of site-specific farming is site-specific weed management. Weed infestation maps created through ground reconnaissance or remote sensing will facilitate spot spraying by allowing the farmer to target each weed species individually and on a spatially specific basis in one pass. This would provide more effective weed control on a whole field basis, leading to increased yields and more prudent use of herbicides. The efficacy of spot spraying and the benefits associated with it are reliant upon the accuracy of the weed infestation map, and its functional lifespan. We can only determine the useful lifespan of a weed map if we understand how, why, and what rate weed patches move.

In order to understand the ecological dynamics of weeds, aspects such as weed biology and the impact of various agricultural practices on a weed population must be examined. Sexsmith and Pittman (1963) found that in areas of higher soil moisture, as is often found in lower landscape positions (foot and toe slopes), weed seeds such as wild oats germinated more readily. Di Tomaso

(1995) found that weeds tended to be more competitive with crops at higher nutrient levels. These results suggest that increased fertility in areas of high soil moisture could lead to increased competitiveness of weeds. Strategies for site-specific fertilizer application, which is the primary focus of research in the precision farming area, include increasing the rate of fertilizer application in low-lying, high fertility areas (Barker, 1998). Though this strategy has been shown to increase net profits on topographically variable fields (Beckie, 1997), it may also result in an unpredicted weed patch spread. This could prove costly for producers in terms of unexpected yield loss and will be of particular concern to producers who are dealing with herbicide resistant weed patches. In addition, it will hinder the development of site-specific weed management because it will lower the value of weed maps by decreasing the predictability of weed patch spread.

Research Objectives

The objective of this project was to determine if the practice of site-specific fertilization influenced the competitive ability of weeds in the field. In order to meet this objective, the most economically important grassy weed (wild oat, *Avena fatua* L.) and the most common broadleaf weed (wild buckwheat, *Polygonum convulvulus* L.) in Manitoba crops (Thomas et al., 1998) were studied in a common crop (spring wheat). The null hypothesis of this project was that the competitiveness of wild oats or wild buckwheat in hard red spring wheat would be unaffected by nitrogen fertilizer rate and landscape position.

Methodology

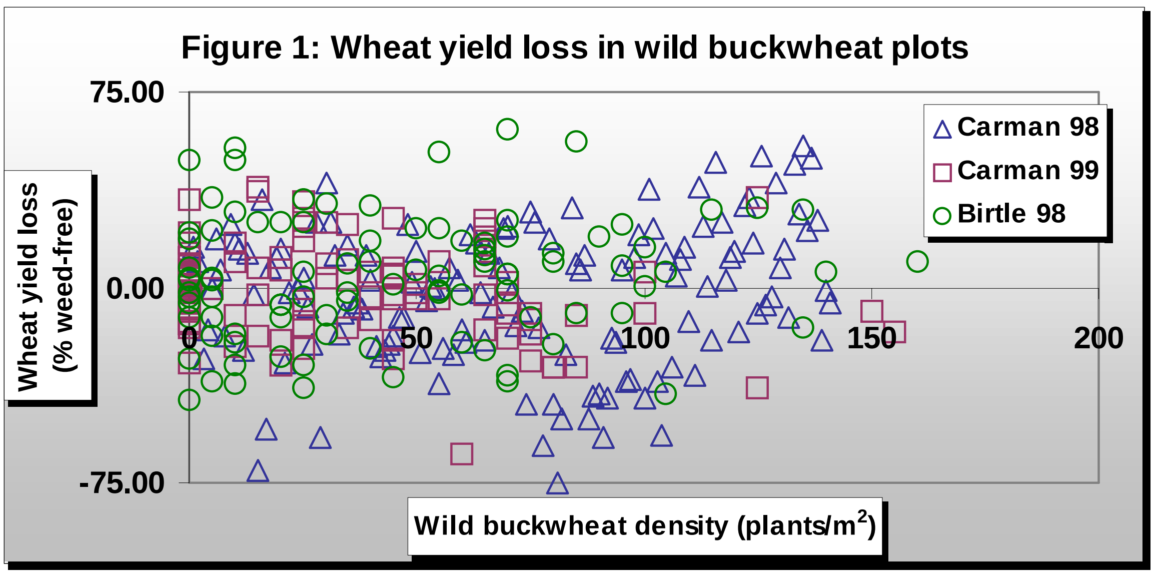
The experimental design was split-split plot wherein the main plot was landscape position, the subplot was nitrogen rate, and the sub-subplot was target weed density. The main plots were planted with either wild oats or wild buckwheat. The experiment was conducted at two sites near Birtle and Carman, Manitoba. The Birtle site is classified as a gently undulating glacial till soil of the Newdale association. The main plots were planted on either the knoll or the footslope, wherein the relief differed by approximately 4m, and slopes did not exceed 4%. The Carman site is classified as a localized depression of the La Salle soil type, ranging from sandy clay loam to clay loam in texture. Relief between main plots on the knoll and the toe differed by approximately 1m, and slopes did not exceed 5%.

Measurements of weed competitiveness included wheat grain yield per plot (as percentage of average weed-free treatment), and plant dry biomass (g/m^2). Other measurements included soil fertility levels, gravimetric moisture levels, soil profile characterization, and site topographical characterization to provide a detailed description of the soil characteristics encountered at each site.

Wheat grain yield was plotted against weed density by weed treatment, and the data was fit to either a rectangular hyperbola or linear equation.

Preliminary Results and Conclusions
Wild Buckwheat

Results from the three site years that were analyzed indicated that wild buckwheat caused consistent reduction in wheat yield as density increased. The factors of year, site, slope and density were found not significantly different for the combined data. Thus the years and sites were combined. The data distribution for wheat yield loss by wild buckwheat density was relatively evenly distributed on either side of 0% yield loss, ranging from approximately 65% yield loss to 75% yield gain. The even distribution of yield loss in wild buckwheat treatments may indicate a lack of competition from wild buckwheat, even when it appears at relatively high densities (>150 plants/m2). The extreme variability in the yield loss was attributed to the inherent variability of yield within the field, and the yield variability among the control plots to which the treatment plots were compared. Results are shown in Figure 1.



ANOVA for the treatment factors (slope, nitrogen rate, density, and slope by nitrogen rate interaction) by site year indicated that the slope*nitrogen rate interaction was significant for the three site years observed (p<0.01, p<0.01, and p<0.1 for Birtle and Carman 1998 and Carman 1999, respectively). Slope position and density were significant (p<0.1) at Carman 1999 only, and nitrogen rate was significant (p<0.05) for Carman 1998 only.

Preliminary analysis of wheat and wild buckwheat biomass measurements, as an indicator of seed return, showed that wild buckwheat dry biomass had no consistent effect on wheat dry biomass.

This data will be more thoroughly analyzed. Birtle 1999 yield data is also being analyzed.

Wild Oats

Trends in yield loss were noted for wild oat treatments for the three site years analyzed. For the combined data, year, slope and slope*N rate interactions were not significant according to ANOVA. Thus the years were combined for data analysis. Analysis of the treatment factors by site-year indicated that slope and density were significantly different at Birtle 1998 ($p<0.01$ and 0.1, respectively). Density was also significant at Carman 1998 ($p<0.01$). None of the treatment factors were significantly different at Carman 1999, possibly due to difficulties during planting (flooding, delayed planting, relatively low emergence of weeds).

Distributions of wheat yield loss by wild oat density were fitted to a rectangular hyperbola equation in order to compare the biologically meaningful parameters of initial slope ('i', indicating competitiveness of the weed as density increases) and the asymptote ('a', indicating the maximum yield loss resulting from high weed densities). Distributions from Birtle 1998 fit the rectangular hyperbola model relatively well ($r^2=0.52$ and 0.60 for low and high nitrogen treatments, respectively). The Carman distribution, combined over years, did not fit this equation. Thus the data was fit to a linear equation ($r^2=0.52$ and 0.58 for low and high nitrogen treatments, respectively), and slope of the equation were compared. The i values for Birtle 1998 low nitrogen ($i=0.26\pm0.07$) and high nitrogen ($i=0.98\pm0.28$) treatments were significantly different ($p<0.01$). Thus under high nitrogen treatments, wild oats become more competitive as density increased. The a values for Birtle 1998 were numerically different (85.3± and 78.1± for the low and high nitrogen treatments, respectively). Significance of these values has yet to be analyzed. The linear slope parameter 'm' differs numerically, with a value of 0.24 for low nitrogen treatments, and 0.30 for the high nitrogen treatments. The m parameter has not yet been analyzed for significance.

Dry biomass data from the Birtle site in 1998 suggests that wheat dry biomass decreases as wild oat dry biomass increases on both the knoll and the footslope, though an increase in variability is apparent at the footslope.

Table 1: Statistical results for rectangular hyperbola and linear equation parameters

		n	i or m	a	r^2
Birtle	**Low N**	41	i = 0.26 ± 0.07	85.3 ± 37.8	0.52
(1998 only)	**High N**	39	i = 0.98 ± 0.28	78.1 ± 33.3	0.60
Carman	**Low N**	70	m = 0.24	.	0.52
(Years	**High N**	68	m = 0.30	.	0.58

Tentative Conclusions

These results indicate that under high nitrogen rates relative wild oat competitiveness may increase. Slope position may also increase competitiveness of wild oat, particularly on larger slopes (Birtle site). Results from both sites in 1998 suggest that wild buckwheat caused no consistent decrease in wheat yield. Birtle 1999 plots and biomass data from all site-years have yet to be analyzed.

Implications

Efficacy of weed control measures is critical in high nitrogen systems, as wild oat competitiveness appears to increase in these conditions. Slope position may have some effect on increasing the relative competitiveness of wild oat at concave landscape positions (footslope). The interactions of slope position and crop yield are complex and difficult to measure accurately under field conditions. Biomass data may demonstrate the effect of slope position more clearly. The effect of slope position may be masked by the variability in the field, and characterization of the slope positions may not have been appropriate for discriminating among slope effects.

Significance to Weed Science and Agriculture

Site-specific farming will become more widely practiced as the technology becomes less expensive. Though farmers have benefited from increased yields through site- specific fertilizer application (Beckie, 1997), there may be an unforeseen effect on weed competitiveness. If weeds gain a competitive advantage under site-specific fertility management, as preliminary results from this experiment suggest for wild oat, then serious weed problems may result in reduced potential yield in the long run. Furthermore, such a competitive advantage for weeds could decrease the predictability of weed patch spread, complicating site-specific weed management. The results of this research will contribute to the understanding of the influence of site-specific fertilization on weed ecology. By improving our understanding in this area, farmers will be better able to integrate facets such as site-specific fertility and weed management into an optimal production system.

References

Barker, B. 1998. Precision farming improves fertilizer economics. Agri-book Magazine/Top Crop Manager 24(12). p. 44-45.

Beckie, H.J., A.P. Moulin and D.J. Pennock. 1997. Strategies for variable rate nitrogen fertilization in hummocky terrain. Can. J. Soil Sci. 77:589-595.

Di Tomaso, J.M. 1995. Approaches for improving crop competitiveness through the manipulation of fertilization strategies. Weed Science 43:491-497.

Sexsmith, J.J. and U.J. Pittman. 1962. Effect of nitrogen fertilizers on germination and stand of wild oats. Weeds. 11:99-101.

Thomas, A.G., B.L. Frick, R.C. Van Acker, S.Z. Knezevic and D. Joosse. 1998. Manitoba weed survey: cereal and oilseed crops. Weed survey series Publication 98-1. Agriculture and Agri-Food Canada, Saskatoon, Saskatchewan, Canada.

Soil and weed management strategies for processing tomato (*Lycopersicon esculentum* Mill.) production in Ontario

R.J. Thomas, J. O'Sullivan, C.J. Swanton
Univ. of Guelph, Simcoe, ON; and A.S. Hamill, Agriculture and Agri-Food Canada, Harrow, ON

Introduction

Processing tomato production in Ontario has traditionally relied on intensive tillage practices which ultimately decreases soil organic matter, damage soil structure, decrease aeration and moisture penetration. Most processing tomato production in Ontario is machine harvested for processing, therefore, any proposed soil management program needs to be designed to allow for these practices. Mechanized tomato production does adversely affect soil structure and needs good crop management to compensate for this. The use of mechanical harvesters for processing tomatoes has resulted in shifts in production away from clay to coarser textured sandy soils (Johnson, 1997). These lighter textured soils are much more subject to erosion. Conservation tillage systems have been used successfully in many field crops such as corn and soybeans, however adoption of these techniques in vegetable production has not been widely accepted.

Concern about soil degradation, sustainability and adverse effects on the environment have increased interest in conservation tillage. Conservation tillage systems are defined by the presence of at least 30% crop residue from previous crops that cover the surface (Swanton and Weise, 1991). Conservation tillage systems for tomatoes need to be examined to determine whether the benefits of these practices could result in comparable or better yields to a conventional system. At present, there is limited information regarding tillage systems and cultural practices in processing tomato production systems. Previous work has demonstrated that yields under conservation tillage systems are comparable to conventional systems of production (Johnson, 1997; Shelby et al. 1988; Swanton et al., 1997).

There have been concerns about reduced yields of tomatoes under no-tillage systems (McKeown et al., 1998). However, soil conditions for no-till tomatoes can be improved by tillage modifications. Opoku et al. (1997) have demonstrated that by modifying no-tillage principles to a zone-till system (in-row soil loosening by attaching fluted coulters to the front of a planter), surface residue in the seeding area can be decreased which leads to improved crop growth and higher yields in corn. Other reservations about no-till tomatoes are delayed maturity due to the presence of lower soil temperatures due to the presence of mulch on the soil surface. Kasper et al. (1990), however, showed that the removal of residues from the center of the row, reduced time to emergence by 2.5 days and increased corn yield. These studies show that soil conditions for no-tillage can be improved by tillage modifications and there is potential for modifying the traditional no-till system for tomato production to maintain or enhance yields.

One of the limitations to the successful adoption of reduced tillage in intensive vegetable production is the concern about managing weeds. Reduced till systems generally preclude the use of preplant incorporated herbicides and cultivation, both of which are a key component of weed management in tomato production. However, with new low rate herbicides becoming available, there is a need to examine these management tools for use in tomato production under reduced tillage systems. There is the perception that weeds will be more difficult to manage under reduced tillage systems, therefore, any proposed tillage modifications must take weed control strategies into account.

Information that helps form a systems approach to processing tomato production is required to demonstrate to growers that conservation tillage is economical and sustainable.

Research objectives

The objectives of this research were to determine:

a) The best weed management system for tomatoes grown under a conservation tillage system with reduced herbicide use.

b) The conservation tillage system that produces growth, development, yield and quality of processing that does not differ to a conventional tillage system.

Materials and methods

Field studies were conducted at the Department of Plant Agriculture, University of Guelph, Simcoe, ON in 1998 and 1999 to investigate tomato growth under reduced tillage systems (disk, zone-till and no-till) compared to conventional tillage. Furthermore, to evaluate weed control under zone-tillage vs. conventional tillage with different herbicide treatments and application timings on coarse textured soils. The main tillage experiment was repeated at Agriculture and Agri-Food Canada's Research Station at Harrow, ON. Rye was fall-seeded prior to trial initiation and allowed to grow a height of 40-50 cm in the spring, before killing with glyphosate. The rye remained standing prior to primary tillage and provided wind protection for the transplants in the reduced tillage plots. A thorough growth analysis was performed including destructive (leaf area and above ground dry matter) and non-destructive (leaf number, plant height, stem diameter and growth stage) measurements. Yield was determined using machine and hand sampling techniques.

A second study was initiated at Simcoe to evaluate different herbicide combinations for weed control between conventional and zone-tillage systems as in objective (a). Conventional herbicide treatments included trifluralin, metribuzin, s-metolachlor, and rimsulfuron, at various application timings. Crop phytotoxicity, weed biomass and yield was recorded for each herbicide treatment and compared to untreated and weeded plots. Yield was obtained by hand sampling 5 plants within each treatment and replication.

Preliminary results

Leaf area and dry matter accumulation was not different between tillage systems at Simcoe in 1999. Regression analysis over the season showed that there were differences in growth between tillage systems at Simcoe in 1998. The no-tillage regression of leaf area index over time was different from the conventional system, however, all other tillage treatments were not different. The disking and conventional regression curves generated for tomato dry matter accumulation were not different in 1998. However, the zone-tillage and no-tillage regression equations did differ to the conventional. There were no differences between any tillage in terms of leaf number, plant height and stem diameter in 1998 and 1999 at Simcoe. Preliminary results from Simcoe and Harrow in 1999 show that growth is unaffected by tillage system.

Yield was assessed at both sites. Pre-etephon application hand sampling was used to determine if there were any maturity differences between tillage treatments at Simcoe. No yield differences were detected over years at Simcoe and Harrow (1999). Yield was reduced in the no-tillage plots at the Harrow location (1998), however, other reduced tillage plots were not different from the conventional plowed plots. In addition, the final hand yield sample was not different from yields obtained by machine sampling. Rye residue was not problematic for machine recovery of tomatoes during harvest. Numerically, the disking treatment (one pass) yielded the highest (from machine harvest) at both locations in 1998. Quality was assessed from hand sampling at Simcoe. There were no differences between characteristics such as Agtron (colour), soluble solids, puree pH and modified Bostwick (viscosity) in all tillage systems when compared over years.

Preemergence applications (post-transplant) of metribuzin and s-metolachlor resulted in significant crop phytotoxicity (plant mortality and stunting). No injury was observed with similar preplant incorporated applications. The predominant weeds present in this trial included hairy nightshade, red-root pigweed, common lamb's-quarters and hairy crabgrass. Preplant incorporated treatments resulted in good to excellent control of most weeds present in the trials. There was no tillage x treatment interaction detected in 1998 or 1999. Furthermore, no effect due to tillage type was found which demonstrates that zone tillage treatments are comparable to conventional tillage practices. Combinations of s-metolachlor and metribuzin followed by rimsulfuron gave excellent control of all weeds present. However, yield was reduced in the preemergence (post-transplant) treatments with s-metolachlor plus metribuzin. No yield reductions were observed with any preplant incorporated treatment in both years. Plots that received rimsulfuron applications generally resulted in increased yields.

Conclusions

Tomatoes can be grown under reduced tillage systems without loss of yield. Experiments conducted at both locations suggest that a single disking or zone-tillage treatment will not result in yield loss, however, data from Harrow in 1998 suggest that yield will be reduced if tomatoes are grown under no-tillage. This research demonstrates that there are opportunities to reduce energy inputs in tomato production by using reduced tillage without sacrificing yield and quality. Current herbicides used in conventional tomato practices can be utilized in a weed management program for zone-tillage systems.

Significance to weed science and agriculture

A system needs to be developed using an integrated weed management (IWM) approach to help the grower come up with alternative methods of growing tomatoes to enhance or maintain yields compared with conventional techniques. There is an opportunity to reduce herbicide and energy input by modifying existing tillage practices used by tomato growers in Ontario. This research can be used as part of an integrated weed management (IWM) program for sustainable agriculture in the future. Alternative management practices could result in more economical production for growers while protecting the soil and the environment.

References

Johnson, R. 1997. *Crop rotation and cover crops in processing tomatoes*. Ridgetown College Report #1, Green Plan (*in press*). pp.1-140.

Kasper, T.C., D.C. Erbach, and R.M. Cruse. 1990. *Corn response to seed-row residue removal*. Soil Sci. Soc. Am. J. 54:1112-1117.

McKeown, A.W., R.F. Cerkauskas, and J.W. Potter. 1998. *Long term evaluation of cover crop and strip-tillage on tomato yield, foliar diseases and nematode populations*. Can. J. Plant Sci. (*in press).*

Opoku, G., T.J. Vyn, and C.J. Swanton. 1997. *Modified no-till systems for corn following wheat on clay soils*. Agron J. 89:549-556.

Shelby, P.P. Jr., D.L. Coffey, G.N. Rhodes Jr., and L.S. Jeffery. 1988. *Tomato production and weed control in no-tillage versus conventional tillage*. J. Amer. Soc. Hort. Sci. 113(5):675-678.

Swanton, C.J. and S.F. Weise. 1991. *Integrated weed management: the rationale and approach*. Weed Tech. 5:657-663.

Swanton, C.J., A.Verhallen, E. Tomecek, J. Zandstra, and K. Janovicek. 1997. *Evaluation of conservation tillage for processing tomato production*. Green Plan Project No. 59, pp.1-15.

The Critical Period of Weed Control in Canola (*Brassica napus* L.)

Steve Martin and Dr. Rene Van Acker
University of Manitoba, Department of Plant Science, Winnipeg, MB, R3T 2N2

Introduction

The critical period of weed control is the primary analysis method for studying the magnitude of yield loss associated with the length of time that weeds affect a crop (Weaver and Tan, 1987). Within this period, weed control measures should be maintained to prevent yield losses due to weed interference.

Canola is grown as a spring-seeded annual crop in western Canada. Critical period research in canola is important to determine the length of time that weeds can be left in the crop, especially with the increased use of herbicide-tolerant canola (HTC) varieties. Critical periods are also important to determine how long soil-residual herbicides need to remain effective to prevent yield loss.

