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Ministry of Agriculture,
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Ministère de l'Agriculture,
de l'Alimentation et des Affaires rurales

Agri-food research La recherche agro-alimentaire

IN ONTARIO

EN ONTARIO

FOOD SYSTEMS
2002

The background image of the cover is a composite. The upper portion shows a field of tall corn plants with their tassels reaching towards a bright blue sky with scattered white clouds. The lower portion features a close-up of two ripe, red tomatoes with green leaves and water droplets on their skin. The cornfield is reflected in a green, wavy surface that looks like water, and the tomatoes are in the foreground, partially overlapping the reflection.

Keeping Ontario
in the forefront
of safe food
production

Research for Reduced Pesticide Use and Sustainable Production

Like many of our successes, safe food production in Ontario is better appreciated abroad than here at home. Take for example a recent global report evaluating pesticide reduction. Canada is leading the world, says the Organization for Economic Cooperation and Development, who also singled out Ontario as Canada's most advanced province in this field. To date, this good-news story has gone largely untold.

That's why this special issue of *Agri-food research in Ontario* is devoted entirely to research funded by Food Systems 2002. Almost a decade into this 15-year program, there are already many achievements to report. But first, a bit of history.

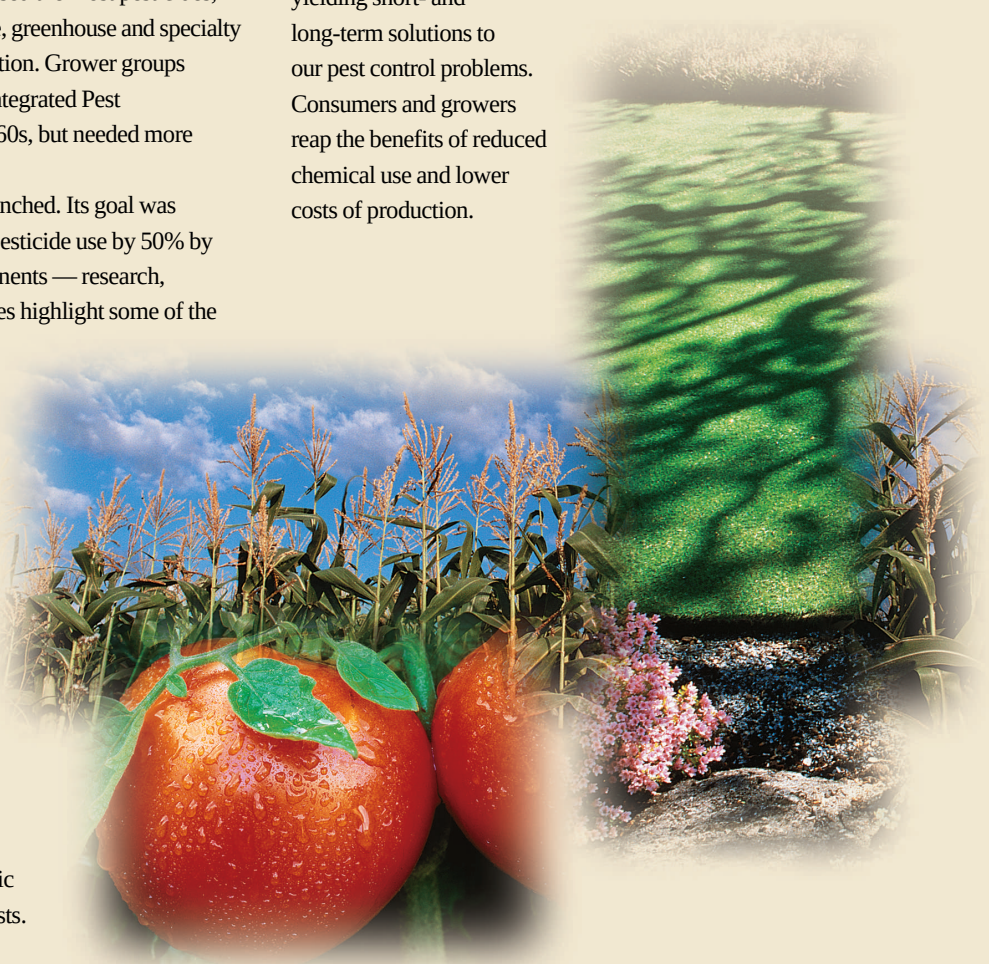
Food Systems 2002 was inspired by concerns about synthetic chemical pesticide use in agriculture. Possible food and water contamination, increasing pest resistance, fewer new pesticides, and a lack of non-chemical alternatives were some of the burgeoning issues. Overall, field crops used the most pesticides, but intense production of fruit, vegetable, greenhouse and specialty crops made them prime targets for reduction. Grower groups had been active in the development of Integrated Pest Management strategies since the late 1960s, but needed more research to further their efforts.

In 1988, Food Systems 2002 was launched. Its goal was ambitious: to help Ontario growers cut pesticide use by 50% by the year 2002. FS 2002 has three components — research, education, and field delivery. These pages highlight some of the innovative research supported by the program. The education component has involved financial support for pesticide certification programs for growers and vendors. Field delivery has meant the hiring of IPM specialists, along with 'partnerships' — before it was a buzzword! — with grower organizations, the pesticide industry, and Ministry of the Environment and Energy. This cooperative effort has, among other things, resulted in over 35,000 kg and 55,000 litres of waste pesticides being collected and safely disposed. And every year, 500,000 plastic pesticide containers are recycled into posts.

Success in pesticide reduction has been directly related to farmers' support for a clean, safe environment, and their openness to change. Active in advisory committees and supporting disease and pest scouting services with their wallets, farmers have also banded together to form the Environmental Farm Coalition. The Coalition has developed an environmental farm planning process that is now the model in 20 countries around the world. Their efforts have been complemented by Best Management Practices publications, which provide sensible guidance for remedial actions on the farm. In word and deed, growers and their organizations have supported FS 2002.

So it's not surprising that pesticide use is on the decline in Ontario: a 28% reduction occurred between 1983 and 1993. In absolute terms, this reduction is especially significant when you consider that agricultural productivity has risen.