Previous studies have shown that early removal of wild mustard from canola, at the 2nd to 4th leaf stage of the weeds, alleviated the yield reductions noticed when weeds were removed later at the 4th to 8th leaf stage (McMullan et al., 1994). Wall (1994) showed that wild mustard could grow with canola until the 4th or 6th leaf stage of development before it caused yield reductions.

The effect of weed density has been noted to diminish the later that volunteer barley emerges relative to the canola crop (O'Donovan et al., 1992). This implies that the minimum length of the weed-free period may not be very long. In fact, the weed-free period required to prevent yield losses in canola occurred before the first leaf stage with competition from a wild mustard population that was broadcast-planted (Wall, 1994).

The objective of this study was to define the critical period of weed control for canola. To ensure the greatest applicability of the critical period of weed control, a natural weed population was used, and the timing was related to days after canola emergence, as well as growth stages of the crop.

Materials and Methods

Trials were conducted at three distinct locations in 1998 and 1999. The first site was located at the University of Manitoba research station in Carman, Manitoba on a Winkler Series soil comprised of 60% sand, 15% silt, and 25% clay. Plot sizes varied in the experiment due to spatial constraints and the equipment available for the seeding and harvesting operations at each site and year. The second site was located at Kelburn Farm, which is owned by James Richardson International, near St. Adolfe, Manitoba on an orthic, dark grey, St. Norbert Clay, having a composition of 7% sand, 27% silt, and 66% clay. The third site was located at the Cyanamid Research Farm, NE of Carman, Manitoba on a soil that was a gleyed, black, Rignold Series with soil texture of 68% sand, 19.1% silt, and 12.9% clay

The plots were cultivated, and in some instances, sprayed shortly before seeding. The crop was seeded at a rate of 6 kg $ha^{-1}$of canola seed plus 6 kg ha^{-1} of terbufos (Counter 5G[1]) granular insecticide. The timing of removal of weeds was based on the development stage of the canola crop making the results biologically based rather than site-year specific.

Each trial had plots kept weed-free and a weed-infested all year. Six of the treatments were allowed weed interference until a specific development stage of the crop, after which, the crop was kept weed-free for the remainder of the season. The remaining six treatments were kept weed-free until the same stages of crop development; after this time weeds that emerged into the crop were allowed to compete for the remainder of the growing season. The stages used to determine the treatment intervals were cotyledon, 2, 4, 6, 8-10th leaf, and early flower.

The variety of canola used was Innovator, which is tolerant to glufosinate ammonium. Weed control for the different treatments was accomplished using the herbicide, glufosinate (Liberty[2]), which was applied via a backpack sprayer. The rates of Liberty used in 1998 were 2L ac^{-1} (741.29 g a.i. ha^{-1}) at a water volume of 45L ac^{-1} and 1.3 L ac^{-1} (593 g a.i. ha^{-1}) in 1999. The rate was reduced since it was thought that control was sufficient at the recommended rate. Perennial weed problems were controlled at all locations prior to seeding with the use of non-residual, pre-emergence herbicides, due to their significantly non-uniform distribution across trials.

A mixed weed species population was utilized in order to test for general weed interference. This was accomplished by using the naturally occurring weed populations at all locations. Some augmentation of these populations was implemented at Kelburn Farm in 1998 and 1999 and at the Carman sites in 1999.

At late flowering, a 0.25 m^2 sample of weedy material was removed from the back of the treatments that were kept weed-free up to each stage of canola development. The samples were separated, counted, dried, and weighed; these were used to monitor the amount of weed regrowth that occurred after each duration of weed-free period.

Non-crop dockage was removed from the yield samples and percentage green seed were counted. The yield after dockage was expressed as a percentage of the yield of the weed-free control.

The length of the critical period was determined by inputting arbitrary levels of acceptable yield loss (2.5, 5, and 10%) into the Gompertz and logistic equations that were fitted to the yield data.

---

[1] Cyanamid Crop Protection, 88 McNabb Street, Markham, Ontario, L3R 6E6
[2] AgrEvo Canada Inc., 295 Henderson Drive, Regina, Saskatchewan, S4N 6C2

Results and Discussion

The Critical Period of Weed Control

A critical period of weed control, as a single discrete period, did not occur in this study. As a result of the variation from planting date, rainfall, and temperature between sites, six distinct site-years were examined.

The early-seeded Carman site in 1999 had a critical weed-free period of 51 days after emergence (DAE) and critical timing of weed removal of 38 DAE at the 5% yield loss level (Table 1 and 2). These occurred at the 6^{th} leaf and 4^{th} leaf stages, respectively. In the case of the late-seeded site, however, the weed-free period was only 3 DAE and the critical timing of weed removal was 17 DAE. The stages of canola growth at these times were cotyledon and 4^{th} leaf, respectively. These results imply that the critical weed-free period may be highly dependent on the crop planting date and the emergence period of weeds. Inconsistency in the critical period response to yield loss between sites will allow us to refer to the critical period of weed control as the critical weed-free period and the critical timing of weed removal.

The Critical Weed-Free Period

The critical weed-free period was quite variable between sites (Table 1). At the 2.5% level, this period ranged from 3 to 65 DAE (cotyledon to harvest). If the acceptable yield loss level was increased to 5%, the weed-free period ranged from 0 to 51 DAE, which corresponded to seeding to 8-10^{th} leaf stages of the crop. However, when up to 10% yield loss was allowed, the crop consistently required a weed-free period extending up to the seeding to 4^{th} leaf stage of the canola.

Table 1. Critical length of the weed-free period, as calculated from the Gompertz equation for 2.5, 5, and 10% yield loss.

		Length and stage of weed-free period required					
		2.5%		5%		10%	
Location	Year	DAE	Stage	DAE	Stage	DAE	Stage
Carman	1998	13	2nd	0	seed	0	seed
Kelburn	1998	65	harvest	42	8-10th	20	2nd
Carman (early-seeded)	1999	62	e. flower	51	6th	39	4th
Carman (late-seeded)	1999	2.9	Cot	3	cot	2	cot
Kelburn	1999	-		8	2nd	1	cot
Cyanamid	1999	-		-		4	cot

The tendency of yield loss to diminish from weeds emerging up to the 4^{th} leaf stage can be related to the sharp decline in regrowth of weeds in treatments kept weed-free for increasing durations.

Weeds that emerged after this time did not accumulate significant biomass to compete with the crop for resources (Figure 1). If the crop was kept weed-free up to about the 4th leaf stage, the density of weeds emerging into the crop was significantly reduced.

The weed biomass and densities of weeds emerging early in the lifecycle of the crop varied greatly among sites until about the 4th leaf stage (Figure 1). This might also explain the large variation in yield loss between sites that existed for the shorter weed-free periods.

Planting dates may also affect the weed populations present since the plots were cultivated or sprayed to remove any weeds present prior to seeding. The two experiments at the Carman site in 1999 were planted on two different dates and were located side by side, yet they had very different weed densities and spectrums. Much of the weed population that emerged at the late-seeded site was removed by the pre-seeding cultivation practice.

Table 2. Critical timing of weed removal, as calculated from the logistic equation for 2.5, 5, and 10% yield loss.

		Length and stage of weed infestation tolerated					
		2.5%		5%		10%	
Location	Year	DAE	Stage	DAE	Stage	DAE	Stage
Carman	1998	44	8-10th	89	harvest	89	harvest
Kelburn	1998	0	seed	30	4th	33	4th
Carman (early-seeded)	1999	38	4th	38	4th	38	4th
Carman (late-seeded)	1999	14	4th	17	4th	19	4th
Kelburn	1999	32	8-10th	34	8-10th	75	harvest
Cyanamid	1999	24	6th	29	8-10th	37	e. flower

Critical Timing of Weed Removal

The timing of weed removal required to prevent yield loss will depend on the biology of the crop and its ability to tolerate competition. Ideally, we would want to leave the weeds in the crop for as long as possible in order to remove as many weeds as possible with post-emergence herbicides.

Our results suggest that canola is quite competitive and can tolerate weed-infestation during the earlier part of its lifecycle. With yield loss levels up to 2.5%, the critical time of weed removal ranged from seeding to 8-10th leaf (0 to 44 DAE). The timing of weed removal ranged consistently from 4th leaf to harvest, when the crop yield loss levels were set up to 5 or 10%. These ranged from 17 to 89 DAE and 19 to 89 DAE, respectively.

The percent yield loss appeared to vary considerably between sites as the length of the weed-infested period increased. This was likely a result of site variations in rainfall, temperature, soil characteristics, and natural weed populations.

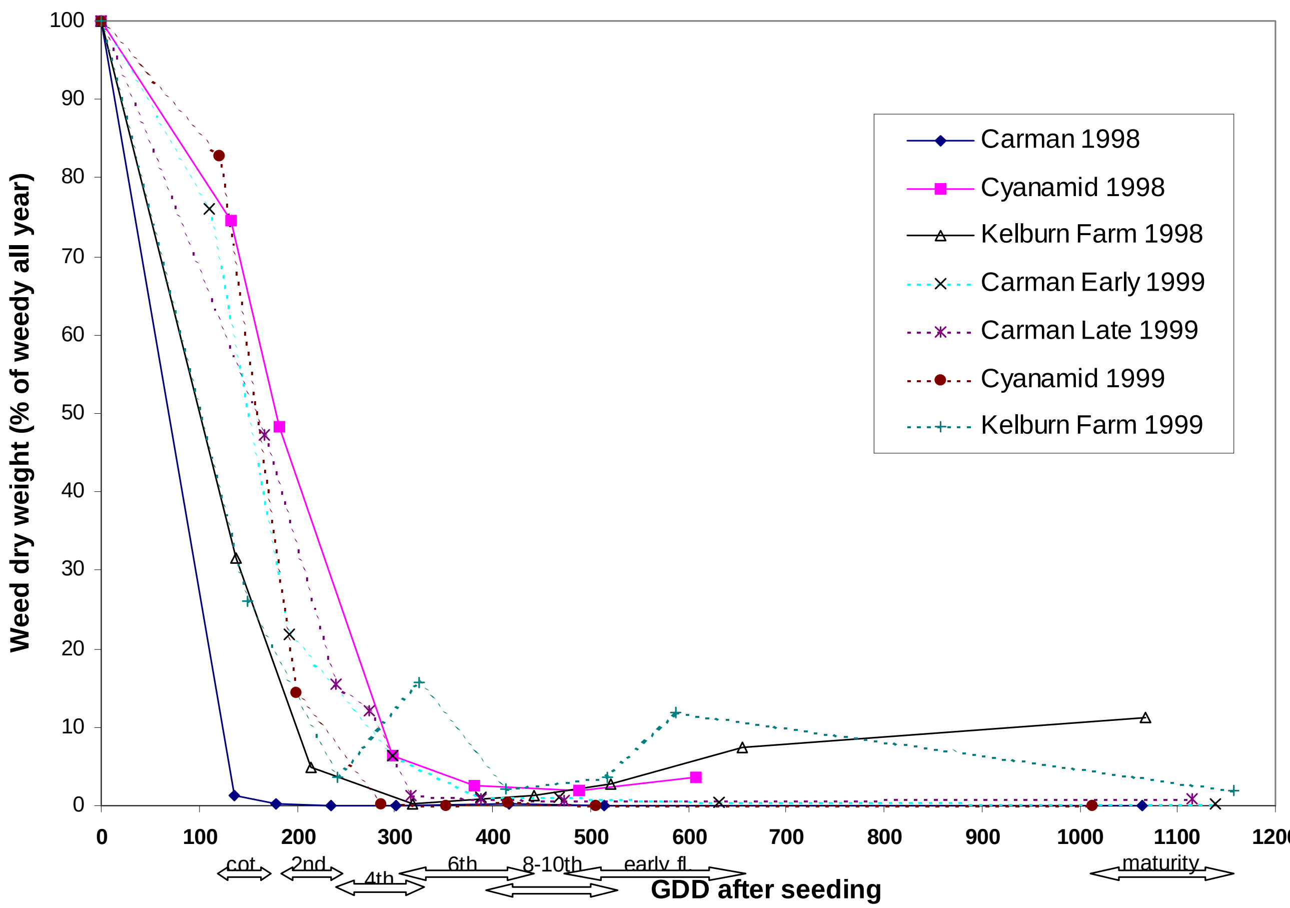


Figure 1. Effect of the weed-free period length on the dry weight of weed regrowth present at late flowering.

Application of the Critical Period

Currently, in western Canada there are two major options for herbicidal weed control in canola. The first option is the use of pre-emergence herbicides, which control many weeds in canola. However, the duration of the weed-free period that is created by using these chemicals must be long enough to prevent yield loss from later emerging weeds. Our study shows that one can consistently expect to lose only 10% of the weed-free yield or less if the crop is maintained weed-free up to the 4^{th} leaf stage of the canola. To obtain a consistently lower yield loss, greater variability occurred in the required length of control, and it became largely dependent on weed population present (species, densities, emergence, etc.) and seeding date relative to the emergence pattern of the weeds.

The second option for herbicidal weed control is to use post-emergence herbicides. This has become increasingly important with the advent and popularity of herbicide-tolerant canola (HTC) varieties. These varieties allow the use of chemicals with wide windows of in-crop application (cotyledon to bolting) and products which control a broad range of weed species. In 1999, HTC varieties mad up 64% of the canola grown in the Manitoba (Manitoba Agriculture, 1999). With this option, the crop must be able to tolerate weed infestation for long enough so that herbicides are applied when most of the weeds have emerged. This would facilitate a single application thus reducing costs and impact on the environment. If weeds were left in the crop until the 4^{th} leaf stage, yield loss never exceeded 5%. After this stage, most weeds present in the field had already emerged, and relatively few grew to compete with the crop and produce seed for subsequent infestations. More work needs to be performed in this area, to find the effects of single applications of herbicide on seed return.

The presence of fewer weeds, of course, will make either choice more effective than the maximum expectations that have been outlined. In the case of soil applied herbicides and single post-emergence applications, delayed seeding can be a benefit since many of the weeds that would be present in the crop will be controlled by pre-seeding weed control.

References

Ratkowsky, D. A. 1990. Handbook of Nonlinear Regression Models. 5: Models with one X variable, sigmoidally shaped curves. Pub. Marcel Dekker, Inc. New York. Vol. 107. p.123-147.

Roberts, H. A. 1976. Weed competition in vegetable crops. Ann. Appl. Biol. 83: 321-347.

Manitoba Agriculture. 1999. Personal communication. Rob Park, oilseed specialist.

McMullan, P. M., J. K. Daun, and D. R. DeClercq. 1994. Effect of wild mustard (*Brassica kaber*) competition on yield and quality of triazine-tolerant and triazine-susceptible canola (*Brassica napus* and *Brassica rapa*). Can. J. Plant Sci. 74(2): 369-374.

O'Donovan, J. T. 1992. Seed yields of canola and volunteer barley as influenced by their relative times of emergence. Can. J. Plant Sci. 72: 263-267.

Wall, D. 1994. Weed Research Report. Agriculture and Agri-food Canada. Research Centre, Morden, Manitoba.

Weaver, S. E. and C. S. Tan. 1987. Critical period of weed interference in transplanted tomatoes and its relation to water stress and shading. Can. J. Plant Sci. 67: 575-583.

Characterization of Imazethapyr and Thifensulfuron-Methyl Resistance in Populations of Green pigweed (*Amaranthus powellii* S. Wats.) And Redroot pigweed (*Amaranthus retroflexus* L.) in Ontario

Gabrielle M. Ferguson[1], Dr. Allan Hamill[2], Dr. François Tardif[1]
[1] University of Guelph, Guelph Ontario
[2] Agriculture and Agri-food Canada, Harrow Research Centre, Harrow, Ontario.

Abstract

Growth room experiments where conducted from 1997 to 1999 to determine the absence or presence of imazethapyr, flumetsulam and thifensulfuron-methyl resistance and to determine cross-resistance patterns between these herbicides applied to 37 populations of *Amaranthus powellii* and *Amaranthus retroflexus*. Preemergence soil applications of imazethapyr (100 g ai ha^{-1}) and flumetsulam (70 g ai ha^{-1}) showed resistance was present in 27 out of 37 collected seed samples. Nine seed samples are resistant to solely imazethapyr, 15 resistant to both imazethapyr and flumetsulam and one site resistant to flumetsulam only. Two samples may have been in the earliest stages of resistance evolution containing both resistant and susceptible plants. Dose response experiments using foliar applied imazethapyr (0.063 to 512 g ai ha^{-1}) and thifensulfuron-methyl (0.031 to 256 g ai ha^{-1}) confirmed ALS inhibitor resistance. Resistance factors for *A. powellii* populations ranged from 1 to >3200-fold the dose of imazethapyr and 0.2 to >1700-fold the dose of thifensulfuron-methyl needed to decrease the dry weight of the *A. powellii* susceptible control population 50 percent. Resistance factors for *A. retroflexus* populations ranged from 0.15 to 191-fold the dose of imazethapyr and 0.23 to >1600- fold the dose of thifensulfuron-methyl needed to decrease the dry weight of the *A. retroflexus* susceptible control population 50 percent.

Introduction

Imidazolinone, sulfonylurea, triazolopyrimidine sulfonanilide and pyrimidinyl thiobenzoate herbicides inhibit the enzyme acetolactate synthase (ALS) which is responsible for catalysing the first reaction in the biosynthesis of the branch-chained amino acids; valine, leucine and isoleucine (Boutsalis and Powles, 1995; DeFelice *et al*., 1974; Shaner and Singh, 1997). In 1992, estimated global sales of ALS inhibitors were more than $1.5 billion, or over 10% of the total herbicide market of $11.4 billion (Shaner and Singh, 1997). These herbicides where applied to 75% and 34% of the 1997 Canadian soybean and corn crop respectively (Criterion Research Corporation and Meritz research, 1997). The popularity of these herbicides is due to their high efficacy, low mammalian toxicity, relatively low application rates, environmental safety and extensive list of in-crop registrations (Saari et al., 1994).

In the fall of 1997 Ontario farmers reported failure of imazethapyr and other ALS inhibitors to control *Amaranthus retroflexus* and *Amaranthus powellii*. These herbicides were reported to have provided adequate control of these species in previous years.

The trend to reduced tillage in the production of soybeans in Ontario increased the prominence of pigweed in this area (Oryokot et al., 1997). This is because pigweed has little endosperm and must be near the surface (0.5 to 5 cm) to germinate and to emerge from soil (Weaver and McWilliams, 1980). Large populations of pigweed together with repetitive applications of ALS inhibitors caused intense selection pressure for ALS-inhibitor resistant biotypes of pigweed.

The objective of this study was to characterize the level of imazethapyr resistance in field sampled *A. retroflexus* and *A. powellii* populations found in Ontario, to determine the pattern of cross-resistance to thifensulfuron-methyl for sampled populations.

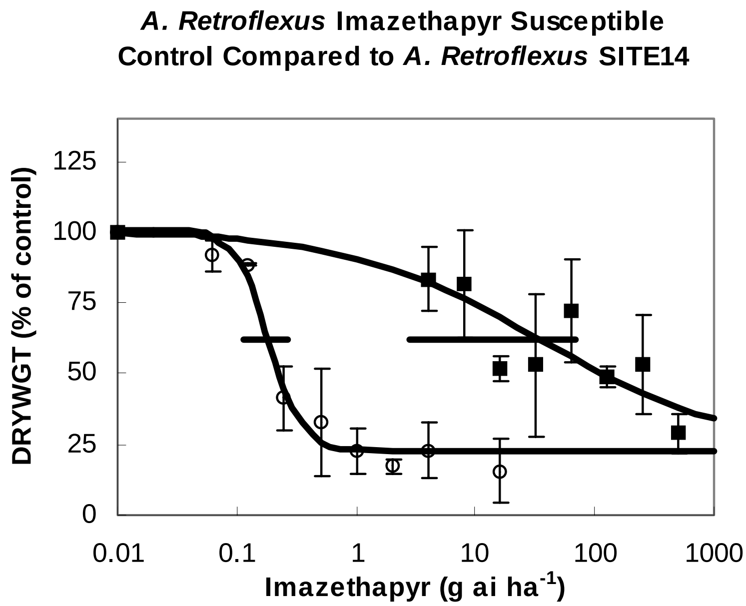
Conclusions

Whole plant dose response bioassay for imazethapyr and thifensulfuron methyl. Resistance to imazethapyr and thifensulfuron-methyl was confirmed (Figure 1). Resistance factors for *A. powellii* populations ranged from 1 to >3200-fold the dose of imazethapyr and 0.2 to >1700-fold the dose of thifensulfuron-methyl needed to decrease the dry weight of the *A. powellii* susceptible control population 50 percent (Table 1). Resistance factors for *A. retroflexus* populations ranged from 0.15 to 191-fold the dose of imazethapyr and 0.23 to >1600- fold the dose of thifensulfuron-methyl needed to decrease the dry weight of the *A. retroflexus* susceptible control population 50 percent (Table 1)

Table 1.Imazethapyr and thifensulfuron-methyl resistance factors and I50's for 20 *Amaranthus sp*. biotypes. Resistance factor (RF) = Dose that caused GR_{50} for a specific biotype/ Dose of herbicide that caused GR_{50} for the respective ALS-susceptible control. Missing data due to poor germination of some populations in the thifensulfuron-methyl experiments prevented accurate estimations of I50 or RF (-).