Almost a decade into its mandate, FS 2002 is yielding short- and long-term solutions to our pest control problems. Consumers and growers reap the benefits of reduced chemical use and lower costs of production.



Agri-food research La recherche agro-alimentaire

IN ONTARIO EN ONTARIO

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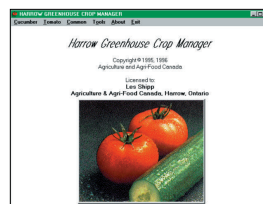
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Food Systems 2002 targets
pesticide reduction in three
major areas: horticultural,
field, and turf crops. By far
the largest is horticultural,
which in addition to fruits
and vegetables includes
specialty crops such as
ginseng and tobacco. Ontario
is a world leader in cutting
pesticide use.

Photos:
Tomatoes and Cornfield —
Mark Tomalty/Masterfile
Turf —
Freeman Patterson/Masterfile

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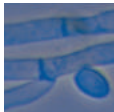
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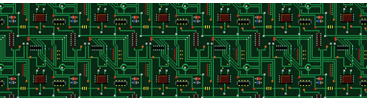
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HARBOURING

Fostering predatory mite populations to fight

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Pesticides that are used to manage insects also inadvertently reduce the natural enemy complex in Ontario's fruit orchards. Without predators, mite control requires extensive acaricide use. Research is underway to conserve predators and restore biological control.

Biological control is but one tool in the sophisticated and interactive management strategy known as IPM. Making biological control work requires a comprehensive understanding of species behaviour, species interaction, ecosystem dynamics, and the impact of control methods – such as predator release and dispersal rates – on the target species and the entire ecosystem.

In most ecosystems, spider mites are controlled by natural predators. In orchard ecosystems, mites are controlled by as many as three acaricide applications – a practice that has, over time, substantially reduced the population and effect of natural predators. It also makes them the most expensive pest of some of Ontario's most valued crops.

A Food Systems 2002 study was conducted in fruit orchards to assess the impact of pesticide and biological control methods on spider mites and their predators. A central concern was the impact of pesticide use on a mass-reared natural enemy, *Amblyseius fallacis*, when released to control spider mites.

One area of research was the combination of chemical and biological control methods. There can be effective pest control when low-dosage

Adult and nymph of the important mite predator, *Amblyseius fallacis*, feeding on eggs of the European red mite on a peach leaf.



THE ENEMY

spider mites and reduce spray use in fruit crops

applications of pyrethroids follow early season predator release. However, a repellent effect of the pesticide application on the predators was discovered, and overcoming this remains a challenge.

To address this, research was conducted on the benefit of placing refuges – or micro-habitats – to protect beneficial predators from the effects of pesticide applications. These were simulated by placing polyethylene sheeting over parts of apple trees to create shelters for predators that, in turn, effectively controlled the phytophagous (plant-damaging) mites. In the control areas, the effect of the sprays was to upset the natural population dynamics for up to 11 weeks.

The research challenge remains to develop effective combinations of predator releases, application of fewer residual sprays, and understand the effects of predator dispersal and refuges in crops.

Growers could save up to \$120 per hectare – or two sprays – if they applied some of the above techniques. Further, less acaricide use could also translate into less contamination of groundwater by some of these materials. ■

Healthy foliage of pear (upper) and damaged foliage, resulting from feeding by European red mite.



Fruit crops receive 38% of the insecticides and acaracides applied annually in Ontario. Apples receive about 21% of the provincial load, and all other fruits together receive 17%.



In a 1996 experiment at Jordan, researcher Rudolf Harmsen attaches plastic bags to apple trees to simulate unsprayed refuge areas.

Polling the Problems in Oriental ^{AND} Ethnic vegetables

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Over 500,000 people of Asian descent live in or near Toronto and Hamilton. Southern Ontario's vegetable growers produce the equivalent of 2500 ha of oriental vegetables to serve this burgeoning market. But not much has been known about disease and pest problems. Until now.

Southern Ontario produces most of the oriental and exotic vegetables grown in Canada. In 1993-94, researchers made a series of visits to growers' fields and greenhouses. Their aim was to produce a comprehensive survey on the incidence and severity of diseases, insects, nematodes, and abiotic problems. This collaborative effort involved Agriculture and Agri-Food Canada, Ontario Ministry of Agriculture Food and Rural Affairs, Stokes Seeds Ltd., and Zhejiang Agricultural University in China. Areas of production and market value were greatest for cruciferous oriental vegetables in comparison to legumes, cucurbits or other vegetable families grown for the oriental market.

The most serious diseases on oriental cruciferous vegetables were:

- downy mildew
- pseudocercospora leaf spot
- turnip mosaic virus
- soft rot
- alternative leaf spot.

SOME BETTER-KNOWN ORIENTAL VEGETABLES:

- *bok choy*
- *snow peas*
- *lo bok (Chinese radish)*
- *guy lahn (Chinese broccoli)*
- *nappa (Chinese cabbage)*

The major pests affecting this group included:

- cabbage maggot
- green peach aphid
- flea beetles.

Other production problems included:

- boron deficiency
- tip burn
- bolting
- losses due to weed infestations arising from no or improper herbicide usage, and
- unharvested plants due to a shortage of labour or poor market conditions.

By identifying these constraints, it was possible to prioritize grower needs with respect to research. Several fungal, viral and bacterial diseases new to Ontario were also noted.

The epidemiology, ecology and methods to control diseases and pests of oriental vegetables have not been investigated in Canada. Also, seed for vegetable production is often imported directly from the Orient without phytosanitary certificates, and may harbour organisms new to Canada that could pose a threat to the production of traditional vegetables.