	I_{50} (g ai h^{-1})		Resistance factor	
SAMPLE	**Ima**	**Thi**	**Ima**	**Thi**
Amaranthus powellii				
Brigden 39	270	3.7	3293	84
Brigden 29	83.5	48.2	1018	1095
Brigden 33	70.7	-	861	-
Brigden 30	64.1	75	782	1703
Huron 9	54.2	0.1	660	2
Brigden 36	45.1	-	550	-
Perth 4	18.6	0.01	230	0.2
Iona 20	13.5	0.09	165	2
Elgin 24	0.31	0.04	3	0.84
Huron 12	0.27	0.05	3	1
Susceptible control	0.081	0.04	1	1
Amaranthus retroflexus				
Parkhill 14	36.1	8.5	191	196
Woodstock 46	13.7	0.7	72	15
Elgin 27	11.3	0.1	60	2
Caledonia 43	8.9	-	47	-
Parkhill 15	5.4	69.8	2	1622
Mosa 17	0.19	-	1	-
Suceptible Control	0.19	0.4	1	1
Mosa 16	0.082	0.01	0.43	0.23
Lobo 13	0.28	0.5	0.15	12

a)



b)

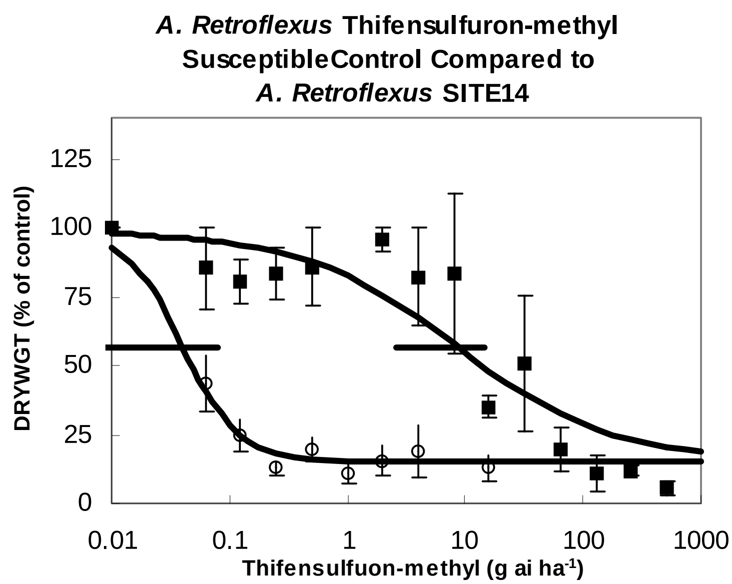


Figure 1. Dry weight of SITE 14(■) *A. retroflexus* plants after treatment with imazethapyr (a) or thifensulfuron-methyl (b) compared to the *A. retroflexus* susceptible control (○). Dose response curves were generated by calculating values for the log-logistic formula y=22.65 + (((100.88 – 22.65) / ((1 + (x / 36.08)$^{0..53}$)) for SITE 14 treated with imazethapyr, y=15.35 + (((98.47 – 15.35) / ((1 + (x / 8.47)$^{0.67}$)) for SITE 14 treated with thifensulfuron-methyl, y=22.65 + (((100.88 – 22.65) / ((1 + (x /0.082)$^{1.79}$)) for the control in imazethapyr analysis and. y=15.35 + (((98.47 – 15.35) / ((1 + (x /0.044)$^{1.05}$)) for the control in thifensulfuron-methyl analysis.

Literature cited

Boutsalis, P.;and S. B. Powles. 1995. Resistance of dicot weeds to acetolactate synthase (ALS)-inhibiting herbicides in Australia. **Weed Research *35*:149-155**.

Criterion Research Corporation and Maritz Marketing Research Incorporated. Canadian Farmers' Herbicide Use Study 1997.

DeFelice, M.; J. Guardiola; B. Esposito, and M. Iaccarino. 1974. Structural genes for a newly recognized acetolactate synthase in *Echerichia coli* K-12. **Journal of Bacteriology 120:1068-1077**.

Oryokot, J. O. E.; S. D. Murphy, and C. J. Swanton. 1997. Effect of tillage and corn on pigweed (A*maranthus* spp.) seedling emergence and density. **Weed Sci. *45:*120-126**.

Saari, L. L.; J. C. Cotterman, and D. C. Thill.1994. Resistance to acetolactate synthase inhibiting herbicides. Pages 141-170 *in* S. B. Powles and J. A. M. Holtum eds. Herbicide Resistance in Plants, Biology and Biochemistry. CRC Press Inc.: Boca Raton, Florida.

Shaner, D. L.; and B. K. Singh. Acetohydroxyacid Synthase Inhibitors. Pages 69-110 *in* R. M. Roes et al..eds. Herbicide Activity: Toxicology, Biochemistry and Molecular biology. IOS Press: New Jersey.

Revisiting Mechanical Weed Control

E. N. Johnson[1], F.A. Holm[2], and K.J. Kirkland[3]
[1]Saskatchewan Agriculture & Food, AAFC and University of Saskatchewan, Scott, Sk. [2] University of Saskatchewan, Saskatoon, Sk. and [3] Agriculture and Agri-Food Canada, Scott, Sk.

Introduction

The use of mechanical weed control practices has declined over the past half-century due to the success of chemical weed control (Edwards and Regnier, 1989). In addition, the deleterious effects of tillage on soil quality have been well-documented (Campbell *et al.*, 1990). However, some European countries and the United States are trying to reduce agriculture's reliance on pesticides. (Matteson, 1996; Economic Research Service USDA, 1997). Mechanical weed control may be an important component of pesticide reduction.

The Canada-Saskatchewan Agri-Food Innovation Fund (AFIF) Special Crop Program was established in Saskatchewan in 1995. The program identified organic crop production as a priority area with the objective to develop weed control technology for the industry. In 1997, funding was provided to initiate mechanical weed control studies at the Scott and Melfort Research Farms. Numerous studies have been undertaken, however this paper focuses on two objectives:

· to determine the effect of harrow type and aggressiveness on selectivity of weed control in post-emergent harrowed pulse crops.;
· to determine the impact of inter-row cultivation on weed interference and field pea yield.

Materials and Methods

Four field experiments were conducted at the Scott Research Farm, Scott, Sk in 1998 and 1999:
1) Selective post-emergent weed control of a rotary harrow vs. tine harrow in field pea.
2) Selective post-emergent weed control of a spring-tooth weeder vs. tine harrow in pulse crops (done at Scott and Saskatoon, 1999).
3) Inter-row cultivation in field pea;
4) Mechanical weed control in short- and long-vined cultivars of field pea.

<u>Experiment 1</u>: Treatments consist of a single and double pass of rotary or tine harrow set at a low and high level of aggressiveness. The treatments were performed when field pea (*cv.* Grande) was in the 4 to 5 node growth stage. Treatment design is a 2 x 2 x 2 factorial with factors being harrow type, aggressiveness, and number of passes (single vs. double). Experimental design is a randomized

complete block with four replicates. Check treatments include a weedy control and a herbicide treatment of imazethapyr/imazamox at 30 g ai/ha.

Experiment 2: A tine harrow is compared with a spring-tooth weeder set at a low, moderate, and high level of aggressiveness. Treatment design is a 4 x 4 factorial with factors being harrow and number of passes (single, double, three, four). Experimental design is a randomized complete block. Two experiments were conducted in 1999, one in field pea on a loam soil at Scott and the other in lentil on a clay soil at Saskatoon. The spring-tooth weeder has been evaluated as a blind harrowing treatment in winter wheat (Welsh *et al.*, 1996), onions and sugar-beets (Ascard and Bellinder, 1996).

Experiment 3: Inter-row cultivations were performed on field pea (*cv.* Radley) seeded in 34-cm rows. Cultivation treatments are single cultvation at the 6-7 node stage; single cultivation at the 8-10 node stage; two cultivations (6-7 node and 8-10 node); and three cultivations (6-7, 8-10, and 11-12 node stage). Check treatments consist of an untreated seeded in 33-cm rows, an untreated seeded in 22-cm rows, and herbicide (22-cm rows). The herbicide check is a sequential treatment of sethoxydim and metribuzin.

Experiment 4: Mechanical weed control is compared in a short-vined (*cv.* CDC Peko) and a long-vined (*cv.* Grande) pea cultivar. Experimental design is a split-plot with cultivar being main plot and weed management as the sub-plot. Weed management treatments include herbicide, post-emergent harrow, post-emergent harrow and inter-row cultivatation in a single-row seeding configuration, and post-emergent harrow and inter-row cultivation in a paired-row configuration. The herbicide treatment is imazethapyr/imazamox at 30 g ai/ha.

The predominate weed species in all of the experiments were wild mustard (*Brassica kaber* (DC.) L. C. Wheeler) and wild oat (*Avena fatua* L.). Wild mustard and wild oat were seeded perpendicular to the crop rows prior to seeding the crop. Data collection for all four experiments included crop density, crop fresh weight, grassy and broadleaf weed density, grassy and broadleaf fresh weight, and crop yield.

Results

Experiment 1

In 1998, broadleaf weed density was lower in the tine harrow treatments, relative to the rotary harrow. There was no difference in crop density, crop fresh weight, broadleaf weed fresh weight, grass weed density, or grass weed fresh weight between the harrow types. Two passes significantly reduced broadleaf weed density relative to a single pass. Harrowing had no effect on grass weed density, grass weed fresh weight or crop yield. Herbicide application increased pea yield by 22% over the untreated check.

In 1999, harrow treatments significantly reduced crop density, broadleaf weed density, and grain yield, but had no effect on broadleaf weed fresh weight, grass weed density, and grass weed fresh weight. Similar to 1998, the tine harrow treatments had lower broadleaf weed densities than the rotary harrow treatments. However, the tine treatments had higher grass weed fresh weight than the rotary treatments. Reduction in crop density and removal of wild mustard competition by the tine implement may account for the increase in grass fresh weight. Although there was a difference in the ratio of broadleaf/grass weed interference, there was no difference in crop yield response between the two harrow types. Post-emergent harrowing and the herbicide treatment increased pea yields by 17% and 109%, respectively.

Experiment 2

Results on field pea at Scott showed a linear increase in yields as the number of harrow passes increased. There was no harrow type X number of passes interaction. Harrow and herbicide treatments increased pea yield by 44% and 109% over the untreated check, respectively. The low aggressive setting on the spring-tooth weeder resulted in higher broadleaf weed density, grass weed density, and grass weed fresh weight than the other harrow treatments. However, the differences between the low setting and the other harrow type/setting combinations declined as the number of passes increased.

At Saskatoon, there was a quadratic yield response to the number of passes. Lentil yield peaked at 3 passes then dropped dramatically with the fourth pass. This may be due to a lower tolerance of lentil to post-emergent harrowing than field pea. Unpublished studies by Johnson and Kirkland (1998) suggest that lentil is not as tolerant to post-emergent harrowing as field pea. There was no harrow type X pass interaction for crop yield. Yield increases from the best harrow treatment and the herbicide treatment was 272 and 518 kg/ha, respectively. Wet conditions at Saskatoon were detrimental to lentil yields in 1999.

Experiment 3

In 1998, a single inter-row cultivation reduced grass weed density and grass weed fresh weight, with sequential cultivations having no further effect. Inter-row cultivation reduced broadleaf weed density but had no significant effect on broadleaf fresh weight. There was a linear increase in crop yield from zero to three inter-row cultivations even though there was no significant improvement in weed control from repeated cultivations. Gonsolus (1990) reported that non-weed control benefits to inter-row cultivation have been reported in corn and soybean. The highest yielding inter-row cultivation treatment and the herbicide treatment increased pea yields by 34% and 57%, respectively.

In 1999, broadleaf weeds were dominant. There was a linear decline in broadleaf weed density from inter-row cultivation. Inter-row cultivation had no effect on grass weed density or fresh weight, likely due to the low numbers of grass weeds present (13 plants/m^2 in untreated check). Yield response trends to inter-row cultivation were similar to 1998. The highest yielding cultivation treatment and the herbicide treatment increased pea yields by 78% and 196%, respectively.

The difference in yield between the herbicide and cultivation treatments is due to significant in-row weed growth in the inter-row cultivation treatments.

Experiment 4

The mechanical weed control X crop cultivar study had a significant cultivar X weed control interaction in 1998. Grande, the long-vined cultivar showed positive yields responses to mechanical weed control treatments while CDC Peko, the short-vined variety did not. Similar trends were observed in 1999, however results were not significant.

Conclusions

The harrow experiments indicate limited potential to improve selective post-emergent weed control with new harrow implements. Post-emergent harrowing tends to be most effective on small-seeded broadleaf weed species, and their removal may select for tolerant grass species.

Potential weed control benefits of inter-row cultivation are limited by significant in-row weed competition. Cultivar selection may be an important component of mechanical weed management. Post-emergent harrowing and inter-row cultivation have limitations as stand-alone weed management tools. Future studies should evaluate mechanical weed management practices in a long-term integrated system to gain an understanding of how these techniques could augment other cultural and chemical weed control practices.

References:

Ascard, J. and R.R. Bellinder. 1996. Mechanical in-row cultivation in row-crops. Proceedings of the Second International Weed Control Congress, Volume III, Copenhagen: 1121-1126.

Campbell, C.A., R.P. Zentner, H.H. Janzen , and K.E. Bowren. 1990. Crop rotation studies on the Canadian Prairies. Agric. Can. Publ. 1841. Ottawa, ON. 133 pp.

Economic Research Service, USDA. 1997. Towards a broader assessment of integrated pest management. Agricultural Outlook [Online]. Available: http://www.econ.ag.gov/ [1997, May].

Edwards, C.A, and E.E. Regnier. 1989. Designing integrated low-input farming systems to achieve effective weed control. Proceedings Brighton Crop Protection Conference – Weeds, 2: 585-589.

Gonsolus J.L. 1990. Mechanical and cultural weed control in corn and soybeans. Am. J. Alt. Agric. 5(1): 114-119.

Johnson E.N, and K.J. Kirkland. 1998. Organic Production Research. Agri-Food Innovation Fund Spoke Program. 1998 report. 25 pp.

Matteson P. 1996. Cutting Pesticide Use, Keeping Agriculture Strong -- Lessons from Northern Europe.

Global Pesticide Campaigner, Vol. 6 (1) [Online]. Available: http://www.panna.org/ [1996, March].

Welsh, J.P, H.A.J. Bulson, C.E. Stopes, R.J. Froud-Williams, and A.J. Murdoch. 1996. Weed control in winter wheat using a spring-tine weeder. Proceedings of the Second International Weed Control Congress, Volume III, Copenhagen: 1127-1132.

Poster abstracts

Weed Management in Solid-Seeded Dry Beans. R. E. Blackshaw. Agriculture and Agri-Food Research Centre, Lethbridge, AB.

Growers in western Canada are adopting upright cultivars of dry beans because they are less susceptible to white mould and they can be direct-cut at harvest. However, adequate weed control in this new production system remains a concern. Field studies were conducted over three years to determine the combined effects of cultivar growth habit, row spacing, plant density, and herbicides on weed management and dry bean yield. In the absence of weeds, upright and viny cultivars yielded similarity, a reduction in row spacing from 69 to 23 cm increased yield by 19%, and an increase in bean density from 20 to 50 plants m^{-2} increased yield by 17%. In the presence of weeds and when herbicides were used, narrow-row and high-density production practices resulted in better weed control over the entire growing season and higher dry bean yields were attained compared to a wide-row and low-density production system. In the absence of tillage, herbicide use in narrow-row dry beans did not necessarily increase. Herbicide combinations, often at reduced rates, controlled weeds as well or better than the full rate of any individual herbicide in solid-seeded dry beans. Ethalfluralin applied preplant incorporated followed by reduced rates of either postemergence imazethapyr or bentazon provided efficacious and economical weed control. Grower recommendations have been developed for weed management in solid-seeded dry beans.

Wild oat and wild mustard interference in canola. Rene C. Van Acker and R. Oree. Dept of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada.

Little information exists on the impact of wild mustard (*Brassica kaber* (D.C.) L.C. Wheeler) and wild oat (*Avena fatua* L.) Interference on canola (*Brassica campestris* L.) yield. Even less information exists on the level of weed seed return from these weeds if they are left uncontrolled, and how that may affect the level of competition in subsequent crops. A three year study was conducted at Carman, MB, in 1996, 1997 and 1998 to investigate the effect of various densities of wild mustard or wild oat on canola yield (cv. Legacy), and to measure the amount of viable weed seed return from the weed infestations. Weed seed return was measured in the spring of the year following the experiment by taking shallow soil samples from each plot and growing out the weed seeds within the samples. Maximum yield loss due to wild oat interference was 80% at a density of 4-500 plants/m^2. In all years it appeared that no more yield loss occurred at densities above 2-300 plants/m^2. Very low densities of wild oat were able to cause yield loss. 10 plants/m^2 for example, caused yield losses of 10 - 20%. Maximum yield loss due to wild mustard interference was 75% at a density of 4-500 plants/m^2. Low densities of wild mustard did not cause as great a yield loss as wild oat. Densities of 10 plants/m^2 only cause yield losses of 5 - 10%. Wild mustard gave a greater return of viable seed per plant than did wild oat. The viable seed return rate in year following an infestation was 5.2 and 2.6 seeds/seedling for wild mustard and wild oat, respectively. On a per plant basis wild oat was more competitive in canola than wild mustard. Wild mustard, however, returned more viable seeds to the soil on a per plant basis.

Wild mustard and wild oat were also grown in combination at various densities and proportions. Additivity of response was witnessed at low densities (10 and 50 plants/m^2, for wild oat and wild mustard, respectively). At higher densities (100 and 250 plants/m^2, for wild oat and wild mustard, respectively) this additive response disappeared.

These results will impact upon weed dynamics models.

Differential Competitive Ability of Tame Oat Genotypes with Wild Oat. S.J. Shirtliffe and B. Rossnagel. 51 Campus Drive, Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK.

As there are no herbicides to selectively remove wild oat from tame oat, yield and quality losses occur whenever wild oat is present. However, the competitive ability of tame oat genotypes with wild oat has not been assessed in any published studies. To determine if there are differences in the competitive ability of oat, genotypes with divergent morphology were grown with different densities of wild oat and the crop yield loss and wild oat seed return was measured. High yielding semi-dwarf oat genotypes, conventional genotypes and forage oat genotypes were evaluated. Wild oat competition reduced yield in the semi-dwarf oat variety by the greatest amount. The yield of forage oat variety was affected the least by wild oat competition. Increasing the seeding density of the oats from 250 plant m^{-2} to 500 plants m^{-2} reduced the yield loss in all varieties.

Survey of Herbicide-Resistant Wild Oat (*Avena fatua* L.) in Two Townships in Saskatchewan. H.J. Beckie[1], A.G. Thomas[1] and F. C. Stevenson. [1] Agric. and Agri-Food Canada, Saskatoon, SK.

The objective of this survey was to determine the nature and occurrence of herbicide resistance in wild oat in 1997 in fields in a township randomly selected in the Grassland region and another in the Parkland region of Saskatchewan. Wild oat seed samples were collected from about 75% of fields (64 ha each) located in each township. Wild oat was tested for resistance to herbicides belonging to Group 1 (aryloxyphenoxy propionates and cyclohexanediones), Group 2 (imidazolinones), and Group 8 (thiocarbamates). The survey found that over one-half of fields in both townships had populations resistant to herbicides from Group 1, 2, and/or 8.
Forty-three percent of fields in the Grassland township and 48% of fields in the Parkland township had Group 1-resistant (R) wild oat; 30% of fields in the Grassland township and 17% of fields in the Parkland township had Group 2-R wild oat, and about 15% of fields in both townships had Group 8-R wild oat. Single (Groups 1, 2, or 8) and multiple-group resistance (1,2; 1,8; 2,8; 1,2,8) was exhibited in populations in fields in both townships. Overall, the resistance pattern was similar among townships, except that fields with Group 2 or Groups 1,2 resistance were more prevalent in the Grassland township. In both townships, farmers with more land tended to have a greater proportion of that land infested with Group 1 and Group 2-R wild oat. The results of this survey indicate that the nature of resistance in wild oat populations in Saskatchewan is more diverse, differences in distribution and abundance of R wild oat biotypes between Grassland and Parkland ecoregions generally less apparent, and occurrence of resistance more prevalent than previously documented.

Residual Weed Populations Associated with Canola Management Practices. A. Gordon Thomas and Julia Y. Leeson. Agriculture and Agri-Food Canada, Saskatoon Research Centre, 107 Science Place, Saskatoon, Saskatchewan, Canada, S7N 0X2

The widespread adoption of herbicide tolerant canola may be expected to change both management practices and weed communities associated with this crop. Information from provincial weed surveys is used to establish a baseline describing weed communities and management practices associated with non-herbicide tolerant canola. Management practices investigated include various aspects of herbicide use, cropping history, fertility management, seeding and tillage. Partial Redundancy Analysis (RDA) is used to associate management practices and location with weeds. 34 % of the explained variance in the weed community was attributable to location alone (meridian and ecoregion), 20 % was attributable to the interaction of location and management, and 46 % was attributable to management alone. Management was significantly associated with weeds after the interaction with location was removed. The interaction of cropping history, fertility management and herbicide use had the largest influence on the weed community, separating the fields along the first axis. Tillage was not correlated with either of the first two axes. The majority of the species were associated with continuous diverse cropping histories (e.g. hemp-nettle, Canada thistle, quack grass). The lowest total weed densities were associated with high fallow frequency. Stinkweed had the highest relative abundance but was not strongly associated with any management practice.

The effect of an application of pre-harvest glyphosate on canada thistle in seed alfalfa fields C.D. Myhre[1], W.E. May[2] and H.A. Loeppky[3]. [1]Agriculture and Agri-Food Canada, Melfort Research Farm, Box 1240, Melfort, SK, S0E 1A0. [2]Agriculture and Agri-Food Canada, Indian Head Research Farm, Box 760, Indian Head, SK, S0G 2K0 [3]Lacombe Research Centre, 6000 C&E Trail, Lacombe, AB, T4L 1W1.

Pre-harvest glyphosate is an effective means of controlling Canada thistle in annual crops. Our objectives were to determine if pre-harvest glyphosate will control Canada thistle in seed alfalfa and will seed alfalfa tolerate pre-harvest glyphosate. Five field experiments were conducted in northeast Saskatchewan between 1995 and 1997. Pre-harvest glyphosate was applied at 60-70% brown pods except at Arborfield where pre-harvest glyphosate was applied at 90%. Seed quality (germination, hard seed, abnormal seedlings and dead seed) of the seed harvested following an application of pre-harvest glyphosate was determined at an accredited lab. Seedling vigour was determined by planting the seed in the growth cabinets to measure seedling emergence. Visual ratings of alfalfa regrowth and Canada thistle control, Canada thistle density and alfalfa seed yield were taken in the year following an application of pre-harvest glyphosate. Seed quality was affected in one of five site years. In 1996, abnormal seedlings increased in a linear fashion as the rate of pre-harvest glyphosate increased at Tisdale #1. Seedling vigour was not affected by the rate of pre-harvest glyphosate. Canada thistle control (visual ratings) increased sharply from 0 to 220 g.a.i. ha^{-1} and then leveled off as the rate of pre-harvest glyphosate increased at all sites. Canada thistle density decreased significantly in 2 of 4 site years with increased rates of pre-harvest glyphosate. Alfalfa regrowth and seed yields in the year following an application of pre-harvest glyphosate was reduced. Using pre-harvest glyphosate at rates higher than 220 g.a.i. ha^{-1} in seed alfalfa is not recommended due to an unexeptable reduction in alfalfa regrowth and seed yield in the following year. However, there is potential for using higher rates of pre-harvest glyphosate in the final year of seed production to facilitate alfalfa removal if seed quality is not reduced. More field trials are needed to determine if pre-harvest glyphosate reduces alfalfa seed quality.

Barley silage reduces wild oat (Avena fatua) populations. K.N. Harker[1] and K.J. Kirkland[2]. [1] Agric. & Agri-Food Canada, Lacombe, AB; [2] Agric. & Agri-Food Canada, Scott, SK.

Field experiments were conducted from 1996 to 1999 at Lacombe, Alberta and Melfort, Saskatchewan to determine if wild oat populations could be effectively managed in two barley silage cutting regimes. Early-cut (heads fully emerged) and normal-cut (soft dough) barley silage with and without wild oat herbicides were compared to barley grain production with and without wild oat herbicides. No differences in spring wild oat emergence were detected in the 1997 after the 1996 treatments. However, after two years of the treatments, wild oat emergence in the spring of 1998 was lower in the early-cut plots than plots that were cut at the normal timing, and even lower than some barley grain plots which included 1/2 rates of imazamethabenz (200 g ha-1) or tralkoxydim (100 g ha-1). Adding wild oat herbicides at 1/2 rates to the early-cut silage treatment did not reduce spring wild oat emergence. However, adding wild oat herbicides at 1/2 rates to the normal-cut silage treatment did reduce spring wild oat emergence in some cases. After, three years of treatments, spring wild oat emergence in 1999 was similar to 1998. Early-cut barley silage has less dry matter yield than normal-cut silage, but could be effectively used to manage wild oat populations whether they are susceptible or resistant to herbicides.

Integrated control of ox-eye daisy (*Chrysanthemum leucanthemum* L.) in pasture and hay land. D.E. Cole[1], J.R. King[2] and F. Young[3]. [1] Alberta Agriculture, Food and Rural Development, Edmonton; [2] Agricultural, Food and Nutritional Science, University of Alberta, Edmonton; [3] Alberta Agriculture, Food and Rural Development, Evansburg.

Ox-eye daisy is an increasing problem in pastures and hay land in west-central Alberta. Infestations are particularly heavy in overgrazed pastures, on low fertility soil. Ox-eye daisy is unpalatable to cattle who thus selectively graze around the weed, reducing forage competition. This non-native perennial plant is difficult and costly to control and it is especially difficult to selectively control with herbicides without removing legumes. Tests were conducted to develop practical, cost-effective means of controlling ox-eye daisy for higher yields of better quality forage and longer maintained stands. Reduced light levels and fertilizer treatments in the greenhouse as well as herbicide and fertilizer and fertilizer alone treatments in the field were included. When artificially shaded, ox-eye daisy biomass decreased linearly with decreasing light intensity. An 85% reduction in light intensity reduced ox-eye daisy rosette biomass by 70%

and seedling biomass by 92%. Under low light conditions the ox-eye daisy plants were unable to respond to increased levels of fertilizer. Two years of spring surface applied fertilizer (NPKS to soil test recommendation) increased forage yield and significantly reduced ox-eye daisy from 100 flowering shoots m^2 to 0 flowering shoots m^2 in fenced-off pasture. Metsulfuron methyl 18 g a.i./ha provided excellent control of ox-eye daisy in the year of application when applied in May to ox-eye daisy that was under 10 cm in height. This herbicide, however, also removed the legume growth reducing competition. Spring applied fertilizer increased grass growth and thus competition to maintain reduced ox-eye daisy numbers into the year following herbicide application.

Warning! Chances of heavy barnyardgrass (*Echinochloa crus-galli*) seed production in corn-soybean rotations using chisel plow tillage and mechanical weed control. F. Perron and A. Légère. Agriculture and Agri-Food Canada, Sainte-Foy, QC.

Seed production of residual weed populations need to be taken into account when evaluating the potential of sustainable agricultural practices. The objective of this experiment was to determine the effects and interactions of crop, weed control, tillage and nutrient source on barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) seed production in a corn-soybean rotation on a Sainte-Rosalie clay. Seed production was estimated from five plants randomly chosen in each experimental unit. Nutrient source did not affect barnyardgrass density and seed production. Herbicide applications were more effective than mechanical weed control in reducing barnyardgrass seed production Mechanical weed control resulted in increased barnyardgrass density, biomass, and seed production per unit area. In 1997, barnyardgrass seed production in corn averaged 326 569 seeds per m^{-2} with mechanical weed control compared with 477 seeds per m^{-2} with chemical weed control. Seed production in soybean under mechanical weed control averaged 250 453 seeds per m^{-2}. There was no or only a few seeds produced in soybean under chemical weed control. Greater seed production was found in soybean with chisel plow tillage under mechanical weed control. Barnyardgrass seed production under these treatments averaged 496 637 seeds per m^{-2}. The thicker crop residue cover found in soybean plots with chisel plow tillage, compared with that in corn, could have been beneficial to barnyardgrass development but also probably hindered mechanical weed control operations. A tillage system combining more intense tillage after corn and less intense tillage after soybean could probably optimize the management of the crop residue cover and consequently, improve the efficacy of mechanical weed control by reducing weed populations and seed return to the seedbank in a corn-soybean rotation.

Persistence of Volunteer Wheat and Canola using Weed Survey Data. A. Gordon Thomas and Julia Y. Leeson. Agriculture and Agri-Food Canada, Saskatoon Research Centre, 107 Science Place, Saskatoon, Saskatchewan, Canada, S7N 0X2

The recent introduction of herbicide tolerant canola and pending introduction of herbicide tolerant wheat have generated interest in the ecology of volunteer crops as weeds, particularly their persistence in the seed bank. In this study, data from the most recent provincial weed surveys are used to determine the persistence of non-herbicide tolerant canola and wheat (durum and spring wheat). The cropping history for the previous five years in each field is known from management questionnaires. Fields were selected such that the surveyed and intervening crops did not include the crop of interest. Fields with canola planted five years previously were not included because of inadequate sample size. Just over 30 % of fields surveyed had volunteers of the previous wheat or canola crop. With one intervening crop the frequency of fields with volunteer wheat and canola dropped significantly. While the frequencies tended to decline further in subsequent years, the decline was not significant. Up to five years after planting wheat, volunteer wheat was still present in 9 % of the fields. Four years after planting canola, volunteers were present in 6 % of fields. Volunteer wheat densities declined more rapidly than frequencies, from approximately 8 per m^2 the year following the wheat crop, to less than 2 per m^2 in the next two years and down to less than 1 per m^2 four years after the wheat crop. The density of volunteer canola was also down to less than 1 per m^2 four years after the canola crop; however, the decline was not as rapid as observed in volunteer wheat. The persistence of non-herbicide tolerant crop volunteers points to potential problems with herbicide tolerant volunteers. Producers should be aware that volunteers might be present at least five years after the crop. Persistence beyond five years could not be determined from the survey data. Herbicide tolerant volunteers must be managed to reduce the risk of contamination of conventional crops and crossing with future herbicide tolerant crops and weedy relatives.

The effect of an application of pre-harvest glyphosate on seed alfalfa. W. E. May[1], C. D. Myhre[2] and H.A. Loeppky[3]. [1] Agriculture and Agri-Food Canada, Indian Head Research Farm, Box 760, Indian Head, SK, S0G 2K0; [2] Agriculture and Agri-Food Canada, Melfort Research Farm, Box 1240, Melfort, SK, S0E 1A0; [3] Lacombe Research Centre, 6000 C&E Trail, Lacombe, AB, T4L 1W1

Canada thistle (*Cirsium arvense)* is increasing in both frequency and density in alfalfa (*Medicago sativa* L.) seed fields in Saskatchewan. No herbicides are currently registered for the control of Canada thistle in established alfalfa seed fields. A pre-harvest application of glyphosate is effective in controlling Canada thistle, however, this application has reduced seed quality in annual crops. The objective of these experiments is to determine the effect a pre-harvest application of glyphosate has on seed quality, seedling vigour, alfalfa regrowth and alfalfa seed yield. The rate of glyphosate applied did not affect seed yield but had large effects on regrowth and seed yield in the following year. Delaying the application of glyphosate during grain filling increased seed yields in the year of application and decreased regrowth the following year. The

response of abnormal seedlings to both rate and timing of application was not consistent. Seedling emergence was not affected by the rate or timing of the glyphosate. Applying pre-harvest glyphosate at rates at or below 880 g.a.i. ha^{-1} and at 76% brown pod did not reduce alfalfa seed quality. Using rates higher than 880 g.a.i. ha^{-1} before 76% pod turn is not recommended due to the potential of increasing abnormal seedlings. More field trials are needed to determine if pre-harvest glyphosate reduces alfalfa seed quality at seed maturity greater than or equal to 76% brown pod.

Airborne Spray Drift with Venturi-Type Nozzles. Brian Storozynsky and Glen Traynor. Alberta Farm Machinery Research Centre, 3000 College Drive, Lethbridge, Alberta, T1K 1L6

Because spray drift characteristics from conventional nozzles are similar among different nozzle manufacturers, past spray drift studies typically used nozzle types from only one nozzle manufacturer. Preliminary test data and visual assessments from producers have shown variations in spray drift characteristics from venturi-type nozzles from different manufacturers. To determine the spray drift characteristics from such nozzles, wind tunnel studies were conducted. The effect of nozzle manufacturer, nozzle size and nozzle pressure were studied. Spray drift was quantified by counting and measuring airborne spray droplets four metres downwind from two nozzles using a laser particle analyser. To facilitate comparisons, airborne droplet data was normalized to factor out differences in nozzle flow. Spray drift from venturi nozzles was compared with Turbo TeeJet (TT) nozzles to indicate reductions in drift. As expected, spray drift from TT nozzles increased as spray pressure increased or nozzle size was reduced. Spray drift from venturi nozzles varied among the nozzle manufacturers, was not affected by nozzle size and increased slightly with nozzle pressure. The venturi's designed pressure range showed a significant effect. Venturi nozzles designed to operate between 100 and 700 kPa reduced spray drift by 35 to 60 percent. Venturi nozzles designed to operate between 275 and 700 kPa reduced spray drift by 60 to 90 percent. Based on the study, venturi nozzles were classified into two categories. Those such as Air Bubble Jet, TurboDrop XL and Ultra Lo-Drift, designed to operate below 275 kPa, were categorised as low pressure venturi's. Nozzles such as TurboDrop, Ultra and AI TeeJet, designed to operate above 275 kPa, were categorised as high pressure venturi's. Effects of nozzle size and pressure on drift were similar among venturi nozzles in the same category. This means producers using venturi nozzles have a wider selection of spraying pressures and application rates without significant increases in spray drift.

Detection of herbicidal and antifungal activity of secondary metabolites produced by a *Phoma* sp. isolated from false cleavers (*Galium spurium*). Wenming Zhang[1] and Karen L. Bailey[2]. [1] Alberta Research Council, Vegreville, AB, Canada; [2] Agriculture and Agri-Food Canada, Saskatoon, SK, Canada.

A biological control program against cleavers (*Galium spurium* and *G. aparine*) has recently been initiated. Several fungal isolates killed cleavers in controlled environmental conditions. Among these fungal isolates, CL98-131 produced metabolites that showed herbicidal activity. The fungus was cultured in modified Richard's solution. Cell-free culture filtrates at concentration of 25% completely inhibited cleavers germination or killed germinated cleavers seedlings. The metabolites demonstrated selectivity between cleavers and canola because seed germination or seedling growth of canola was not affected by the cell-free culture filtrates. Saprophytic fungal growth was always observed on plain medium control but not on culture filtrates treatment. This led to the study on antifungal activity of the metabolites. Cell-free culture filtrates at concentrations ranging from 12.5% to 50% significantly inhibited the growth of *Leptosphaeria maculans*, *Sclerotinia sclerotiorum*, *Rhizoctonia solani*, and *Ascochyta pisi*. Preliminary isolation indicated that the active compound was present in aqueous fraction.

Weed Control in Herbicide Tolerant Canola With Low-Drift Nozzles. Thomas M. Wolf*, Brian C. Caldwell, Guy Lafond, and Eric Johnson. Agriculture and Agri-Food Canada, Saskatoon, SK.

Coarser sprays are a proven means of reducing herbicide spray drift. To verify the biological performance of these nozzles, efficacy and retention studies were conducted at Saskatoon, SK. Glyphosate and glufosinate-ammonium sprays were applied to simulated weeds in 100 L/ha using five different application methods: (a) a conventional spray (TeeJet XR8002), (b) a drift-reducing adjuvant spray, (c) low drift nozzle #1 (Turbo TeeJet TT11002), (d) low drift nozzle #2 (TurboDrop TD110015 ‘venturi’ nozzle), and (e) a twin fluid nozzle (AirJet). In additional experiments, eight different ‘venturi’ tips were compared to a standard flat fan nozzle. ‘Venturi’ tips with an 015 flow rate were operated at approximately 415 kPa, whereas a flat fan nozzle with an 02 flow rate was operated at 240 kPa. Overall, glyphosate efficacy was similar on broadleaf and grass species for all nozzles. Glufosinate-ammonium performance was not affected by nozzles for broadleaf species, but some reductions occurred on grass species, particularly with the coarsest sprays. Increasing spray pressure ameliorated the reductions in glufosinate-ammonium efficacy for some, but not all, nozzles. Efficacy was not always related to spray retention *per se*, but also depended on deposit uniformity. According to these data, it appears that most low-drift or venturi tips are suitable for use with glyphosate. Coarser sprays may cause efficacy reductions with glufosinate-ammonium on grassy weeds, particularly if applied at low pressures.

Crop seeding rate effect on crop competitiveness and the rate of herbicide required for satisfactory weed control in wheat, barley and lentil. Kenneth J. Kirkland[1], Frederick A. Holm[2] and F. Craig. Stevenson[3]. [1] Agriculture and Agri-Food Canada, Scott, SK; [2] University of Saskatchewan, Saskatoon, SK; [3] Saskatoon, SK.

A study was conducted at three locations in Saskatchewan in 1996 and 1997 to determine if a higher-than- recommended seeding rate will maintain crop productivity as herbicide rates are reduced. The experiment included four grassy and broadleaf weed herbicide rates (check and

1/2, 3/4, and full label rate), two crop seeding rates (recommended and 1.5 times recommended), and three crops (barley, wheat, and lentil). Crop grain yield and net return generally were lower, and broadleaf and grassy weed fresh wt. were higher, when herbicides were not applied at Saskatoon, but not at the other locations. There was no indication that a higher-than-recommended seeding rate maintained weed control and/or crop productivity when herbicide use was reduced. Wheat grain yield was 16% lower at Scott and Melfort, and lentil grain yield and net return were 66% lower at Saskatoon, when herbicide rate was reduced from the full and 3/4 label rate to the 1/2 label rate. Higher weed fresh wt. with the 1/2 label rate compared with higher herbicide rates often occurred at Scott, but not at the other locations. Yield advantages from 14 to 39% in four instances, and an 8% yield reduction in one instance, were observed with a higher-than-recommended seeding rate only in 1996. Positive yield responses to a higher seeding rate corresponded with lower weed fresh wt. only for barley at Saskatoon. Otherwise, seeding rate effects on weeds corresponded with no response or a similar response for weed fresh weight. At two of three locations net return for lentil was greater for the higher-than-recommended seeding rate, a reflection of the higher commodity price for lentil. Otherwise, the influence of seeding rate on net return generally was similar to that on grain yield. A higher-than-recommended seeding rate in certain situations may be an effective integrated weed management tool on its own, but not as a tool to supplement weed control when herbicide rates are reduced.

Warning! Chances of heavy lambsquarters (*Chenopodium album*) seed production in corn-soybean rotations using mechanical weed control. F. Perron and A. Légère. Agriculture and Agri-Food Canada, Sainte-Foy, QC.

Sustainable agricultural practices that allow weeds from residual populations to set seed could compromise future crops by replenishing the seedbank. The objective of this experiment was to measure the effects and interactions of crop, weed control, tillage and nutrient source on the seed production of common lambsquarter (*Chenopodium album* L.) in a corn-soybean rotation on a Duravin loam. Seed production was estimated from five plants randomly chosen in each experimental unit. Common lambsquarter seed production was greater under mechanical weed control compared with chemical weed control. Common lambsquarter seed production in soybean was correlated with mid-season biomass. Plants that survived rotary hoeing grew larger, produced more seeds and had greater seed to biomass ratio than plants under chemical weed control. In 1997, common lambsquarter seed production in soybean averaged 497 859 seeds per m^{-2} under mechanical weed control. There was no or only few seeds produced in soybean under chemical weed control. Greater common lambsquarter seed production in corn under mechanical weed control did not reflect mid-season biomass but was correlated with population density. Very dense common lambsquarter stands resulted in lower weed biomass per plant, likely due to intra- and interspecific competition. Average seed production in 1997 in corn was 766 495 seeds per m^{-2} under mechanical weed control compared with 73 625 seeds per m^{-2} under chemical weed control. Tillage intensity and nutrient source did not affect common lambsquarter seed production. The weed control treatments used in this experiment allowed heavy common lambsquarter seed production, suggesting that both programs would need to be modified in order to be more efficient. Herbicide banding combined to mechanical weed control may be a better weed management approach when dealing with large common lambsquarters populations.

Pollen flow between herbicide tolerant canola (Brassica napus) is the cause of multiple resistant canola volunteers. K.Topinka[1], L. M. Hall[1], J. Huffman[1], and A. Good[2]. [1] Alberta Agriculture, Food and Rural Development, Edmonton, Canada; [2] Univ. of Alberta, Edmonton, Canada.

In 1998, a field was investigated in which canola volunteers were not controlled by several applications of glyphosate. In 1997, the field had been planted with imidazolinone-tolerant and glufosinate-tolerant canola, but an adjacent field had contained glyphosate tolerant canola. Seeds from 35 volunteers were sprayed with glyphosate at 440 gai/ha and survivors sprayed with either glufosinate or imazethapyr at 400, 50 gai ha-1, respectively. Where seed number permitted (14 plants) seedlings were also sequentially sprayed with glyphosate, glufosinate and imazethapyr, at 440/400/50 gai ha-1. In total, 48% of the seedlings were resistant to glyphosate, with resistance diminishing with distance from the putative pollen source. Seedlings from all 9 plants collected from the glufosinate tolerant area showed multiple resistance to glyphosate and glufosinate while seedlings from ten of 11 plants collected from the imidazolinone tolerant area showed resistant to imazethapyr and glyphosate. Two seedlings were resistant to all three herbicides. DNA analysis of the seedlings indicated contributions from more than one resistant parent, clearly indicating that the multiple resistance had arisen from pollen transfer, rather than mutation. Evidence is consistent with resistant gene movement via pollen flow from one field to another. The presence of multiple resistant canola volunteers suggests altered management modifications for canola volunteers.