The results of this survey will assist in the development of increased market potential and production for export to Asian communities in the United States. Also, Ontario's vegetable pest management programs have been enhanced as a result of the new production, disease and pest information that was obtained. Other regions that grow these crops, such as Vancouver, Montreal and parts of Alberta, can benefit too. Inspired by the survey initiative, Ontario oriental vegetable growers organized their first meeting to discuss production constraints. A list of multilingual names of oriental vegetables was compiled for inclusion in OMAFRA's Publication 363, *Ontario Vegetable Production Guide*. ■

Bacterial inoculants

crops can say no to plant disease

IPM techniques often focus on pest identification, monitoring, and control methods. But there's much to be said for prevention. Healthy, fast-growing crops not only yield more, but can better resist stress, disease, and insect infestation.

Modern plant breeding and improvements in cultural methods have enhanced crop performance and resistance to pests. This progress can be further enhanced by advancements in other areas of research.

One such area is rootzone (rhizosphere) organisms. These organisms, beneficial bacteria and vesicular arbuscular mycorrhizae (VAM), can improve nutrient uptake, control disease using fungi and bacteria, induce disease resistance mechanisms in plants, and raise levels of plant growth-related hormones. Growers recognize these benefits in terms of reduced fertilizer and pesticide costs, improved crop performance and better yields.

This particular study focused on the impact of a *Pseudomonas* sp. bacterium on the growth of tomato and potato. The research question was: would inoculated plants outperform non-inoculated ones?

To answer this, the study was divided into two parts. The first was a controlled study to observe performance differences in a controlled environment using tissue culture. The second was an in-field comparison of inoculated and non-treated transplants.

Results of the first study showed conclusively that inoculated plants were taller, had greater biomass, more lignin, better root development, and better photosynthate production. The second (field) study results showed significant yield increases with inoculated crops, but the results varied by site and cultivar. The most common response of bacterized plants in the field-grown potatoes was earlier stolon and tuber formation, plus an increase in tuber yield. Earlier blooming and fruit set were also recorded with tomatoes.

However, in some cases there were no yield increases. Deducing that there must be antagonists reducing the impact of the inoculated bacteria on plant performance, a followup study was conducted. A mutagenetic strain of the *Pseudomonas* bacteria was used to investigate the molecular regulation of growth promotion. A DNA fragment related to growth promotion was identified and sequenced. And, when placed into a plasmid vector, growth promoting activity was restored. The challenge remains to isolate and efficiently replace the smallest region of DNA that can have the same impact.

The significance of this work is that bacterization can improve potato yields by 10%, accelerate harvests by two weeks and perhaps, more profoundly, buffer prolonged stress effects while maintaining productivity. Dependence upon pest control products is reduced with bacterized, stronger crops.

The challenge remains to find and learn to manage similar, beneficial rhizosphere organisms for other high value crops. ■

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Shown below are the significant growth improvements in bacterized potato explants grown under tissue culture.



GET THE DRIFT?

Sprayer technology research keeps vineyard pest management on target

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For effective pesticide application in vineyards, grape growers must know their target, select the right control method, and adjust for conditions. By evaluating vineyard sprayers, researchers are helping growers hit the mark.

A common objective in pest management programs is optimum pest control with minimum economic and environmental costs. The costs and effectiveness of pesticide application depend on the efficient deposition of active spray ingredients on the target crop. Ideally, all spray should reach the target crop.

However, sprayer performance will influence the deposition and dispersion of spray in the environment. With the rapid expansion of urban development and proximity of residential areas to farms and vineyards, the off-target drift of agrochemicals is a mounting concern. Besides

wasting time and money, drift can cause off-site damage to the environment, wildlife habitat and beneficial insects.

Until recently, not many reliable data had been compiled on the nature and extent of spray droplet drift from air-blast sprayers used in vineyards. A collaborative project involving the Horticultural Research Institute of Ontario and Agri-food Laboratory Services was initiated to study drift, sprayer performance and image analysis detection techniques.

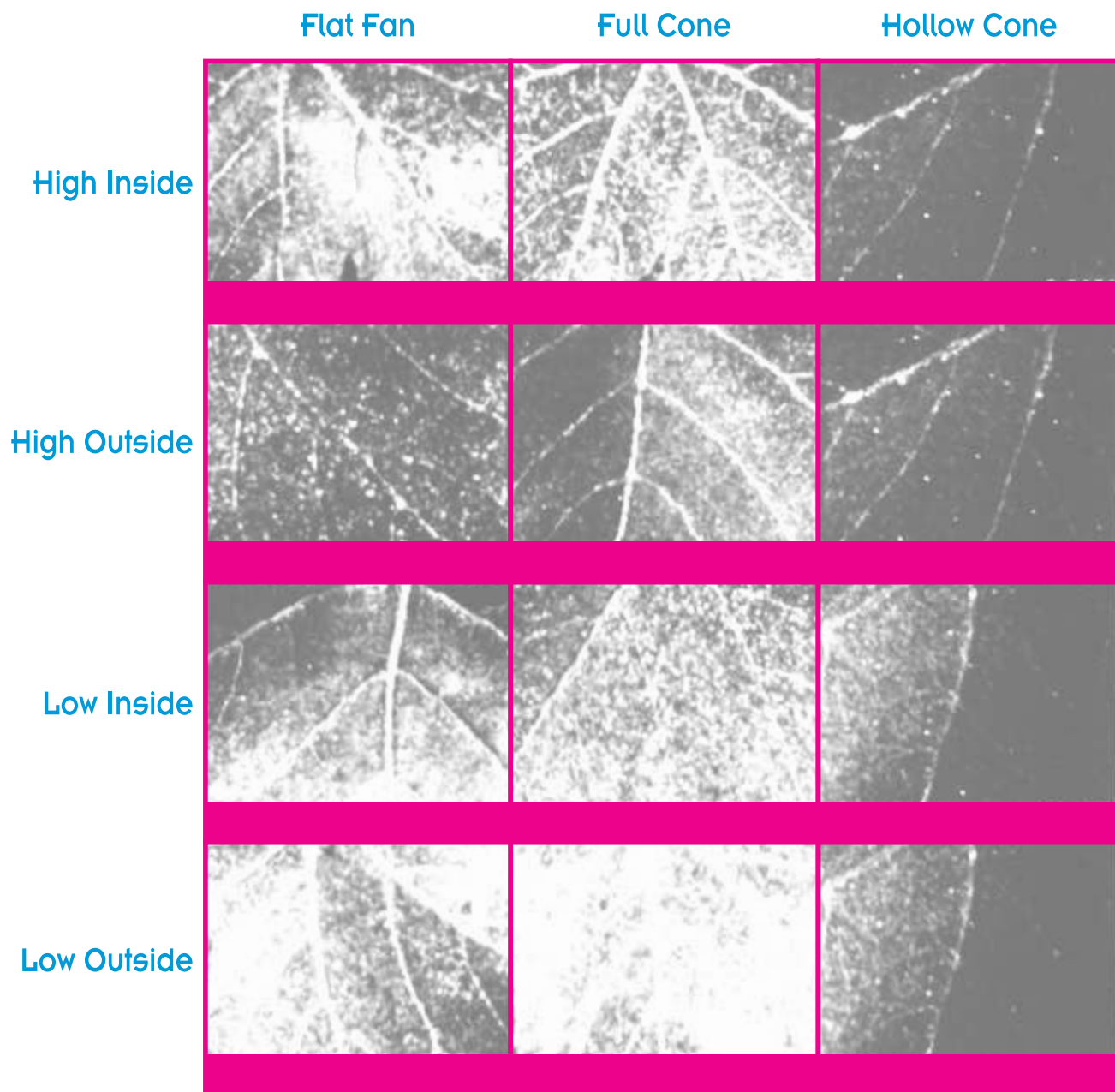
Researchers used Uvitex OB™, a fluorescent food whitener, to mimic pesticide deposits on target grape leaves. Horizontal drift was measured by placing paper sheets at 5, 10, 20, 40 and 80 metres from sprayed rows. Vertical drift was measured with string suspended between 6-metre vertical masts, placed up to 80 metres downwind of the vineyard. Three techniques were used to analyze tracer deposits: chemical analysis to measure the drifted droplets that landed on the paper and strings, and image and chemical analyses were done on the leaves.