Study of yellow nutsedge (Cyperus esculentus L.) agroecology and development of an integrated management program for onions (Allium cepa L.) grown in muck soil. C. La Hovary[1], M.-J. Hotte[2], P. Smith[1], D. L. Benoit[2] et F. J. Tardif[1]. [1] Department of Plant Agriculture, University of Guelph, Guelph, Ontario, N1G 2W1; [2]Agric. and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC.

Yellow nutsedge (Cyperus esculentus L.) is a perennial weed that is a major impediment for economical onion production in muck soil. Control measures based solely on herbicides have proved to be of little effectiveness and are not sustainable in the long term. This project aims at developing an integrated management program based on critical knowledge of the life cycle and growth characteristics of yellow nutsedge in muck soil. Since the main mode of propagation of this weed is by the production of tubers which remain viable in the soil during 3 to 4 years, studies are conducted on different management operations to reduce tuber production and increase tuber winter kill.

Experiments were initiated in the spring of 1997 and repeated in 1998 in the Bradford Marsh area in Ontario and at sites near Agriculture and Agri-Food Canada's Horticultural Research and Development Center in St-Jean-sur-Richelieu, Quebec. The first experiment was set to determine the best timing for intervention in order to reduce the formation of new yellow nutsedge tubers; we measured the effect of delaying yellow nutsedge emergence or interrupting its growth on tuber numbers. Tuber counts were performed in the spring and in the fall. In 1997, delaying emergence for 15 and 45 days was necessary to reduce tuber production in Ontario and Quebec, respectively. In 1998, a 45 day delay of emergence was necessary to reduce tuber production in Ontario and Quebec. In 1997, interrupting growth at 15 and 30 days after emergence reduced tuber production in Ontario and Quebec, respectively. In 1998, interrupting growth at 15 days after emergence reduced tuber production at both sites. The second experiment consisted in measuring the effects of different fall soil preparation treatments on winter tuber mortality caused by frost or dessication. High variability at both sites didn't allow for any differentiation between treatments.

Committee Reports

Committee Report - Nominations and Elections

December 1, 1999

Board of Directors

Three positions were filled on the Board of Directors as part of the normal rotation of Officers and Directors. These positions are for a term of three years (December 1999 to December 2002). In addition, the position of Research Reports Director was filled for a term of two years to synchronize the election with the rotation of other positions as defined in the By-laws.

2nd Vice-Chair	Jerry Ivany (elected by acclamation)
Secretary	Kevin McCully (elected by ballot)
Extension Rep.	Roy Cranston (elected by ballot)
Research Reports Director	Linda Hall (elected by acclamation)
Local Arrangements 2000	Denise Maurice (*ex officio*)
Local Arrangements 2001	Danielle Bernier (*ex officio*)

Committees

The membership of three committees is defined by the by-laws:

- Finance
- Nominations and Elections
- Reports and Publications

The members on following committees are either elected at the annual meeting or appointed by the Board of Directors. An * after a member's name indicates the chair of the committee in 2000 and the date in parentheses indicates the year they will leave the committee.

<u>Membership</u>: Al Hamill* (2000)
Leslie Huffman (2001)
Bill McGregor (2002)

<u>Resolutions</u>: Linda Hall* (2000)
Don Hare (2001)
Al Hamill (2002)

<u>Scholarships and Awards</u>: François Tardif* (2000)
Bruce Murray (2001)
Luc Bourgeois (2001)
Carol Bubar (2002)
Danielle Bernier (2002)

Mahesh Upadhyaya (2003)

ECW/CEM Database Committee: John O'Sullivan*
Chris Hall
Bill Deen
Leslie Huffman
Ian MacDonald
Len Juras
Denise Maurice

Biology of Canadian Weeds: Paul Cavers*
Suzanne Warwick
David Clements

History and Archives: Bill Vanden Born*
Jack Alex

Report Submitted by Nominations and Elections Committee:
A. Gordon Thomas (Chair)
Diane Benoit (Eastern Member-at-Large)
Hugh Beckie (Western Member-at-Large)

Working Groups Reports

Working Group Report - Application Technology

Submitted by Tom Wolf

Agriculture and Agri-Food Canada, Saskatoon, SK

The Application Technology Working Group meeting was attended by approximately 50 people. The following items were discussed:

1) Review of 1999 Low Drift Nozzle Efficacy database

Results from the 1999 (second year) Low Drift Nozzle Initiative were reviewed.

- Fifteen organizations voluntarily participated, conducting 51 trials on 21 weed species with 21 herbicides, 2 insecticides, and 1 fungicide. Herbicides represented 9 mode of action groups (1, 2, 4, 5, 6, 8, 9, 10, and 16).
- At the time of the meeting, some data were not available for analysis, therefore only preliminary results were discussed.
- In each trial, 3 nozzles were compared: a standard flat fan (finest spray), a TurboTeeJet (intermediate spray), and a venturi-type (coarsest spray). The venturi nozzles were one of: Greenleaf TurboDrop, Air Bubble Jet, SprayMaster Ultra, and TeeJet Air Induction. To provide more challenging conditions, nozzles were compared at either 2 weed growth stages, 2 pressures, or 2 herbicide rates.
- Significant changes in efficacy were more likely to be the result of rate and staging changes than of nozzle or pressure choice. Nozzle choice had an impact on efficacy in 29% of cases, compared to 68% (rate), 100% (staging) and 25% (pressure).
- In all cases, higher rates, higher pressures, and earlier staging improved control when these variables were statistically significant.
- When nozzle choice had a statistically significant impact, low-drift nozzles most often performed less well than the standard. As last year, changes in weed control were typically in the order of 10 to 15%.
- Venturi nozzles typically performed worse on grassy weeds, regardless of mode of action. Grassy weed control was reduced with Group 1 products (15% of cases), Group 2 products (36% of cases), a Group 4 product (60% of cases), and a Group 10 product (20% of cases). In the remaining cases, nozzles had either no impact, or the low drift nozzles performed better.
- The comparatively poor performance of Group 2 and 4 products relative to last year reflects a shift to graminicide product tests within those groups this year.
- In summary, full recommended rates and higher pressures were able to retain good venturi nozzle performance in most cases. Reductions occurred when rates were reduced, pressures were low, or spraying was delayed to a later growth stage.

- Next year represents the last year of this initiative. Interested participants are to contact Tom Wolf for protocol and nozzle distribution.

2) Handling of Performance Complaints with New Nozzles

The majority of complaints involve Group 1 products. There is still no clear decision by chemical companies whether to label against low-drift nozzles in general or be product-specific.

3) Incorporation of New Technologies into Labels

The PMRA is committed to evaluating the database for use in amending product labels to accommodate low-drift nozzle technology where appropriate. The database may need to be strengthened for some products and weeds. There are currently no data requirements for labelling against an application method.

4) Sprayer Tank cleanout for Group 2 Products:

a) Some problems were observed in 1999 with persistent Group 2 residues in sprayer tanks. A review of product labels revealed a lack of consistency in cleanout procedures.

b) Since new Group 2 products continue to appear on the market, it was suggested that sprayer tank cleanout procedures be reviewed and standardized. Although product-specific cleanout may be necessary in some cases, too many procedures will be confusing in the marketplace.

c) Sprayer tank manufacturers have expressed interest in improving their product to prevent future problems.

d) ***Action Item:*** Chemical companies were contacted by Tom Wolf in January, 2000, to determine interest in pursuing a joint approach towards the improving of cleanout procedures. Responses are due mid-February.

5) Filling of Committee Vacancies

a) Committee vacancies left by Ralph Walker and Mike Crutchley need to be filled.

b) It was suggested that Ralph Brown (U of Guelph) and Helmut Spieser (OMAFRA, Ridgetown College) be approached to participate in the Working Group.

c) ***Action Item:*** Ralph Brown and Helmut Spieser have agreed to serve on the Committee. Other committee members are: Pat Bulman (Bayer, Saskatoon), Lyle Drew (Cyanamid, Regina), Brian Storozynsky (AFMRC, Lethbridge), and Tom Wolf (AAFC, Saskatoon).

6) CARC Research Priorities

a) Working Groups were asked to submit a research priority for the Canadian Agri-Foods Research Council (CARC). After some discussion, the following was submitted:

Develop and maintain infrastructure for the conduct of application technology research within Canada

b) Although this is not a research priority per se, the Group felt that it is a prerequisite for any work to be done in the future. The main driving forces for this priority are: the heightened need for reduction of environmental impact of pesticide use while maintaining adequate efficacy; the development of practical use restrictions of pesticides (in the context of buffer zones); and the need to develop unique application solutions that are responsive to regional concerns (i.e., where international solutions are either not appropriate or not relevant). The group felt that infrastructure support was tenuous, and in light of present needs should be enhanced. Currently, there are only five research programs in spray technology nationally:
- AAFC, Saint-Jean-sur-Richelieu (B. Panneton)
- U of Guelph (R. Brown)
- U of Guelph, Ridgetown (H. Spieser, vice-Crutchley)
- AAFC, Saskatoon (T. Wolf)
- AFMRC, Lethbridge (B. Storozynsky)

7) IPM in Buffer Zones

Due to time constraints, the issue of weed management in unsprayed buffer zones was not addressed.

Working Group Report - Biological Control

Submitted by: Karen L. Bailey
Agriculture and Agri-Food Canada, Saskatoon Research Centre

ECW Biocontrol Working Group Meeting 1999

At the Biocontrol Working Group meeting, a round table discussion informed the participants of current research and other activities proceeding in both classical and inundative biocontrol using insect and pathogens. Dr. Gary Peng (Agriculture and Agri-Food Canada, Saskatoon) was appointed to the Biocontrol Working Group Committee. The Chairperson will be selected from the members of the committee.

It was announced that the USDA Southern Regional Working Group on Biological Control S-268 will be held in early May, 2000 in Saskatoon. People interested in more information on this bioherbicide meeting should contact either Karen Bailey or Susan Boyetchko.

The topic selected for next years meeting was “The Environmental Impact of Biological Control” with regulatory, classical biocontrol, and inundative biocontrol perspectives.

Research Issues In Biological Control (all of equal importance)

◆ There is a lack of people with expertise to provide systematics and taxonomic services for biological control. This gap in identification services in increasing and occurs within the government, universities, and private industry. Accurate taxonomic identification provided within a reasonable time frame is essential for the successful introduction and application of biological control. The past few years, provincial advisory boards and government working groups have forwarded the concerns of dwindling expertise. Action needs to be taken on two levels: i) increase job opportunities in this area, and ii) increase training of people to provide this expertise.

◆ Biological control must develop strategies to effectively handle issues relating to host specificity, selection of host and non-host target plants for testing, and assessing the environmental impact of biological control agents on non-target plants. Currently , the action is proceeding through discussions of researchers and regulators at various meetings.

◆Basic knowledge on ecological systems and the impact of biological control is not being conducted at most universities or other research institutions. Funding agencies should be encouraged to support applications addressing this issue.

◆The commercialization of bioherbicides has proven to be a difficult step in the process of transferring research to the public. After the basic research has been completed for a bioherbicide, there is still a large component of research involved with the development and commercialization phase. The problem is recognized but need to have a flexible granting mechanism to assist in bridging the gap from completing basic research to completing developmental research.

◆ A strategic alliance should be developed to encourage interdisciplinary and multi-disciplinary studies, particularly for a systems approach using pathogens and insects. Currently, discussions are proceeding among researchers, but it is necessary to have funding agencies support proposals in these areas even though the collaborations may be across provincial boundaries.

Working Group Report - Herbicide Resistance

Submitted by: Luc Bourgeois, Bayer Canada
François Tardif, University of Guelph.

This year working group was well attended. The first item on the agenda was the composition of the executive. Luc Bourgeois expressed his desire to leave the working group. We attempted to find a replacement but were unsuccessful. It was suggested that Luc Bourgeois' replacement should come from the industry. This issue was left unresolved and we will attempt to recruit someone in the upcoming months.
François Tardif is current chair and Todd Andrews (Manitoba Agriculture) is co-chair.

We had five speakers whose talks are summarized as follows:

Todd Andrews, Manitoba Agriculture – Western Canada Summary

MB: Group 1 and Group 2 herbicide resistance risk map updated using data from 1997 and 1998. Maps showed slight decrease in Group 1 high risk townships and an increase in Group 2 high risk townships. However, these conclusions were drawn using the 1997 and 1998 data only. Several attendees suggested that herbicide resistance risk maps should include a minimum of 5 years of herbicide use history.
Dr. Andrews also worked on validation of Petri-dish resistance tests. He concluded that Petri-dish tests overestimated the level of resistance and that results were not meaningful to producers.

SK: A large survey of Group 2 resistance was conducted over 120 high risk fields. Seeds are screened and results are expected in the spring. In addition, Saskatchewan has shifted resources toward research of gene flow from herbicide tolerant canola to wild mustard as well as the study of multiple resistance in herbicide tolerant canola.

AB: A study was conducted on Muster resistant ball mustard. The study concluded that the resistance resulted from enhanced metabolism and that there was no cross-resistance to other Group 2 herbicides. Another new resistance study involved Group 4 resistant hemp-nettle. This weed has low level of resistance and was selected by repeated use of Dyvel. The mechanism of resistance is currently unknown. Finally, wild oat patch testing is on-going as part of extension services.

Hugh Martin, Ontario Ministry of Agriculture, Food and Rural Affairs – Eastern Canada Summary

Main resistance concern in the East is Group 5 (triazines) (since 74) and Group 2 (since 97). A Group 5 and Group 2 resistant population of green pigweed was confirmed in 1999. Extension focuses on rotation and tank mixes of herbicides, especially for areas with soybeans grown after soybean in the rotation. The awareness of resistance is generally high but producers tend to rely on herbicide tolerant crops to ward off resistance.

David Jones, PMRA - Labeling for Resistance Management

Historic:
- 1993: CPI propose a generic statement;
- 1995 ECW sub-committee was formed;
- 1996 Herbicide resistance Committee;
- 1996 Pro 96-03 published by PMRA;
- 1998-97 NAFTA initiative to harmonize Grouping of Herbicides in North America;
- 1999 Research Directive.

Highlight of the Research Directive:
- Labeling is on a voluntary basis;
- Product Group on primary panel;
- General and Management statement in label text.

The working group decided on 2 actions following the presentation:
·What is the rate of uptake, or what is the percentage of product with the resistance labeling.
·Herbicide Grouping should be revisited to include new active ingredients.

Bob Blackshaw, AAFC Lethbridge – A year in Australia

Dr. Blackshaw spent a year in Australia with the objective of learning more about integrated weed management to control herbicide resistant weeds. Similarly to western Canada, wheat is the number one crop with 15 million hectares (58%). Other crops are barley, oats, canola, flax, sunflower, safflower, lupins, and chickpeas. The large farms (average farm size is 1578 ha) contributed to the rapid evolution of resistance because of the intensive use of herbicides.

Annual Ryegrass is the major weed resistance problem in Australia. This weed has widespread Group 1 and Group 2 multiple-resistant populations. Some populations have multiple resistance to as many as 6 Groups of herbicides. Three populations have glyphosate resistance (7 to 11 fold). A glyphosate resistance survey is currently underway.

Other Group 1 resistance cases include wild oat, barley grass and annual phalaris. These resistant populations evolved under a haloxifop and diclofop selection pressure. Group 2 resistant weeds include wild radish, wild turnip, indian hedge mustard, and prickly lettuce.

Integrated weed management techniques revolve around reducing weed seed return. Some techniques include desiccation (pulse/legume crops). The herbicide Mataven is used at tiller elongation of the wild oat to reduce seed setting. Although fairly new, silage and green manure expend rapidly because of their effectiveness in reducing seed return. Research also focus in improving crop competitiveness (seeding rate, row spacing, genetic), crop rotation (short term forage, summer crops), and harvesting procedures (chaff carts, heat/carbon monoxide treatment in the combine).

Susan Warwick AAFC - Herbicide resistance in crops and introgression into weeds

Dr. Warwick is currently working on the possibility of using genes from wild species of *brassicacea*. She is also investigating natural gene exchange between wild and cultivated *brassicacea* species. Canola is used as the model crop because it is the most widely cultivated in Canada. Potential crossings are under investigation with the following wild relatives :wild rape, wild radish, and dog mustard.

Working Group Report - Noxious Weed

Submitted by Stephen Darbyshire
Agriculture and Agri-Food Canada, Eastern Cereal and Oilseed Research Centre, Ottawa

Chair: Stephen Darbyshire
Present: Shaffeek Ali, Hameed A. Baloch, Manon Bélanger, Diane Lyse Benoit, Danielle Bernier, Clark Brenzil, Victoria Brookes, Kim Brown, Francine Brunet, Carol Bubar, Dan Cole, Roy Cranston, Lilian DeLuna, Jim Johnson, Chuck Lemmon, Najib Mailb, Hugh Martin, Rhomela F. Masangkay, Sue McColl, Kevin McCully, Clayton Myhre, Derek Oudit, Randy Preater, A. Gordon Thomas, Suzanne Warwick, Wenming Zhang

Stephen Darbyshire stepped down as chair of the study group and Roy Cranston has agreed to fill the breach.

A call was made during the meeting on the Monday for each study group to come up with an issue of concern that ECW could forward to CARC as a perceived priority issue for agricultural research. The problem of weed quarantine was identified as being of high priority because of the increasing danger of alien weeds entering Canada with the increasingly global nature of trade in agricultural products and related goods. Concerns of high priority are identifying which species pose a threat to Canadian agriculture and what are the pathways that are most likely to provide access for new weeds. The first step is to provide the regulatory mechanisms to quarantine weed pests under the CFIA mandate. A motion to be drafted and put to the final general ECW meeting for the President to write the Minister of Agriculture expressing ECW concerns on this matter.

The motion as presented Wednesday, 1 December 1999, to the ECW annual business meeting:

> "Where as there is not a national policy on weed and invasive species control and quarantine, and where as the Canadian Food Inspection Agency is mandated with the responsibility for such national concerns, be it moved that the ECW send a letter to the Minister of Agriculture to request that a national policy be developed to address these concerns."

The original motion moved that the ECW send a letter to CFIA, and this was amended with a proposal from the floor to read as above. The form above was voted on and accepted at the meeting.

A letter to the Minister of Agriculture for Chris Hall's signature is to be drafted by Roy Cranston, Derek Oudit and Stephen Darbyshire and then sent to the group for comment.

Provincial Reports

BC See report attached below.

AB The weed control regulations received a thorough review in 1980 and since that time seem to be working well. The classification of weeds now has the category "restricted" weed, which is the only category where action must be taken.

The popularity of many noxious weeds for herbal medicine (e.g. tansy, scentless chamomile, etc.) is becoming more of a concern as these species are being deliberately grown and spread around the province. The Ministry is trying to work with nurseries and seed companies to stop the problem of the within-province sale of noxious weeds as wild flowers, herbs and medicinal plants (e.g. no more purple loosestrife is sold in the province by nurseries).

Orange hawkweed (*Hieracium aurantiacum*) is spreading in the province weed and hound's tongue (*Cynoglossum officinale*) has been detected at a few more sites.

Difficulty in administering the weed control act is being encountered in and around federal lands because of the lack of access. The large acreage in Alberta owned or controlled by the federal government is, or can be, a reservoir for and source of weeds for surrounding areas.

A voluntary program to have hay certified as weed free was introduced Province-wide in 1999. Some 30 producers participated. Over 5,000 acres were inspected of which 95% was certified. Certification is being offered as a free service at the moment and there is as yet no price premium for certified hay.

SK In 1998 the Noxious Weeds Act was changed. The list of weeds was moved out of the body of the act and into a Regulation, where the weed species designated can be more easily modified by Order-in-Council. Cannabis sativa and common milkweed (Asclepias syriaca) have been removed from the act. Purple loosestrife *(Lythrum salicaria*) and Japanese brome (*Bromus japonicus*) have been added. A review of weed control acts in neighbouring jurisdictions has been started in an attempt to find out what other provinces/states are doing.

Populations of scentless chamomile have been exploding in recent years and a biological control program is being promoted through the funding of a position dedicated to Integrated Noxious Weed Control.

Yellow nutsedge (*Cyperus esculentus*) has been reported from the province for the first time.

Downy brome (*Bromus tectorum*) and leafy spurge (*Euphorbia esula*) are increasing as problem weeds. Due to wet conditions in SE Saskatchewan, weeds of moister habitats, such as docks, have become a problem. Reduced and zero till practices are encouraging a new suit of weeds that normally exist in habitats where there is minimal disturbance.

MB The noxious weed act continues to be a problem with neighbours using it against one another in community squabbles.

Climate shifts in recent years seem to be inducing a shift in the weeds which pose major problems.