The results were somewhat surprising. Contrary to the claim of those who believe air-blast sprayers produce significant drift, more than 99% of the pesticides remained in the vineyards. In fact, no more than 0.2% of spray solution was deposited 5 metres or more from the canopy. Only 0.05% of the solution was airborne, detected 40 and 80 metres downwind.

The flat fan nozzle did not produce less drift than the hollow cone and full cone nozzles. However, the flat fan nozzle deposited more tracer on both upper and lower leaf surfaces.

This research confirms that when growers follow proper procedures with air-blast sprayers in vineyards, drift is minimal. Further research may lead to improved product deposition and help reduce overall pesticide use in vineyards. ■

N O Z Z L E T Y P E



Tracer percent area coverage on the lower surface of grape leaves at growth stage 3 (veraison), when berries turn colour. Leaves were collected from four parts of the grape canopy after spraying. This photo reveals the droplets of Uvitex OB™ fluorescing on the leaves' surface for each nozzle type.

LETTING IN THE LIGHT

leaf removal helps fight GRAPE BUNCH ROT

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Seasonal crop losses to bunch rot in a vineyard can be as high as 100%. Leaf removal can reduce bunch rot disease — and the pesticides used to control it — without reducing grape yields or quality.

Botrytis bunch rot or grey mold is a fungal infection that grape growers don't want to see in their vineyards. This fungus can infect the blossom and the fruit, and is one of the most damaging diseases to affect wine grapes in Ontario. It can be a particular problem in the Niagara region. Within the canopy, the warm, humid micro-climate further encourages infection and growth of this disease.

Chemical resistance is another problem. There are few effective pest control products, and growers need to spray several times during the growing season. A team of researchers at Vineland looked at how cultural methods could strengthen grapes' natural defenses against fungal infection.

Grape growers and researchers alike had noticed that grape bunches fully exposed to wind and sunlight developed thicker cuticle and wax layers. Berries with enhanced cuticle and epicuticular wax development were also able to resist *Botrytis* bunch rot better than shaded, crowded fruit, and some varieties were much more responsive than others. The research challenge was to develop practical cultural methods that would capitalize on this response, particularly for susceptible cultivars.

Leaf removal treatments were applied to Riesling 1990 and to Riesling, Cabernet Franc and Optima vines in 1991. Shaded and exposed clusters were sampled prior to veraison (for Riesling) and before harvest (for all three varieties).

Observations were made by cultivar regarding berry exposure, berry-to-berry skin contact and time of sampling on cuticle formation and incidence of bunch rot. Qualitative assessment of membrane and wax development on contact and non-contact berries



was conducted using cryogenic electron microscopy. Enzymatic separation and chloroform extraction techniques were used for quantitative assessment.

The results were conclusive. Exposed Riesling berries had significantly more wax and cuticle development than shaded berries. Also, loose, open berries had more wax development than similar skin areas where berries touched adjacent berries. Although there were differences among cultivars – Cabernet Franc was the most tolerant and Optima the most susceptible to *Botrytis* bunch rot –

there was generally more wax and cuticle on exposed samples.

In summary, exposure, cultivar and amount of surface area contact were all important factors in cuticular membrane formation, which in turn was directly related to bunch rot resistance.

Thicker cuticle and increased wax formation helped reduce the incidence of bunch rot, thereby improving fruit quality. Growers can benefit from this research by adjusting their cultural practices: leaf removal improves fruit quality. ■



Researchers Helen Fisher and Dave Percival examine grapes for incidence and severity of bunch rot disease.

Baiting harvester ants in tobacco seedling greenhouses

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Harvester ants have been a significant problem in tobacco greenhouses for almost 20 years. The subsequent use of insecticides has taken a heavy toll in time, resources, and worker exposure. Analysis of the problem and a management program are providing another way out.

In the late 1970s, a few tobacco producers began to see mysterious thin patches in seedling beds in their greenhouses. Seedling numbers were reduced, and in extreme cases no useful transplants could be harvested. More greenhouses were affected in following years. Finally, in 1984 an alert grower observed ants in the affected area of the seedbed as they collected and carried seed back to nondescript burrows that were frequently located along the central walkway of the greenhouse.