Although listed on the weed control act, cultivation of St. John's wort is now being permitted under contract.

ON Enforcement of the weed control act continues on a strictly complaint based response. Of the complaints, 95% are non-agricultural in urban areas (health, property standards, etc.). The main targets of the act are ragweed and poison ivy.

QC See the full report attached below.

Major problems in the past year are ragweed in urban areas.

A safety issue becoming more of a concern for weed inspectors is that of inspecting corn fields which contain hidden marihuana.

NB A new weed for the province was found in a cranberry bog, Cyperus strigosus. This is a native plant of eastern North American wetlands and was introduced with cranberry vines imported from Massachusetts.

BRITISH COLUMBIA

Submitted by Roy Cranston
B.C. Ministry of Agriculture and Food

- "Weed Alerts" were issued province-wide for **common bugloss** (*Anchusa officinalis*). Efforts to increase awareness and control of **perennial pepperweed, wild chervil, carpet burweed, parasitic dodder** and **rush skeletonweed** were continued with distribution of "Alert" posters, newspaper/radio presentations, field days, educational seminars, etc. **Orange** and **yellow hawkweeds** continue to expand throughout the southern interior and Central B.C. Research trials are underway to determine cost/effective hawkweed control.

  Three reports were received regarding **giant ragweed** (*Ambrosia trifida*). This brings to six the number of reports concerning this weed in two years. Ragweed is exceptionally rare in B.C. All reports to date are associated as contaminants of birdseed. Increasing concern regarding introduction of invasive plants through nursery chains, the mail and the Internet resulted in issuance of an **"Invasive Plant Alert"** which was distributed to the nursery trades, Master Gardeners, educational institutions, regional governments, etc.

- B.C. (Ministries of Agriculture and Forests) contributed $134,000 to European bioagent collection, screening and shipment in 1999. Work was targeted at **hound's-tongue, Dalmatian toadflax** and **sulphur cinquefoil**. B.C., in partnership with AAFC, Lethbridge leverages funding as part of an International Consortium on weed biocontrol. **St. Johnswort, nodding thistle** and **bull thistle** are effectively controlled by natural agents. Specialized agents have reduced densities of the **knapweed species**, **tansy ragwort, Dalmatian toadflax** and **leafy spurge** in localized areas throughout B.C. Introduction and provincial redistribution of agents continues. There are currently 57 agents released against 20 serious weeds in B.C. The current popularity of St. Johnswort as a neutracutical crop continues to cause conflict with growers concerned about attack by *Chrysolina* bioagents which were first released to B.C. in the 1940's.

- Industry sponsors were found to enable continued publication of Crop Production Guides for Vegetables and Floriculture 1999, and Berry for 2000. BCMAF published a 1999/2000 Field Crop Pest Control Guide despite failure to attract sponsorship. An Integrated Weed Management Manual was produced as well as a second printing of the colour "Field Guide to Noxious and Other Selected Weeds of British Columbia." A third printing update is currently "in press" as a result of provincial government and corporate sponsorships from BC Hydro, Telus and Westcoast Energy. This guide as well as other weed information such as "Alerts", the IWM Manual, weed monographs are available on the BCMAF Website @ **http://www.agf.gov.bc.ca/croplive/cropprot/weeds.htm**

- The Minor Use of Pesticides Program continues to be critical to the needs of B.C.'s small acreage nursery, vegetable and berry producers as well as to tree fruit, cereal and forage producers in the Okanagan/Kootenay regions. BCMAF is expediting URMULE's for turf, landscape, forage corn, rangeland. Gene Hogue, AAFC, Summerland (ret.) continues work on tree fruits and special crops and Victoria Brookes, AAFC, Agassiz continues herbicide research on strawberries and nursery. Basagran was registered for **yellow nutsedge** control in highbush blueberries in 1999. Requirement for GLP testing will have a suppressive effect on undertaking MU herbicide research, at least in the short term.

! BCMAF provided incentive Grants-in-aid totalling $218,000 to regional district governments that undertake the noxious weed control function. Fourteen local Weed Control Programs were funded in 1999. BCMAF grants represent roughly 20% of total program expenditures. Increased funding to the North Okanagan Regional District allowed expansion of efforts to control rush skeletonweed.

! Order-in-Council changes to Weed Control Act Regulations were approved, thereby adding five new species to regional noxious weed lists. These included **field scabious, wild chervil, perennial pepperweed, meadow knapweed** and **Scotch thistle**. The Act is enabling legislation, allowing local governments to enforce provisions, if they so choose. Very little enforcement is undertaken in the province. Resources for mandated weed control on public lands are in decline at a time when awareness and concern about invasive plant species is at an all time high.

QUÉBEC

Submitted by Alain Garneau, agronome, M.Sc
Direction des services technologiques, MAPAQ, Inspecteur général des mauvaises herbes par intérim

LOI SUR LES ABUS PRÉJUDICIABLES À L'AGRICULTURE (L.R.Q., c. A-2)
Section IV – Mauvaises herbes - Rapport d'activités pour 1999

1) Nomination des inspecteurs/inspectrices des mauvaises herbes

La section IV des mauvaises herbes de la Loi sur les abus préjudiciables à l'agriculture (Agricultural Abuses Act – Division IV, Noxious Weeds) est appliquée par des inspecteurs et des inspectrices désignés spécifiquement par les municipalités. En 1999, quinze (15) municipalités ont fait connaître à l'inspecteur général des mauvaises herbes la nomination d'inspecteurs ou d'inspectrices nommés spécifiquement pour appliquer cette réglementation dans leur municipalité.

2) Révision réglementaire

Dans le cadre de l'harmonisation des diverses lois au nouveau Code civil du Québec, les modifications réglementaires prévues pour 1999 à la Loi sur les abus préjudiciables à l'agriculture ont été reportées à l'automne 2000.

3) Problèmes d'éradication de l'herbe à poux (*Ambrosia* sp.)

La présence de l'herbe à poux fait de plus en plus l'objet d'interventions dans certaines municipalités du Québec spécialement dans la région de la Montérégie. Même si l'herbe à poux fait partie des plantes visées par règlement, les interventions réalisées par les municipalités le sont pour des considérations de santé publique. On évalue actuellement que 10 % de la population québécoise souffre de rhinite allergique causée principalement par l'herbe à poux. Les principaux sites visés ont été les bords de route, les dépôts à neige, les terrains vagues et industriels. Les productions agricoles et particulièrement les productions de soja et de maïs font maintenant partie des sites à problème avec des cas importants d'infestation. Afin de favoriser une concertation entre les organismes dans leur lutte contre l'*Ambrosia* sp., une Table intersectorielle provincial sur l'herbe à poux a été formée. Un représentant du ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec y siège avec d'autres représentants ministériels (ministères des Transport du Québec et des Affaires municipales et de la Métropole) et d'organismes publiques (Canadien National, Hydro-Québec, Union des municipalités du Québec, Départements de santé publique). Au niveau du MAPAQ, une sensibilisation des producteurs et productrices concernant les impacts de la présence de l'herbe à poux sur la santé publique est préconisée. De plus, cette représentation permet de guider les recommandations ce regroupement qui pourraient avoir des répercussions négatives sur l'agriculture.

4) Gestion et entretien des bandes riveraines en milieu agricole

Dans son futur Règlement sur la réduction de la pollution d'origine agricole et plus spécialement concernant le respect des bandes de protection en bordure des cours d'eau en milieu agricole, le ministère de l'Environnement et de la Faune du Québec (MEF) envisageait de créer l'obligation de conserver intactes les bandes de protection riveraine. Une recommandation permettant aux agriculteurs et agricultrices de faucher ou de récolter la végétation présente sur ces bandes de terrain avait été déposée alors au Groupe technique de travail sur les bandes de protection. Actuellement, aucune décision n'a encore été prise. De plus, des négociations avec l'Union des producteurs agricoles sont en cours afin d'établir un consensus entre le MEF et les producteurs visés par cette réglementation. Le problème vient en fait de la perte d'utilisation de cette bande de terrain et par le fait même de revenu pour les producteurs.

Below is my crude attempt at translation of the report by A. Garneau. This is only meant to give a sense of the document for those who do not speak any French. My apologies to M. Garneau and to readers for any misinterpretation on my part. Stephen Darbyshire

1) Nominations of noxious weed inspectors

Section IV, Noxious Weeds, of the Agricultural Abuses Act is enforced by inspectors designated by the municipalities. In 1999, 15 municipalities made nominations for inspectors in their jurisdiction to the inspector general.

2) Revision of regulations

Toward the harmonization of various regulations in the new Civil Code of Quebec, the changes to the Agricultural Abuses Act forecasted in 1999, will be reported in the fall of 2000.

3) Problems in the eradication of ragweed (*Ambrosia* sp.)

The presence of ragweed is more and more becoming an issue in Quebec municipalities, especially in the Montérégie region. Although ragweed is one of the regulated plants, the actions of municipalities are taken based on public health considerations. An estimated 10% of the Quebec population suffers from allergies caused principally by ragweed. The main sites of occurrence are roadsides, snow-dump areas, industrial and vacant lands. Agriculture, particularly fields of soya and corn are also sites of infestation. In order to coordinate various organizations and the regulations on ragweed a provincial round-table has been formed. A representative of the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) sits with representatives of the ministries of Transport and Municipal Affairs, as well as other organizations, including Canadian National, Hydro-Québec, Union of Quebec Municipalities and Department of Public Health. MAPAQ is trying to sensitize producers to the ragweed impacts on public health. This stand will form a guide for the recommendations that may have a negative impact on agriculture.

4) Management and Maintenance of riparian zones in agricultural areas.

In its future regulations aimed at reducing pollution of agricultural origin, especially concerning buffer zones along water courses through agricultural areas, the ministère de l'Environnement et de la Faune du Québec (MEF) envisions manditory untouched buffer zones to protect riparian systems. A recommendation to allow producers to till or cut vegetation in buffer zones has been forwarded to the technical working group on buffer zones. A decision on this is not yet made. Negotiations with the agricultural producers union are trying to establish a consensus between the MEF and producers over this regulation. The concern is over the loss of use of buffer zones and the lost revenues to producers.

Working Group Report - Product Profiles

Submitted by Marvin J. Faber
Dow AgroSciences Canada Inc., London ON

Three excellent presentations were made which are briefly summarized below. I would like to thank the presenters and their associated companies for their time and effort to prepare for these talks. I have received feedback from various people in attendance at ECW last year and the they all felt that the information was valuable and they appreciated getting an early look at some of these new up and coming products.

Also, if you are interested in presenting this coming winter then please do not hesitate to give me a call. Here are some general guidelines for topics that would be consistent with the Product Profiles Working Groups theme.

- New chemistry, new formulations, new uses, new minor use products, biocontrol agents, and label changes
- Re-evaluation of products after several years of use
- Fate and persistence of products (new or old) in plants, animals, soil etc. including toxicology and ecotoxicological aspects.
- New uses of products to combat herbicide resistance problems.

Marvin J. Faber
Chairperson – Product Profiles Working Group
mjfaber@dowagro.com
(519) 685-5161

Performance of Flucarbazone-sodium in Commercially Grown Wheat Results of the 1999 Canadian Research Permit Trials. Dave Feindel, Bayer Incorporated, Canada

Abstract: Flucarbazone sodium (MKH 6562) is a new low rate, experimental grass herbicide being developed by Bayer for postemergence grass control in wheat. The product belongs to the chemical class of sulfonylaminocarbonyltriazolinones, representing a novel class of herbicides. Flucarbazone sodium has shown crop tolerance in wheat (spring, durum & winter) with activity on major annual grasses and many important broadleaf weeds, when applied postemergence. The use rate for annual grass control is 30 g ai/ha and the addition of a non-ionic surfactant in the spray solution is recommended. Flucarbazone sodium must be applied in combination with a broadleaf herbicide (phenoxy, sulfonyluruea, benzonitrile). Flucarbazone sodium provides control of susceptible Avena fatua and Setaria viridis as well as Group 1, 3 and 8 resistant Avena fatua, and Group 1 and 3 resistant Setaria viridis.

Bayer Canada received a Research Permit for a broad scale field trial program in March 1999 and a total of 124 fields of 40 Acres (16 ha) were applied by growers across the prairie provinces of Manitoba, Saskatchewan and Alberta. The results of the Research Permit suggested flucarbazone sodium provided superior Setaria viridis control compared to the standards and was equal to or superior to the standards for control of Avena fatua. Crop tolerance was acceptable across a range of broadleaf mix partners. Crop yields were not different when compared to the standards. Flucarbazone sodium performance was not affected by sprayer type, nozzle type or water volume (exception the Sprayair at 20 l/ha). Grower satisfaction level with flucarbazone sodium was high.

Bromoxynil resistant canola - The Navigator/Compas System. Bruce Murray, Rhone-Poulenc, Canada.

Abstract: Navigator is the name associated with any new canola variety that has a specific nitrilase gene insertion for resistance to bromoxynil. Currently there are 4 varieties being registered. Compas is the herbicide package being marketed for use on Navigator varieties. Compas is comprised of 3 components: Clethodim, Bromoxynil, and an adjuvant. A number of FRP sites throughout western Canada were conducted this year and the efficacy and crop tolerance looked quite good.

Mesotrione: A New Corn Herbicide for Preemergence and Postemergence Weed Control in Canada. Caroline Dykstra Nielsen, Zeneca Agro, Canada.

Abstract: Mesotrione (2-[4-methylsulfonyl-2-nitrobenzoyl]-1,3-cyclohexanedione code ZA1296) is an experimental herbicide being developed by ZENECA for use in corn. Mesotrione is a member of the triketone family of herbicides and has activity on many broadleaf weeds. Mesotrione can be applied preemergence or postemergence and controls redroot pigweed (*Amaranthus retroflexus*), lamb's-quarters (*Chenopodium album*), velvetleaf *(Abutilon theophrasti*), common ragweed (*Ambrosia artemisiifolia*) and several other important broadleaf weeds. Field trials indicate that rates of 140 to 175 g ai/ha applied preemergence and 100 g ai/ha applied postemergence will provide control of all important broadleaf weeds in eastern Canada. For broad spectrum preemergence weed control, mesotrione can be applied with acetanilide herbicides. For broad spectrum weed control postemergence, mesotrione can be applied alone, tank mixed with 280 g ai/ha atrazine - following a preemergence grass herbicide, or tank mixed with postemergence graminicides (i.e. rimsulfuron, nicosulfuron). Postemergence applications of mesotrione will include a crop oil concentrate alone and UAN fertilizer. Corn has excellent crop tolerance to mesotrione.

Table 1. Mesotrione: Pre-emergent / corn spike application. Crop tolerance (%) and visual weed control (%), 1995-1999.

		% Visual weed control		
TREATMENT	% Crop Tolerance	Common Ragweed	Lamb's-quarters	Pigweed sp.
Mesotrione (140 g ai/ha)	100	85	87	94
Mesotrione (175 g ai/ha)	100	100	100	98
Mesotrione + Metolachlor (140 + 1600-2130 g ai/ha)	100	93	99	99
Mesotrione + Metolachlor (175 + 1600 g ai/ha)	100	100	98	98
Mesotrione + Dimethanamid (140 + 1125-1250 g ai/ha)	100	95	99	99
Mesotrione + Dimethanamid (175 + 1250 g ai/ha)	100	100	99	99

Table 2. Mesotrione: Post-emergent application. Crop tolerance (%) and visual weed control (%), 1994-1999.

		% Visual weed control			
TREATMENT	% Crop Tolerance	Common Ragweed	Lamb's-quarters	Pigweed sp.	Velvetleaf
Mesotrione (100 g ai/ha)	97	91	93	96	97
Mesotrione + Atrazine (100 + 280 g ai/ha)	97	96	95	97	99
Mesotrione + Nicosulfuron / Rimsulfuron (100 + 25 g ai/ha)	96	87	90	100	96
Mesotrione + Nicosulfuron (100 + 25 g ai/ha)	98	95	97	96	91

Working Group Report - Site Specific Weed Management

The following presentations were made at the Ottawa meeting.

Site-specific Weed Management: Weed Aggregation and Density Thresholds

Mike Cowbrough[1], and François Tardif[2],

Abstract: Advances in sprayer application technology, GPS and mapping using GIS software have allowed for site-specific weed management. Following weed patch detection in the field, grid units are super-imposed over the weed patch map. The size of the grid unit is usually a function of the herbicide application device. The weed species and density within a specific grid unit determines whether application is necessary. Hence, grid units are called "decision units", and make up a prescription map. In a prescription map, weed populations may be either homogeneously or heterogeneously distributed within a decision unit. It is uncertain how weeds distributed heterogeneously affect crop yield, and other production variables. It is assumed that, depending on the level of heterogeneity within a decision unit, application may not be warranted, thus herbicide costs would be reduced. Preliminary field results conducted at the Woodstock Research Station[3] have shown differences in yield, dockage, and moisture content of soybean (*Glycine max*) between decision units having common ragweed (*Ambrosia artemisiifolia*) distributed homogeneously and heterogeneously. The average densities of common ragweed ranged from 0 to 16 plants/m^2. Further experimentation will be conducted in 2000 to validate these results.

[1] Graduate Student. Department of Plant Agriculture, University of Guelph, mcowbro@plant.uoguelph.ca.
[2] Professor. Department of Plant Agriculture, University of Guelph, ftardif@plant.uoguelph.ca.Woodstock Research Station, University of Guelph. Woodstock, Ontario.

Landscape influence on wild oat (*Avena fatua*) distribution.

T. Faechner[1], and L.M. Hall[2]

High herbicide input costs may be reduced if herbicide can be applied only where required. Accurate and efficient methods of mapping or predicting weed populations are required before site-specific applications can be implemented. Landscape mapping was examined as a way to predict the density of wild oat. A high-resolution (5 m) digital elevation model (DEM) was used to classify a 60 ha wheat field near Calgary, Alberta, Canada into 15 landform units. Wild oat density measured in four 64-sample grids in each of four landscape units. In addition, wild oat density was estimated by GPS-guided scouting prior to herbicide application and at harvest, using a yield monitor. Wild oat density was highly correlated with landscape unit. Wild oat densities were highest, averaging 125 plant m^{-2}, in convergent back slopes (CBS) where the DEM predicts water moves and accumulates. Within CBS areas, wild oat densities were higher on cooler slopes with north facing aspects than those with drier south facing slopes. Wild oat densities were lower on backslopes, and lowest on toeslopes and hilltops, averaging 57, 9 and 3 plant m^{-2}, respectively. Wild oat densities were also influenced by historical wild oat distributions. Wild oat densities averaged 196 plant m^{-2} in a patch detected at harvest in 1997. Scouting prior to herbicide application overestimated wild oat populations but information was inexpensive to obtain. Scouting at harvest may assist with weed distribution predictions in the following years. Landform units may provide a basis for predicting spatial and temporal variation in the location of wild oats.

[1] Graduate Student, Engineering, University of Alberta and AAFRD
[2] Research Scientist, Agronomy Unit, Alberta Agriculture, Food and Rural Development

Spatial Variability of Weed Populations in the Scott Alternative Cropping Study

A. G. Thomas[1], J. Leeson[1], A. Moulin[2], F. Selles[3], D. Derksen[2], B. Frick[1], S. Brandt[1]
Agriculture and Agri-Food Canada,

Weed distributions on sites chosen for experimental studies are often non-uniform. The observed variation in the weed community across a site prior to any experimental treatment may be due to the interaction of environmental, historical, and spatial factors. We examined the relative influence of these sources of variation on the densities of 33 species found within a 16 ha split-split plot experimental study. Physical and chemical soil properties were obtained for each plot by kriging data from samples placed in a pseudo random pattern. Historical factors considered were the past management of the site. The significant terms of the cubic trend surface equation and the replicate structure of the experiment were used to describe spatial variability. An examination of the residual weed density data illustrated the potential influence of these factors on the weed community. A series of partial Redundancy Analyses (RDA) was used to determine the percentage of the variance in each weed community data set explained by the factors. For each factor and combination of factors a separate analysis was conducted in which the axes of the resultant ordination were constrained to be linear combinations of the factor after the variance in the weed densities due to the other factors was removed. Monte Carlo permutation tests were used to identify factors that were significantly associated with the variance in the weed community. The non-uniform weed distribution across the experimental site was significantly associated with the factors examined in this study. This study illustrates the importance of considering the initial variance of the weed community in the analysis of data from subsequent years.

[1] Saskatoon, SK
[2] Brandon, MB
[3] Swift Current, SK

Spatial heterogeneity of Weed Populations – Current research projects at The University of Manitoba

R. C. Van Acker[1], R. Oree[2], G. Martens[3], D. Ross[4], K. Anaka[4] and D. Reid[5]
Dept. of Plant Science, University of Manitoba

The topic of spatial heterogeneity of weeds is being tackled on a series of fronts at the University of Manitoba. To setup for future work we have established a permanent monitoring site at Carman. MB, at the Plants Science Research Farm. On this site we have mapped the weed infestations on a 10 m by 10 m grid in a 60m X 390 m field. We found a total of 10 species including; green foxtail, barnyardgrass, redroot pigweed, wild oat, wild mustard, smartweed, wild buckwheat, lamb's quarters, dandelion and Canada thistle. We have also collected seedbank and early spring gravimetric soil samples at each grid point. We will be monitoring the movement of these weeds on this 60 m x 390 m section over time as the section is normally cropped. We have also outlined three 10m X 10m sections within this are in which we are conducting very fine scale surveys of the weed species associations. This work is being conducted by Kurt Anaka. He is mapping to a scale of 10 cm X 10 cm. In one of the 10 m X 10 m areas he has found that there is a very significant negative association between wild oat and barnyardgrass at this scale. This was unsuspected because good weed control has been practiced on this land for at least 6 years, and this would have included good grass seedling control. This would have eliminated, therefore, the opportunity for these species to actively compete and establish a negative association. We are also looking at seedbank samples and conducting replacement series experiments to try to understand the mechanism behind the negative association. This has implications for weed species invasion and patch movement. At a more gross scale, we also have Delaney Ross (an MSc student) working on characterizing the effects of varying N rate on the competitiveness of wild oat or wild buckwheat in wheat at two landscape positions. The implication is that if variable rate N gives advantage to the weeds this may promote patch spread. On a very practical level, Gary Martens (an instructor in our departments and a renowned crop scout) and myself are trying to find simple means for mapping weed patches. In his small airplane we have discovered that it is easy to map wild oats pre-seeding, just post-spraying with group 1 herbicide (when it turns a distinctive yellow-green) and pre-harvest (when the patches show white above most crops). We are considering approaching custom aerial applicators to develop this mapping approach for their clients, in hopes that they may be able to cordon off areas in the producers fields which need no-wild oat herbicide.

[1] Asst Prof, [2] Research Technician, [3] Instructor and Field scout, [4] Graduate students, [5] Summer NSERC research student, Department of Plant Science, University of Manitoba.

Provincial Reports

1999 Report to the Expert Committee on Weeds
Alberta

Prepared by Linda Hall, Dan Cole, Keith Topinka and Shaffeek Ali
Alberta Agriculture, Food and Rural Development

General

Weather conditions varied considerably across the province in 1999. The southern and central portion of the province experienced cool, wet growing conditions for most of May, June and July. Crop yields were reduced and harvest delayed. In the Peace River region, it was also cool, with frost reported in every month, but rainfall varied considerably. Some areas experienced their second year of drought and poor crops, while other areas had average yields. In eastern Alberta, adequate moisture contributed to good crops but there was some reduction of quality due to frost damage on late harvested crops.

Problem Weeds

Crop Weeds

Annual sow-thistle was problematic around the province, especially in pea crops. Difficulties were encountered with the correct identification of perennial and annual sow-thistles. Rapid growth rates and extended emergence make this weed difficult to control.

Field violet was reported as a problem in direct seeded fields in several parts of the province. This weed is a concern because it is a dominant weed in Europe. Canada thistle remained a weed of concern for most of the province. Wild buckwheat appeared to be increasing in canola crops. Wild oat populations were high in the province, along with other weeds which germinate throughout the year.

In direct seeding systems, winter annual weeds, including flixweed, stork’s-bill, narrow-leaved hawk’s-beard, and downy brome were reported to be increasing. In addition, perennial weeds dandelion, foxtail barley, perennial sow-thistle and Canada thistle were concerns.

Fall seeded canola increased in the province to approximately 300,000 acres. Effects on weed populations are unknown. There are indications that canola yield potential can be increased by fall seeding.

Forage, Pastures and Forage, Pastures and Rangeland
Orange hawkweed is spreading in Alberta. Four municipalities reported this weed in roadside, pasture and non-cropland. It may be possible to eradicate this weed with a prompt awareness program and action by municipalities.

Canada thistle remains the weed of greatest concern in forages, pastures and rangelands.

Weed Free Hay Program
In 1999, Alberta operated a province wide Weed Free Hay Program as a method to prevent the spread of weeds through hay movement. Hay fields were inspected prior to cut for weeds in their propagative stage. Disallowed weeds were those listed under Alberta's Weed Control Act. If approved, producers were given a maximum 10 days to cut the hay. A certificate was issued and the hay was baled using special color twine. The program was voluntary and the inspection service provided at no cost. This year 30 producers requested inspections and 95% were certified, encompassing 4,790 acres. The program received excellent support from the industry.

Roadside Weeds
Tall buttercup, spreading dogbane, downy brome and bull thistle increased in southern and central Alberta. Common tansy and ox-eye daisy were a concern in western, central and northeastern Alberta. Field scabious spread in the foothills. Tall hedge mustard has appeared in the Stettler area where it has also invaded overgrazed pasture areas. Purple loosestrife has been sighted along Lesser Slave Lake.

Eradication Programs
Diffuse and spotted knapweed, nodding thistle and purple loosestrife eradication programs continued to reduce infestation levels. Ducks Unlimited and Alberta Conservation Tillage Association provided funding to support purple loosestrife control. Several volunteer groups were involved in hand pulling of purple loosestrife.

Herbicide Performance
Herbicide tolerant canola varieties occupied 75% of the Alberta canola acreage. Control of wild buckwheat in Roundup Ready canola was a concern, as were residues from Pursuit and Odyssey. Record keeping is essential to control herbicide tolerant canola volunteers.

Sundance and Anthem residues caused considerable difficulties after multiple tanks had been sprayed. Residues blocked nozzles, hoses and screens and caused damage to pea and canola crops if sprayers were not cleaned completely before changing crops. Monsanto has introduced a new mixing protocol to eliminate these problems in 2000.

The cool, wet conditions throughout most of the province allowed many weeds, including wild oat, cleavers, and chickweed, to produce multiple flushes. Products containing bromoxynil were reported to work poorly in the Lethbridge area, perhaps due to cool, cloudy conditions.

Herbicide Resistance
A Group 2 resistant ball mustard (*Neslia paniculata*) was reported in eastern Alberta.

Herbicide resistant wild oat became an increasing concern in the Peace Region and in south/central Alberta. Group 2 resistant chickweed is so common that it is no longer being reported. Resistance in kochia was reported to be increasing in the southern part of the province.

Biological Control
Insect releases have been made of a gall midge *Rhopalomyia* n.sp. for scentless chamomile control, in addition to the stem-mining weevil *Microplontus edentulus* and the seed weevil *Omphalapion hookeri* already established in Alberta. Releases contined for common and Dalmatian toadflax control by the stem-mining weevil *Mecinus janthinus*. The Canada thistle control program with the leaf-feeding beetle *Lema cyanella* has been discontinued. Successful leafy spurge control with the root-feeding beetles *Aphthona lacertosa* and *Aphthona czwalinae* was continued. The gall mite *Aceria malherbae* successfully controlled field bindweed in southern Alberta. Two European root-feeding insects, *Mogulones cruciger* and *Longitarsus quadriguttatus* controlled hound's tongue on rangeland. The leaf-feeding beetle *Galerucella calmariensis* released for purple loosestrife control in1998 has become established.
A joint Alberta/Saskatchewan/Manitoba fact sheet entitled "Biological Control of Weeds on the Prairies" will be available this winter.

Minor Use
There was an increasing concern that minor use funding is not sufficient to meet the needs of a diversifying crop industry. Additionally, the requirement for GLP standards for research conducted under minor use agreements will increase the costs associated with research.

In order to remain competitive with producers from other countries, minor use registrations must be encouraged by increased funding, streamlining of the administrative procedures and support from user groups.

1999 Report to the Expert Committee on Weeds
Québec

Présenté par Danielle Bernier, Direction des services technologiques, MAPAQ

Informations générales

Pour une deuxième année consécutive, l'efficacité des herbicides de prélevée a été réduite compte tenu du temps sec en début de saison.

La régie de l'assurance récolte et l'industrie a du défrayer les coûts de nouvelles applications. d'herbicides en postlevée. Cependant les frais encourus ont été moindres que l'année précédente.

Laboratoire de diagnostic

Le laboratoire poursuit toujours ses activités. L'identification de mauvaises herbes, l'évaluation visuelle de phytotoxicité, de nombreuses recommandations herbicides sont les services offerts. De multiples informations concernant la répression des mauvaises, les herbicides et les techniques de désherbage sont aussi transmises à la population. Des cours, conférences et formations diverses sont aussi données aux intervenants en agriculture (producteurs, agronomes, étudiants, techniciens).

Commission de malherbologie

La commission de malherbologie a été très active. Le 7 et le 8 juillet 1999, la "Tournée des mauvaises herbes" a connu, encore une fois, un vif succès dans la région de Sainte-Anne de Bellevue.

Quelques membres de la Commission de malherbologie ont collaboré avec le président de la Commission de Protection des Cultures, à organiser le colloque "La protection de vos grandes cultures: êtes-vous à jour?" Ce colloque sera présenté dans le cadre du salon de l'agriculteur en janvier 2000.

L'activité majeure de la Commission de malherbologie fut sans aucun doute la publication du guide "Traitements herbicides-Grandes cultures 2000". La majorité des membres a participé à un moment ou à un autre, de près ou de loin, à la réalisation de ce guide complètement transformé. Le guide a un nouveau format plus pratique. La nouvelle présentation visuelle et la reliure facilitent la consultation du guide. L'ajout de nouvelles sections, notamment celle contenant l'information sur les différents herbicides apporte un complément d'information apprécié par les intervenants du milieu.

Le réseau d'essais herbicides a poursuivi ses activités à l'Université Laval et au Campus MacDonald.

Un merci spécial est adressée à Madame Diane Lyse Benoît et son équipe pour sa participation et son implication dans la réalisation du guide "Traitements herbicides-Grandes cultures 2000".

Documents

Tel que mentionné précédemment le nouveau guide Traitements herbicides-Grandes cultures 2000 sera disponible au début de l'année 2000.

Le logiciel DESHERB-maïs est maintenant disponible via Internet à l'adresse suivante: www.agr.gouv.qc.ca/dgpar/arico.

Divers

M, Claude J. Bouchard est le représentant du ministère de l'Agriculture des Pêcheries et de l'Alimentation du Québec au comité interministérielle sur l'herbe à poux.

Le ministère de l'Agriculture des Pêcheries et de l'Alimentation a mis sur pied un comité chargé d'étudier le dossier des OGM. M Daniel Chez est responsable de ce comité.

1999 Report to the Expert Committee on Weeds
Saskatchewan

Prepared by Clark Brenzil, Provincial Weed Control Specialist
Saskatchewan Agriculture and Food

General

1999 was a year of polar opposites for Saskatchewan producers with the Southeast area of the province in the new every day over the wet weather that plagued the area to the continued dry weather in the Northwest. This past year was a disastrous one for many agricultural producers in the southeastern area of Saskatchewan with only 20% of intended seeding completed in some Rural Municipalities. Crops seeded before the nearly continuous rain, were the only crops that completed their lifecycle. Much of the seeding that was completed was late and into wet soil. The combination of a full soil recharge in the fall of 1998 plus rainfall occurring in the spring nearly every other day, left many areas saturated until late June. In areas outside of southeast Saskatchewan, frequent rainfall made it difficult to complete field operations in a timely fashion. While wet weather made crops that were planted very productive, weeds in general were also very productive.

Weed Concerns

Many weed problems that were reported in Saskatchewan in 1999 that are usually relegated to swamps and slough boundaries. Docks (*Rumex spp.*) were a major concern in the spring and early summer while members of the evening-primrose (*Onagraceae*) family including yellow evening-primrose (*Oenothera biennis*), fireweed & willowherb (*Epilobium sp.*), and Asters (*Aster sp.*) in pasture and summer fallow dominated questions during mid-summer.

An increasing number of questions on control of native plants, biennial and perennial plants in reduced tillage fields reflects the shift in populations as tillage is reduced in crop production systems. Some of the specific plants where concerns were raised include dandelion (*Taraxacum officinale*), Canada fleabane (*Erigeron canadensis*), Canada thistle (*Cirsium arvense*), downy brome (*Bromus tectorum*) and perennial sow-thistle (*Sonchus arvensis*). Cleavers (*Galium aparine*) is continuing to move south with canola acres.

The moist weather was also favourable for the growth of scentless chamomile (*Triplerospermum perforatum*). The combination of wet weather and poor economic times in agriculture led to the abandonment of several quarters of farmland in prime scentless chamomile areas. Many of these fields went uncontrolled until well after flowering allowing the build-up of seed to unimaginable numbers. Many producers and municipalities feel that the task of controlling the weed has gone beyond their ability and budget.

Bio-control of Weeds
With funding from the Agri-Food Innovation Fund, the Saskatchewan Association of Rural Municipalities has hired Dr. Garry Bowes as the Co-ordinator of the Integrated Noxious Weeds Management Program to work in co-operation with the Provincial Weed Control Specialist. With a primary focus on scentless chamomile, the main goal of the program is to develop integrated programs with and for municipalities and producers that include cultural control methods, herbicides and classical biological control agents. Dr. Bowes is also co-ordinating redistribution of present biological control agents on various weeds and distributing new bio-control agents in scentless chamomile. Investigations of past releases of the scentless chamomile seed head weevil (*Omphalapion hookeri*) revealed that the bio-control agent is surviving quite nicely in Saskatchewan. If conditions are not ideal at their original release site the weevils move readily to new locations. With this habit of quick dispersion into the surrounding environment, it will be some time before we see a significant impact of the weevil on the weed, although some of the original release sites were devoid of chamomile. A single release of the scentless chamomile stem-mining weevil (*Microplontus edentulus*) is still in the assessment stage. Dr. Bowes made several releases of a new agent on scentless chamomile known as the scentless chamomile gall midge (*Rhopalomyia n. sp.*), in co-operation with Dr. Alec McClay, Alberta Research Council, Vegreville.

Legislation
Changes to *The Noxious Weeds Act, 1984* were given approval in 1998 that allowed the removal of the Schedule naming noxious weeds to be controlled under the Act and approved the development of regulations that list noxious weeds. *The Noxious Weeds Designation Regulations, 1999* were approved in February. The new regulations now list weeds by both common name and botanical name. Two plants were removed from the list of noxious weeds and two were added. *Cannabis sativa*, which can mean either narcotic marijuana or industrial hemp for fibre or oil, was removed from the list of noxious weeds to facilitate the development of the hemp industry. Common milkweed (*Asclepias syriaca*) was removed from the list of noxious weeds since it is also a rare native plant in Saskatchewan. Purple loosestrife (*Lythrum salicaria*) was finally added to the list of noxious weeds. With the discovery of Japanese brome (*Bromus japonicus*) thriving in the absence of downy brome (*Bromus tectorum*) outside of the typical range of downy brome, and the similarity of the two plants, made it imperative that it be added to the list of noxious weeds. Research on weed control legislation from other jurisdictions will be conducted over the coming months to prepare for a substantial revision of *The Noxious Weeds Act, 1984* to be undertaken in the next couple years.

Recent attrition of weed inspectors in Saskatchewan has left local municipalities with an acute shortage of weed inspectors, and concern over the qualifications of any new Weed Inspectors that might be appointed as replacements. A program of training for Weed Inspectors is planned in order to increase their knowledge of The Noxious Weeds Act, Identification and control of some of the more common noxious weeds, weed control options for organic producers, and dealing with public.

Notable Events

Larry Lee, Extension Agrologist in Nipiwan, SK., discovered the first reported yellow nutsedge (*Cyperus esculentus*) for the province of Saskatchewan. The sample that was submitted to the Saskatchewan Crop Protection Laboratory had survived at least one winter. With the current mild winter it may have survived another winter if left undisturbed. The sample submitted was propagated in the lab from tubers and pressed for inclusion in the herbarium at Agriculture and Agri-Food Canada in Saskatoon. All remaining yellow nutsedge plants at the discovery site were destroyed and the site will be monitored for the next couple of years to ensure eradication. The sample was discovered in a garden suggesting that it may have been introduced with an import of seed or bulbs.

ECW Bibliography of Weed Research in Canada

ECW Bibliography of Weed Research in Canada

Compiled by Judy Hume

Ball-Coelho, B.R., Roy, R.C. and Swanton, C.J. 1998. Tillage alters corn root distribution in coarse-textured soil. Soil & Tillage Res. 45:237-249.

Beckie, H.J. 1999. What is the cost to the producer in managing herbicide-resistant weeds? Pages 25-32 *in:* Proc. 27th Saskatchewan Alfalfa Seed Producers' Association (SASPA) annual meeting, Saskatoon, SK.

Beckie, H.J., Chang, F. and Stevenson, F.C. 1999. The effect of labeling herbicides with their site of action: A Canadian perspective. Weed Technol. 13:655-661.

Beckie, H.J., Chang, F. and Stevenson, F.C. 1999. The impact of labeling herbicides with their site of action. Pages 383-390 *in:* Proc. Soils and Crops'99, Extension Division, University of Saskatchewan.

Beckie, H.J., Thomas, A.G. and Légère, A. 1999. Herbicide resistance management tools and strategies. Pages 134-137 *in:* Proc. Western Canada Agronomy Workshop, Brandon, MB.

Beckie, H.J., Thomas, A.G. and Légère, A. 1999. Nature, occurrence, and cost of herbicide-resistant green foxtail (*Setaria viridis*) across Saskatchewan ecoregions. Weed Technol. 13:626-631.

Beckie, H.J., Thomas, A.G., Légère, A., Kelner, D.J., Van Acker, R.C. and Meers, S. 1999. Nature, occurrence, and cost of herbicide-resistant wild oat (*Avena fatua*) in small-grain production areas. Weed Technol. 13:612-625.

Beckie, H.J., Thomas, A.G., Légère, A., Kelner, D.J., Van Acker, R.C. and Meers, S. 1999. What is the cost to manage herbicide-resistant wild oat and green foxtail? Pages 376-382 *in:* Proc. Soils and Crops'99, Extension Division, University of Saskatchewan.

Beckie, H.J., Thomas, A.G. and Stevenson, F.C. 1999. Saskatchewan weed survey: herbicide-resistant wild oat 1997. Agriculture and Agri-Food Canada Weed Survey Ser. Publ. No. 99-4, Saskatoon, SK 32 pp.

Belaoussoff, S., Guenther, D.S., Kevan, P.G., Murphy, S. and Swanton, C. 1998. Do tillage regimes and crop types influence terrestrial isopod diversity? (With a practical key to identification of species in northeastern North America). Proceedings of the Entomological Society of Ontario 128:39-45.

Betts, M., Cranston, R. and Moyer, J.R. 1999. Weed management. Chapter 4, Pages 53-58 *in*: Bittman, S., Schmidt, O., and Cramer, T.N., eds. Advanced Forage Management: A production guide for coastal British Columbia and the Pacific Northwest. Pacific Field Corn Association, Agassiz, BC.

Blackshaw, R.E., Semach, G., Xiangju, Li, O'Donovan, J.T., and Harker, K.N. 1999. An integrated weed management approach to managing foxtail barley (*Hordeum jubatum*) in conservation tillage systems. Weed Technol. 13:347-353.

Boyetchko, S.M. 1999. Biological control agents of canola and rapeseed diseases - status and practical approaches. Pages 51-71 *in*: Mukerji, K.G., Chamola, B.P., and Upadhyay, K., eds. Biotechnological Approaches in Biocontrol of Plant Pathogens. Kluwer Academic/Plenum Publishers, London.

Boyetchko, S.M. 1999. Innovative applications of microbial agents for biological weed control. Pages 73-97 *in*: Mukerji, K.G., Chamola, B.P., and Upadhyay, K., eds. Biotechnological Approaches in Biocontrol of Plant Pathogens. Kluwer Academic/Plenum Publishers, London.

Boyetchko, S.M., Pedersen, E., Punja, Z. and Reddy, M. 1999. Formulations of biopesticides. Pages 487-508 *in*: Hall, F.R. and Menn, J.J., eds. Methods in Biotechnology, vol 5: Biopesticides: Use and Delivery. Humana Press, Totowa, NJ

Chao, J.F., Hsiao, A.I. and Quick, W.A. 1997. Tillers do not influence phytotoxicity of imazamethabenz in wild oat (*Avena fatua*). J. Plant Growth Regul. 16:173-179.

Cowan, P., Weaver, S.E. and Swanton, C.J. 1998. Interference between pigweed (*Amaranthus* spp.), barnyardgrass (*Echinochloa crus-galli)* and soybean (*Glycine max*). Weed Sci. 46:533-539.

Cromar, H.E., Murphy, S.D. and Swanton, C.J. 1999. Influence of tillage and crop residue on postdispersal predation of weed seeds. Weed Sci. 47:184-194.

Darwent, A.L. and Moyer, J.R. 1999. Control of wild oat in the year of smooth bromegrass establishment and its effect on the yield and quality of subsequent seed crops. Can. J. Plant Sci. 79: 447-454.

Deen, W., Hunt, L.A. and Swanton, C.J. 1998. Photothermal time describes common ragweed (*Ambrosia artemisiifolia* L.) phenological develoment and growth. Weed Sci. 46:561-568.

Deen, W., Hunt, L.A. and Swanton, C.J. 1998. Influence of temperature, photoperiod and irradiance on the phenological development of common ragweed *(Ambrosia artemisiifolia).* Weed Sci. 46:555-560.