By 1993, some growers attempting to control ants in their greenhouses were applying insecticides two to three times per week. In extreme cases, daily application was reported. Costs to affected growers in time, resources and worker exposure were thus quite high. In 1994, to both provide Ontario growers with a more effective ant-management program and reduce worker exposure to insecticides, Food Systems 2002 funded research to identify, quantify and develop effective management programs for harvester ants.

Surveys suggested that ants were present in approximately 20% of greenhouses. From 1994-95, more than 23,000 ants were collected from over 20 problem greenhouses. Two species of ants known to harvest seeds were identified. The pavement ant, *Tetramorium caespitum*, an introduced species that was captured in every greenhouse, comprised over 60% of total captures. The thief ant, *Solenopsis molesta*, is a tiny, native species that also contributed to the problem. Populations were generally unevenly distributed in the greenhouse.

Early management programs that involved spraying insecticides onto the seedbed, only killed ants foraging for seed. Ant baits, treated with slow-

Spreading granular ant bait in tobacco seedbeds. A new bait that can eliminate entire ant colonies should be available by the end of this year.



safer, cheaper alternatives to insecticide spray programs

acting stomach poisons, have been shown to effectively eliminate entire colonies – foragers return the bait to the nest where worker ants then feed it to the queen and the brood. This project identified a granular ant bait that satisfactorily controlled both artificial colonies in the greenhouse and single colonies of the pavement ant in the field. The bait should be available to Ontario growers in late 1997. Insecticides providing superior control of foraging ants were also identified. Label expansion to include pavement ant is being pursued.

Given a choice, pavement ants much preferred fresh corn meal to dry tobacco seed. By providing a continuous supply of corn meal, diligent growers might well avoid use of insecticides during the critical period of seed sprouting and seedling establishment. Alternatively, growers can monitor harvesting of corn meal from bait stations and concentrate management programs in problem areas of the greenhouse.

Print, oral and extension materials have already circulated results of this study to the grower community. ■



Pavement ant, *Tetramorium caespitum*, is the main harvester ant in Ontario tobacco greenhouses.



Pavement ants feeding on corn meal, which they prefer to tobacco seed. Growers can avoid insecticide use during critical periods by providing a continuous supply of corn meal.

LES SHIPP

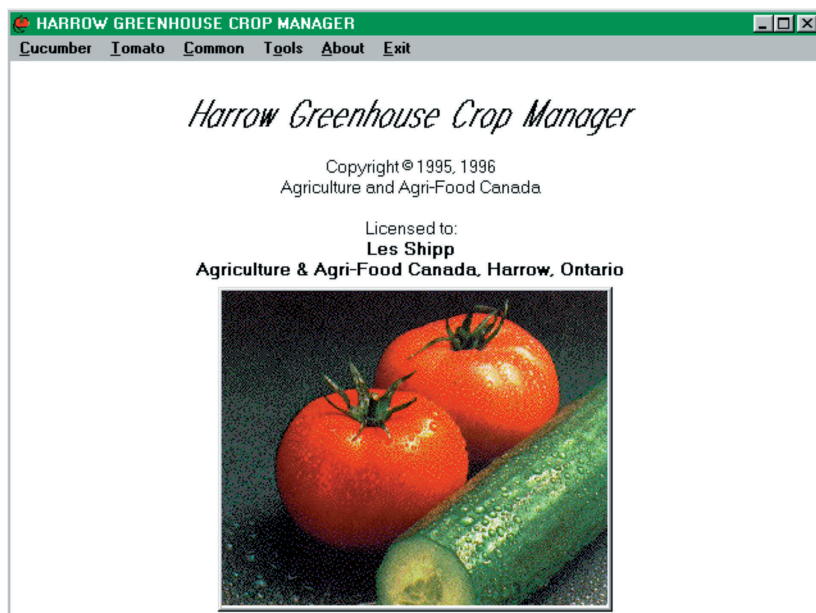
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under new

a decision-support system HELPS GREENHOUSE

Ontario's greenhouse vegetable industry is very technologically advanced, progressive, and fast-growing — expanding at a rate of 20% over the last two years. It's also fiercely competitive. A decision-support system is currently being field-tested that will help growers keep pace with the latest production and control practices, and integrate them, where appropriate, into their own operations.

Main interface screen for the Harrow Greenhouse Crop Manager.



At the Greenhouse and Processing Crops Research Centre, a software program has been developed for integrated crop management of greenhouse tomato. Its purpose is to assist the grower in:

- eliminating pesticides through the use of non-chemical disease and arthropod pest control strategies
- reducing energy consumption by optimizing the greenhouse environment, and
- conserving water and fertilizer use in greenhouse tomato production.

The software also aids the integration of all crop management practices into one common farm management approach — helping the grower make decisions and solve problems.

A multidisciplinary team, consisting of experts in pest management, crop management and engineering, extension advisors (pest and production), computer experts from private industry, and growers, was used to develop the interactive user-friendly decision-support system known as Harrow Greenhouse Crop Manager, or HGCM.

The HGCM assists the grower in accessing, assimilating and integrating the latest production and control practices into their commercial operations. It provides advice on identification and control of pests and physiological disorders, and information on all aspects of production. A database is included to help the user record, tabulate and present graphical and tabular reports on the efficacy of different greenhouse tasks, yield data, pest monitoring, material purchases and employee records. In addition, the HGCM includes programs that calculate climate information, such as vapor pressure deficit or dew point, and the concentration levels of nutrients for fertigation systems.