Dunn, R. and Moyer, J.R. 1999. Dandelion control in direct seeding systems. Alberta Agriculture, Food and Rural Development. Agdex 519-26. 5 pp.

Gao, Y.P., Johnson, E., Kirkland, K. and Gusta, L.V. 1999. Fall seeding of canola: Potential of polymer coatings. Ann. Rep.1997-1998, Crop Dev. Centre, Univ. of Saskatchewan, Saskatoon. 29 pp.

Grover, R., Maybank, J., Caldwell, B.C. and Wolf, T. 1997. Airborne off-target losses and deposition characteristics from a self-propelled, high speed, and high clearance ground sprayer. Can. J. Plant Sci. 77:493-500.

Grover, R., Wolt, J.D., Cessna, A.J., and Schiefer, H.B. 1997. Environmental fate of trifluralin. Rev. Environ. Contam. Toxicol. 153:1-64.

Hall, L., Beckie, H. and Wolf, T.M. 1999. How Herbicides Work: Biology to Application. Alberta Agriculture, Food and Rural Development, Edmonton, AB. 134 pp. ISBN 0-7732-6131-1

Hall, J.C., O'Donovan, J.T. and Hall, L.M. 1999. Basis for resistance of a wild mustard (*Sinapis arvensis* L.) biotype to ethametsulfuron-methyl. Page 123 *in:* Proc. Weed Sci Soc. of America, San Diego, Ca.

Hill B.D., Moyer, J.R., Inaba, D.J. and Doram, R. 1998. Effect of moisture on quinclorac dissipation in Lethbridge soil. Can. J. Plant Sci. 78:697-702.

Holm, F.A., Kirkland K.J. and Stevenson, F.C. 1999. Defining optimum herbicide rates and timing for wild oat control. Proc. Western Soc. of Weed Sci. 52:62

Holm, F.A., Kirkland K.J. and Stevenson, F.C. 1998. Defining optimum herbicide rates and timing for wild oat control. Pages 79-80 *in:* Proc. National Expert Committee on Weeds.

Holm, F.A., Kirkland K.J. and McVicar, R. 1999. Evaluating herbicides for special crops. Pages 64-69 *in:* Proc. Western Canada Agronomy Workshop, Canadian Fertilizer Institute, Ottawa, ON K1P 5V9.

Holm, F.A., Kirkland K.J. and Stevenson, F.C. 1999. Defining optimum herbicide rates and timing for wild oat control. Page 438 *in:* Proc. Soils and Crops'99, Extension Division, University of Saskatchewan.

Holm, F.A., Kirkland K.J. and Stevenson, F.C. 1999. Defining optimum herbicide rates and timing for wild oat control. Page 152 *in:* Proc. Saskatchewan Soil Conservation Association, Indian Head, SK.

Hooker, D.C., Vyn, T.J. and Swanton, C.J. 1998 Alternative weed management strategies in conservation tillage systems for white beans (*Phaseolus vulgaris* L.). Can. J. Plant Sci. 78:363-370.

Hunt, L.A., Kuchar, L. and Swanton, C.J. 1998. Estimation of solar radiation for use in crop modelling. Agric. & Forest Meteor. 91:293-300.

Kirkland, K.J. 1997. Implications of late fall and early spring 2,4-D applications on subsequent canola production on Black, Dark Brown and Gray Wooded Soil. Can. J. Plant Sci.77:699-702.

Kirkland, K.J. and Beckie, H. 1998. Contribution of nitrogen fertilizer placement to weed management in spring wheat (*Triticum aestivum*). Weed Technol. 12:507-514.

Kirkland, K.J. and Holm, F.A. 1999. New herbicide developments for pulse crops. Pages 93-95 *in:* Proc. Pulse Days, 1999. Saskatchewan Pulse Growers, Saskatoon, SK.

Kirkland, K.J. and Johnson, E.N. 1999. Summary of late fall and early spring seeding of herbicide tolerant canola, 1994-1998. Pages 70-76 *in:* Proc. 11th Annual Conference, Saskatchewan Soil Conservation Association, Indian Head, SK.

Kirkland, K.J. and Johnson, E.N. 1999. Summary of late fall and early spring seeding of herbicide tolerant canola, 1994-1998. Pages 143-149 *in:* Proc. 21st Annual Manitoba-North Dakota Zero Tillage Workshop, Brandon, MB.

Kirkland, K.J. and Johnson, E.N. 1999. Fall seeding: avoiding environmental stress. Pages 8-9 *in:* PBI Bulletin, National Research Council of Canada, Saskatoon, SK, May 1999.

Kirkland, K.J. and Johnson, E.N. 1999. Management of fall and early spring seeded herbicide tolerant canola. Final Report, CARP Project # 9602. 21pp.

Kirkland, K.J. and Johnson, E.N. 1999. Seeding canola in the Fall, 1993-1998 Results. Pages 40-44 *in:* Proc. Western Canada Agronomy Workshop, Canadian Fertilizer Institute, Ottawa, ON K1P 5V9.

Knezevic, S.Z., Sikkema, P.H., Tardif, F., Hamill, A.S., Chandler, K. and Swanton, C.J. 1998. Biologically effective dose and selectivity of RPA 201772 for preemergence weed control (*Zea mays* L.). Weed Technol. 12:670-676.

Kuchar, L., Hunt, L.A. and Swanton, C.J. 1998. Generating daily meteorological data for agronomic models. Polish Scientific Journal Contents - Agric. & Biol. Sci. 4/98:41-50.

Kutcher, H.R. and Mortensen, K. 1999. Genotypic and pathenogenic variation of *Colletotrichum gloeosporioides* f. sp. *malvae*. Can. J. Plant Pathol. 21:37-41.

Makowski, R.M.D. and Mortensen, K. 1998. Latent infections and penetration of the bioherbicide agent *Colletotrichum gloeosporioides* f. sp. *malvae* in non-target field crops under controlled environmental conditions. Mycol. Res. 102:1545-1552.

McIntyre, G.I. and Cessna, A.J. 1998. Studies on the growth and development of the rhizome and lateral rhizome buds in *Elytrigia repens*: some effects of parent shoot excision. Can. J. Bot. 76:769-776.

Mortensen, K. 1998. Biological control of weeds using microorganisms. Pages 223-248 *in*: Boland, G.J. and Kuykendall, L.D., eds. Plant-microbe interactions and biological control. Marcel Dekker, Inc. New York, Basel, Hong Kong.

Moyer, J.R., Esau, R. and Boswall, A.L. 1999. Effect of quinclorac on following rotational crops. Weed Technol. 13:548-553.

Moyer, J.R., Fraser, J., Rode, L.M. and Topinka, A.K. 1999. Effect of cutting management systems on alfalfa and weed yields and forage quality. Can. J. Plant Sci. 79:243-247.

Neeser, C., Aguero, R. and Swanton, C.J. 1998. A mechanistic model of purple nutsedge *(Cyperus rotundus)* population dynamics. Weed Sci. 46:673-681.

O'Donovan, J.T., Newman, J.C., Blackshaw, R.E., Harker, K.N., Derksen, D.A. and Thomas, A.G. 1999. Growth, competitiveness, and seed germination of triallate/difenzoquat susceptible and resistant wild oat populations. Can. J. Plant Sci. 79:303-312.

O'Donovan, J.T., Newman, J.C., Harker, K.N., Blackshaw, R.E. and McAndrew, D.W. 1999. Effect of barley plant density on wild oat interference, shoot biomass and seed yield under zero tillage. Can. J. Plant Sci. 79:655-662.

O'Donovan, J.T., Harker, K.N. and Clayton, G. 1999. Weed management in barley with competitive cultivars, high seeding rates and low herbicide rates. Pages 92-94 *in:* Proc. Agronomy Update '99, Lethbridge, Alberta.

O'Donovan, J.T., Rashid A., Zhang, R. and Pharis, R.P. 1999. Wild oat (*Avena fatua*) resistance to triallate and difenzoquat is linked to elevated levels of gibberellins. Pages 40-41 *in:* Proc. Weed Sci. Soc. of America, San Diego, Ca.

Opoku, G., Vyn, T.J. and Swanton, C.J. 1998. Modified no-till systems for corn after wheat on clay soils. Agronomy J. 89:549-556.

Peterson, D. and Prasad, R. 1998. The biology of Canadian weeds. 109. *Cystisus scoparius* (L.) Link. Can. J. Plant Sci. 78:497-504.

Prasad, R. 1999. Mechanisms of invasiveness of the exotic weed Scotchbroom (*Cystisus scoparius*) in British Columbia. Proc. Weed Sci. Soc. Am. 39:19-20.

Prasad, R. 1999. Evaluation of some fungi for bioherbicidal potential against Scotchbroom (*Cystisus scoparius* Link.) under greenhouse conditions. Proc. Weed Sci. Soc. Am. 39:93-94.

Quick, W.A., Hsiao, A.I. and Hanes, J.A. 1997. Dormancy implications of phosphorus levels in developing caryopses of wild oats (*Avena fatua* L.). J. Plant Growth Regul. 16:27-34.

Rashid, A., O'Donovan, J.T., Khan, A.A., Blackshaw, R.E. and Harker, K.N. 1998. A possible involvement of gibberellin in the mechanism of *Avena fatua* resistance to triallate and cross-resistance to difenzoquat. Weed Res. 38:461-466.

Roman, E.S., Thomas, A.G., Murphy, S.D. and Swanton, C.J. 1998. Modeling germination and shoot elongation of common lambsquarters (*Chenopodium album).* Weed Sci. 47:149-155.

Stevenson, F.C. and Johnston, A.M. 1999. Annual broadleaf crop frequency and residual weed populations in Saskatchewan Parkland. Weed Sci. 47:208-214.

Swanton, C.J., Chandler, K. and Shrestha, A. 1998. Weed seed return as influenced by the critical weed-free period in corn (*Zea mays* L.). Can. J. Plant Sci. 79:165-167.

Swanton, C.J., Chandler, K. and Shrestha, A. 1998 Control of established alfalfa *(Medicago sativa* L.) and red clover (*Trifolium pratense* L.) in a no-till corn (*Zea mays* L.) cropping sequence. Can. J. Plant Sci. 79:175-177.

Swanton, C.J. and Shrestha, A. 1998. Integrated weed management in white beans. The Emerging Bean.

Swanton, C.J., Vyn, T.J., Chandler, K. and Shrestha, A. 1998. Weed management strategies for no-till soybean (*Glycine max*) grown on clay soils. Weed Technol. 12:660-669.

Swanton, C.J., Weaver, S., Cowan, P., Van Acker, R., Deen, W. and Shrestha, A. 1999. Weed Thresholds: Theory and Applicability in Expanding the Context of Weed Management. J. Crop Prod. 2:9-29.

Ulrich, D., Martin, K., Kutcher, H.R., Brandt, S.A., Johnston, A.M. and Kirkland, K.J. 1999. Increasing the frequency of canola and pea in rotations. Page 158 *in:* Proc. Saskatchewan Soil Conservation Association, Indian Head, SK.

Ulrich, D., Martin, K., Kutcher, H.R., Brandt, S.A., Johnston, A.M. and Kirkland, K.J. 1999. Increasing the frequency of canola and pea in rotations. Pages 421-425 *in:* Proc. Soils and Crops'99, Extension Division, University of Saskatchewan.

Vyn, T.J., Opoku, G. and Swanton, C.J. 1998. Residue management and minimum tillage systems for soybean following wheat. Agron. J. 90:131-138.

Wall, D.A. and Smith, M.A.H. 1999. Weed management in common buckwheat (*Fagopyrum esculentum*). Can. J. Plant Sci. 79:455-461.

Wall, D.A. and Smith, M.A.H. 1999. Control of volunteer flax in wheat. Can. J. Plant Sci. 79:463-468.

Wall, E., Weersink, A. and Swanton, C. 1998. Ontario Agriculture and ISO 14000. Rpt. for the Ontario Farm Environmental Coalition and the Ontario Federation of Agriculture. 47 pp.

Wolf, T. [1999.] Making sense of new nozzle choices. [Agriculture and Agri-Food Canada, Alberta Agriculture, Food and Rural Development, Dow AgroSciences, Manitoba Agriculture, Saskatchewan Agriculture and Food.] Agdex 744-1. 6 pp.

Wolf, T.M. 2000. Low-drift nozzle efficacy with respect to herbicide mode of action. Aspects Appl. Biol. 57:29-34.

Xie, H.S., Caldwell, B.C., Hsiao, A.I., Quick, W.A. and Chao, J.F. 1995. Spray deposition of fenoxaprop and imazamethabenz on wild oat (*Avena fatua*) as influenced by environment. Weed Sci. 43: 179-183.

Xie, H.S., Hsiao, A.I. and Quick, W.A. 1994. Effect of temperature on the phytotoxicity of imazamethabenz and fenoxaprop to wild oat (*Avena fatua*). Crop Prot. 13:376-380.

Xie, H.S., Hsiao, A.I. and Quick, W.A. 1994. Effect of shading on the activity of imazamethabenz and fenoxaprop in wild oat (*Avena fatua*). Weed Sci. 42:66-69.

Xie, H.S., Hsiao, A.I. and Quick, W.A. 1996. Influence of temperature and light intensity on the absorption, translocation, and phytotoxicity of fenoxaprop and imazamethabenz in *Avena fatua*. J. Plant Growth Regul. 15: 57-62.

Xie, H.S., Hsiao, A.I. and Quick, W.A. 1997. Influence of drought on graminicide phytotoxicity in wild oat (*Avena fatua*) grown under different temperature and humidity conditions. J. Plant Growth Regul. 16:233-237.

Xie, H.S., Hsiao, A.I. and Quick, W.A. 1997. Effect of environment on wild oat (*Avena fatua*) control with imazamethabenz or fenoxaprop tank-mixed with additives or MCPA. J. Plant Growth Regul. 16: 63-67.

Xie, H.S., Hsiao, A.I., Quick, W.A. and Hume, J. 1996. Influence of water stress on the absorption, translocation, and phytotoxicity of fenoxaprop and imazamethabenz in *Avena fatua*. Weed Res. 36: 65-71.

Xie, H.S., Quick, W.A. and Hsiao, A.I. 1994. Spring cereal response to imazamethabenz and fenoxaprop-P-ethyl as influenced by environment. Weed Technol. 8:713-716.

Xie, H.S., Quick, W.A. and Hsiao, A.I. 1994. Effect of drought and formulation on wild oat (*Avena fatua*) control with imazamethabenz and fenoxaprop. Crop Prot. 13:195-200.

Minutes from the Herbicide Resistance Action Committee

November 15, 1999
By Jamie Retzinger, Secretary

The technical representatives from the main herbicide-producing Companies form the industry-led Herbicide Resistance Action Committee (HRAC) met in Brighton, UK. The purpose of this working group is to establish more effective communications to alert all people involved in the research, production, marketing, registration and use of herbicides to the potential problems of herbicide resistance and how it can be prevented/managed.

The HRAC web page (**http://www.plantprotection.org/HRAC/**) has been recently updated to include the following publications: Role of Industry in Resistance Management, Weed Resistance Guidelines, in 2000 an updated HRAC Herbicide Classification containing the new herbicides introduced at the Brighton conference, a publication authored by Dr. Stephen Moss, "Detecting Herbicide Resistance", "Financial Risk of Resistance" by James Orson. A color poster on " The World of Herbicides" which groups herbicides by location in the plant and site of action". This poster will be put on the web page in early 2000 and have color copies available for order in 2000.

There are direct links to Ian Heap's Weed Resistance Survey, a HRAC supported project, along with hot links to the Fungicide Resistance Action Committee, Insecticide Resistance Action Committee, Global Crop Protection Federation and the Plant Pathology Internet guidebook. Ian Heap maintains a listing of confirmed resistant weeds from around the world, 232 as of 11/15/99 (http://weedscience.com). Soon to be added will be the ability to search by: resistant species by country, degree of infestation by species, species by herbicide. Hot links will be added from Ian's site to HRAC publications.

Dale Shaner, HRAC Chairman, presented a paper on "Effectiveness of mode of action labeling for resistance management: a survey of Australian farmers" at the Brighton conference. A copy of the paper is available from the HRAC web site.

Guidelines for research proposals dealing with resistance management can be found on the HRAC web site.

Dr. Max Landes, BASF was voted the new Chairperson for HRAC.

The European Herbicide Resistance Working Group Report reported the inclusion of new members from Poland, Hungary, and the Czech Republic . *Papaver rhoeas* (poppy) has been found that is resistant to the ALS, hormone and both herbicide groups in Spain. In Greece, and Italy *Papaver* resistance has been confirmed to both 2,4-D, sulfonylureas (SU's) and imazethapyr but not to other IMI's.

In Saudi Arabia, *Lolium rigidum* resistance in cereals is an increasing problem with *Lolium* resistant to trifluralin, pendamethalin, chlorotoluron and isoproturon soil applied. Variable control, ranging from good to poor depending on the population was achieved with clodinafop, diclofop-methyl, tralkoxydim, and flurtamone.
Mexican HRAC sponsored an International Seminar on Herbicide Resistant Weeds in Guanuajuato, Gto. March 5-7, 1999. Trials and demo plots having problems with *Phalaris* resistant to herbicides in wheat was viewed by 200 weed control specialists.
The group has translated the following reprints in Spanish:

- Classification of Herbicides According to Mode of Action
- HRAC Guidelines - How to Minimize Resistance and How to Respond to Cases of Suspected and Confirmed Resistance.

The North American Herbicide Resistance Working Group conducted an e-mail exchange of information as the fall meeting was postponed to December 16-17.
1. The following information has been shared on any new confirmed and suspected cases of resistant weeds in the US and Canada. 1- Group 22(D) 1- Group 4 (O) 9- Group 2 (B) Seven new species the rest just additional locations.

a. Paraquat tolerant/resistant goosegrass in Florida
b. Suspected ALS resistant shattercane (*Sorghum bicolor*) in Missouri
c. Group 4 (synthetic auxin) resistant hemp nettle (*Galeopsis tetrahit*) western Canada
d. ALS resistant ball mustard (*Neslia paniculata*) western Canada
e. ALS resistant green foxtail (*Seteria viridis*), giant foxtail (*Seteria faberi*)in Wisconsin and Illinois.
f. ALS (FIRSTRATE & SPIRIT) resistant ragweed (*Ambrosia* sp) in Indiana, Ohio and Iowa.
g. ALS-IMI resistant NIGHTSHADE black nightshade (*Solanum nigrum*) and Eastern Black nightshade (*Solanum ptycanthum*) in Minnesota, Wisconsin and North Dakota
h. North Dakota : ALS (not SU) resistant redroot pigweed (*Amaranthus retroflexus*) North Dakota
i. ALS (both IMI and SU) waterhemp pigweed (*Amaranthus rudis*) North Dakota
j. ALS (both IMI and SU) wild mustard, *(Sinapis arvensis*), - North Dakota
k. ALS resistant downy brome (*Bromus tectorum*) in Oregon.

New business will include a discussion on the gene movement in herbicide tolerant crops

a. In Canada there are confirmed reports of gene infiltration between Roundup Ready (glyphosate) and Liberty Link (glufosinate ammonium) canola (*Brassica napus* L). fields, creating crop volunteers with stacked genes (double resistance). This has created some problems in controlling volunteers, particularly with organic growers and no-till growers who routinely apply Roundup as a pre-seeding burn-off. First season field surveys have been completed. Monitoring for out crossing from Brassica napus to wild mustard *(Sinapis arvensis*), dog mustard, (*Erucastrum gallium*) and Brassica rapa is being monitored. No cases of out crossing have been reported to date.

b. Roundup Ready spring wheat registration is pending in Canada and discussions in managing herbicide tolerant (HT) volunteers and gene flow to weedy species.
c. The development of Roundup Ready, IMI, and SU resistant cultivated sunflower in North Dakota.
d. In Oregon ROUNDUP READY bentgrass and Kentucky bluegrass have raised some interesting questions for the Willemette Valley of Oregon. This area produces grass for use on golf courses and for turf. These perennial species outcross with native and naturalized relatives, and are weedy in their own right.
e. Update on the continuing studies on gene flow between wheat and jointed goatgrass. More hybrids are being found under field conditions than have previously been reported and selfing BC1 plants in greenhouse studies

Minutes from The Herbicide Resistance Action Committee – North America (HRAC-NA) formerly known as the North American Herbicide Resistance Working Group (NAHRWG)

HRAC-NA is focusing efforts on 3 primary charters relative to resistance management and communication efforts:

Identification of Weed Resistance
Educational Tools to Promote Resistance Mgmt
Educational Strategies

In pursuit of these objectives, HRAC-NA is sponsoring intensive use of Ian Heap's, weedscience.com, which will be redesigned to include a portion of the website devoted to HRAC-NA objectives. In addition, a promotional effort will insure increased awareness that will make the site a centralized resistance management resource acting as a repository of resistance management tools, as well as an access point for local information across North America.

Local resistance information access (i.e., individual state resistance recommendations/data) will require support from resources within each state university.

Ian will be contacting individuals within state or provincial government systems to assist our efforts with the site. HRAC-NA wishes to thank those of you that agree to support our efforts to make resistance management tools more accessible.