management

TOMATO GROWERS slash pesticide use

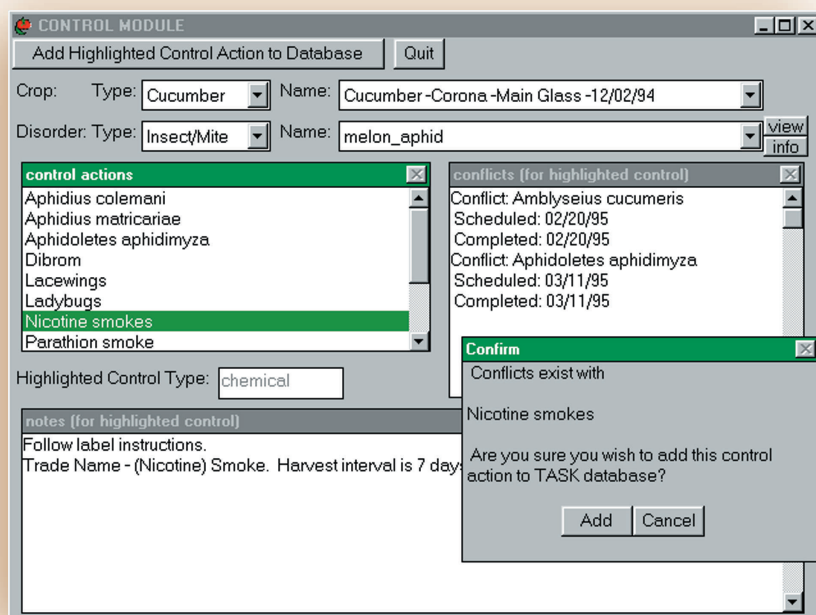
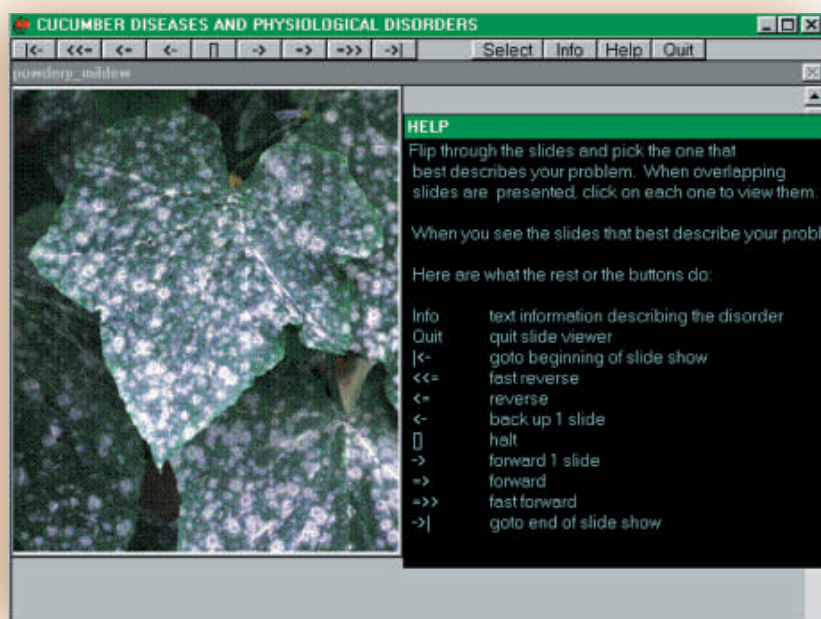
Sample screen of the diagnostic module showing powdery mildew symptoms and how to use the picture key.

The program's major benefits include:

- 80-90% reduction (or even complete elimination) in pesticide use
- 40-80% reduction in fertilizer and water output into the environment
- creation of a healthier work environmental and greenhouse ecosystem
- 24-hour access to a centralized and well-organized information system containing data on all aspects of greenhouse production
- avoidance of potential conflicting recommendations through the use of a common decision-making process
- presentation of greenhouse information in a variety of formats including pictures, text, graphs and tables.

The HGCM is currently being field-tested by a select number of greenhouse growers and evaluated by other experts to ensure the information is correct and up-to-date. Thus far, the responses from growers, extension advisors, industry personnel and researchers who have seen demonstrations have been very positive. ■

Sample screen demonstrating the control and conflict resolution modules. In this example, a selected control measure (nicotine smokes) will conflict with control actions (biological control agents) that are currently being used.



A GENTLER alternative FOR THINNING APPLES

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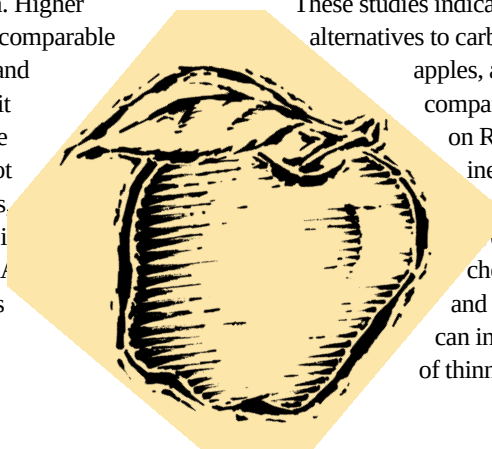
To improve fruit size and minimize alternate bearing, commercial apple growers must annually regulate the number of apple fruits on their trees at or shortly following bloom. But some of the chemical thinners used to ease the process can be toxic to bees and other beneficial insects. Alternatives were assessed in a series of orchard studies.

Regulating the number of apples is labour-intensive, expensive, and cannot be completed until the stage of "June drop", approximately 30 days after flowering. Synthetic chemicals such as carbaryl (CB), and natural chemicals such as benzyl adenine (BA) and naphthalene acetic acid (NAA), can be used to facilitate thinning shortly after flowering. However, the toxicity of carbaryl in particular is a concern.

In the first orchard study, NAA, BA and CB were evaluated on 9-year-old Starkrimson Delicious trees on MM.106 rootstock. BA was applied at three concentrations on June 8 when the fruitlets had a mean diameter of 10.46 ± 1.5 mm. Higher concentrations of BA produced comparable thinning effects to NAA or CB and resulted in an increase in the fruit length:diameter ratios. While the number of seeds per fruit was not affected by any of the treatments, there was an increase in fruit weight with greater concentrations of BA. This increase in fruit weight was greater than the effects of either NAA or CB.

In a second trial, Wilthin, an experimental bloom thinner, was applied to 11-year-old Idared and Empire trees on M.26 rootstock at full bloom (May 19), and to 9-year-old Redspur Delicious on MM.106 and 60-80% full bloom (May 20). These treatments were compared with CB and NAA applied on June 6 when the fruitlets were approximately 10 mm diameter. For Idared, NAA and CB thinned, but there was no significant difference in the number of fruit per tree or total yield between the Wilthin treatments and the unsprayed trees. No differences were observed in the length: diameter ratio between treatments, but NAA substantially reduced the number of normally developed seeds in fruit. For Empire, there was a reduction in the number of fruit per tree on the trees sprayed with various concentrations of Wilthin. However, the thinning effect was less than that caused by NAA or CB. For Redspur Delicious, there was a linear decrease in fruit set with increasing concentrations of Wilthin. Higher concentrations of Wilthin thinned as well or better than NAA or Carbaryl. Trees with the greatest yield reduction had the largest increases in trunk cross-sectional area. Fruit from trees sprayed with the highest concentration of Wilthin had a slight decrease in length: diameter ratio. Wilthin treatments also slightly reduced the number of normally developed seeds.

These studies indicate that there are useful alternatives to carbaryl for chemically thinning apples, and that Wilthin was comparable to carbaryl when used on Red Delicious, while ineffective on Idared or Empire. Also, NAA and BA were proven effective for chemically thinning Idared and Empire, and benzyl adenine can increase fruit size independent of thinning. ■



ORIENTAL FRUIT MOTH *and alternative insecticides* AN OFFER IT couldn't 'resist'

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Peach growers
are only too familiar with the
oriental fruit moth. It's the pest that
causes worms in the fruit of peaches and
nectarines. And, since nobody wants wormy
fruit, growers have had to control it. For
nearly 30 years, a spray program using
organophosphorus insecticides
did the job.



AARCF/ KÄTHLER

Oriental fruit moth injury on green peach. Researchers have identified chemical rotations that minimize the risk of resistance.

Unfortunately, the oriental fruit moth and its larvae fought back. It has now become resistant to several organophosphate (e.g., Imidan™) and carbamate insecticides (e.g., Sevin™).

Food Systems 2002 funded a study to assess resistance and to develop sustainable, alternative control methods. The work is ongoing. Here are some of the current findings.

Initial assessments in Niagara and southwestern Ontario revealed that oriental fruit moth was resistant to some – but not all – organophosphate products. For example, the pest was found to be resistant to azinphosmethyl and phosmet, but not acephate and chlorpyrifos, which are difficult for the pest to detoxify.

Recent findings indicate that the mechanisms for

resistance are enzymatic in nature: enhanced detoxification (using esterases) and the selection of a target enzyme (cholinesterase), which is not blocked or inhibited.

The use of pyrethroids provide an immediate control alternative to organophosphates, but they come with their own risks. Pyrethroids, because they can damage beneficial pest populations, are known to induce secondary pests such as phytophagous mites. Here, too, repeated applications run the risk of resistance.

The best advice to date is to apply rotations of acephate and chlorpyrifos and pyrethroids. So far, this method allows for effective control while minimizing the risk of resistance to pyrethroids. Assessment of this and similar techniques will continue during the 1997 season. ■

WIN—WIN

Fast-tracking herbicide registrations has vegetable growers and the environment on side

Many vegetable crops have great potential for expanded production in Ontario. But vegetable growers are facing an ever-dwindling selection of crop protection products. The market is simply not large enough for manufacturers to justify the research needed to obtain registration. The URMULE program aims to provide growers with quick access to newer, safer and more effective herbicides.

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"Minor" crops are generally understood to include most of the vegetables produced in Ontario. Growers of these small hectareage crops do not always have the benefit of pest management strategies that are available to growers of "major" crops.

Ontario growers have fewer pesticides available to them than their rivals elsewhere. To maintain competitiveness, local vegetable growers need access to a full complement of pesticide technology. At the same time, there is a need for pest management programs that are environmentally compatible and sustainable.

One solution offered by the federal government is the URMULE (user requested minor use label expansion) program. Under URMULE, the required information for registration is developed by researchers, not the manufacturers.

Currently there are few herbicides registered for use, yet weed control is one of the major problems facing growers. Lack of registered herbicides means higher input costs for hoeing and mechanical weeding, and reduced competitiveness in the market.

The availability of new, especially low-use rate herbicides for vegetable crops would minimize the impact on the environment of herbicide applications, and encourage sustainable production of these crops. Registration of such herbicides would lead to an integrated weed management



system for vegetable growers that includes use of herbicides and timely cultivations – in turn, reducing the cost of production and improving competitiveness.

Our research aimed to evaluate herbicides for weed control efficacy and crop tolerance in a number of vegetable crops. Field research was conducted on product effectiveness and crop safety, and for laboratory assays to determine the extent of residue levels (if any) in the raw product. Over the last two years, the herbicides were tested on several vegetable crops at the Horticultural Research Institute of Ontario in Simcoe. The vegetable crops grown included ethnic vegetables such as cole crops and snow peas, traditional cole crops such as cabbage, cauliflower and broccoli, and vine crops such as pumpkins and squash, as well as peppers and garlic.

Herbicides were applied at the proposed recommended rate, as well as twice the recommended rate to evaluate crop tolerance. Crop

injury was evaluated, weed biomass was recorded, and yield was recorded at harvest. Crop residues were taken as required. Where residues were required from three or more geographic areas, trials were also conducted on growers' fields.

Under the program, all data are submitted, with concurrence of the registrant, for registration to the Pest Management Regulatory Agency. The final step in the clearance procedure is labelling the minor use by the seller of the product in order that the vegetable grower will have available a fully tested and labelled product that can be legally used.

To date, in 1997, minor use registration has been obtained for Poast™ (sethoxydim), a postemergence grass herbicide, for use on broccoli and ethnic cole crops including Chinese cabbage, Chinese broccoli, bok choy, kohlrabi, and lo bok. Prowl™ (pendimethalin) has been labelled for use on onions grown on mineral soils. A number of other minor use registrations are pending. ■

Pesticides are often the single largest production cost for vegetable growers.

Weed management studies at Simcoe are helping speed up the registration process for new, environmentally compatible herbicides for Ontario-grown vegetables.



Knowing when to fight or switch

EARLY WARNING SYSTEM ALERTS GROWERS TO INSECTICIDE RESISTANCE

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Colorado potato beetle.

The Colorado potato beetle has demonstrated a high degree of resistance to insecticides. A system that provides early warning of resistance would be a valuable tool for growers to avoid loss of insecticides before field-level resistance occurs.

The discriminating bioassay technique and computer-based mapping and record-keeping process developed in this project will allow growers to monitor effectively and predict insecticide resistance.

The Colorado potato beetle (CPB) is the most important pest of potato and tomato crops in Ontario, and has been the focus of extensive control efforts using insecticides. Repeatedly, the beetle has developed resistance to each new class of insecticide introduced to control it. Current methods for monitoring resistance – while useful for identifying resistant populations – are not capable of detecting early stages of developing resistance prior to breakdown of insecticide control.

The purpose of this study is to develop a quick and easy method of identifying populations of potato beetles that are beginning to develop a low expression of resistance. This information will then be geographically referenced and coupled with a history of insecticide use on a field-by-field basis to predict future potential control failures. Armed with this information, potato and tomato growers and their consultants will then have the advantage of being able to choose alternative control strategies in order to avoid or slow the development of field expression of resistance. This will further benefit the industry by increasing the lifespan of current and new insecticides.

The first goal of this study is to evaluate current and modified bioassay techniques in order to determine the simplest and most efficient methods for exposing beetles to various insecticides. For those insecticides that act primarily on contact, a simple filter paper bioassay will be used. In this method, first instar larvae are exposed to a filter paper treated with insecticide (see below), and mortality rates are determined after 24 hours. For those insecticides such as *Bacillus thuringiensis tenebrionis* (Novodor™) that require ingestion in order to become active, some form of diet-incorporated bioassay, such as a leaf-dip method shown on the right, will be used. The leaf-dip bioassay method involves feeding first instar larvae a leaf that has been dipped into a specific dosage of insecticide. Mortality is determined after 48-72 hours.

Subsequently, these bioassay methods will be used to determine base-line susceptibility of populations of CPBs. Base-line susceptibility is the dosage of insecticide required to kill more than 95% of a completely susceptible strain of beetles. This dosage is known as a discriminating dose because it allows you to determine whether a population is completely susceptible to an insecticide or whether it is showing an increased level of tolerance. The discriminating dose will be used as a screen to distinguish quickly those populations of concern. If the discriminating dose kills at least 95% of a tested population, then those beetles are considered completely susceptible. If it kills less than 95%, there is reason to pursue more intensive bioassays on that population in order to determine if there is a relative

increase in tolerance. Screening only the suspect populations will reduce the time and effort required to evaluate and classify the populations.

These data and the history of insecticide usage in the fields where beetles were collected will be collated with geographic references into a Geographical Information System (GIS) database. This is a computer-based mapping and analysis system. Once in GIS, data can be displayed in an easy-to-understand visual

representation. Growers can see where resistance problems are beginning to develop in a region, and over time they can map the change and spread of resistance. This will allow growers to identify which areas are at risk of insecticide failures due to resistance, and provide a choice of using alternative management strategies to avoid widespread resistance.

Preliminary data obtained in 1996 have established base-line information for populations of CPBs in four major potato and tomato growing regions of Ontario (see table). These data indicate that most populations are resistant to several insecticides that have been used extensively, such as Guthion™, Ripcord™ and Thiodan™. No evidence of tolerance to the recently registered product, Admire™, was detected. ■



First instar larvae of the Colorado potato beetle placed on an insecticide-treated leaf surface.

First instar larvae of the Colorado potato beetle just after hatching from an egg mass and prior to exposure to an insecticide-treated filter paper.



LOCATION	AVERAGE LC ₅₀ VALUES ¹ FOR THE FOLLOWING INSECTICIDES			
	Guthion	Ripcord	Thiodan	Admire
Alliston	5.2a	0.16a	0.94a	0.14a
Essex/Kent	2.5a	0.06b	—	0.06a
Simcoe	7.3a	0.24a	0.78a	0.13a
Thedford	6.5a	0.17a	0.73a	0.19a
Control Std.	0.1b	0.03b	0.03b	0.12a

¹ values in each column followed by the same letter are not significantly different at P=0.05 (LSD test).

Average concentrations ($\mu\text{g}/\text{cm}^2$) of various insecticides used in filter paper bioassays that caused 50% mortality to first instar Colorado potato beetles collected from four growing regions in Ontario during 1996.

Health management

High yields of fungicide-free fruit satisfy

Many Ontarions count strawberries among their favourite foods, and seek berries of good eye-appeal and taste.

Production of high quality strawberries, however, requires a great deal of skill and attention by the grower, and the right tools to keep the crop healthy and vigorous. A broad study of disease management is yielding alternative control methods for growers, greater productivity of high quality fruit, and reduced fungicide use.



Botrytis fruit rot of strawberry. This disease can now be controlled by means of biological agents, without using fungicides.

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Ontario strawberries need protection from three destructive diseases – *Botrytis*, scorch and leaf spot – that variously affect the foliage, flowers and fruits. Common berry rot associated with *Botrytis* is familiar to almost everyone. Leaf scorch and leaf spot reduce plant vigor and fruit production in the field.

Protecting strawberries has become increasingly difficult in the last 20 years. Fungicides, traditionally the mainstay of strawberry protection, are less and less effective, because the pathogenic fungi that cause diseases have become increasingly insensitive to them. Further, the public has become concerned about residues of fungicides and other pesticides in food crops like strawberries. Clearly, alternative disease management methods are needed.

The goal of this study was to improve health management in June-bearing and day-neutral (“everbearing”) strawberries, while minimizing the need for fungicides. This goal was met by critical exploration of disease resistance in strawberries, development of effective biological control, identifying health problems in strawberry transplants, and integrating the available tools in a health management program.

Special techniques were developed that allow rapid and realistic quantification of disease resistance in large numbers of strawberry genotypes. The techniques involved use of leaf disks and detached flowers, and also seedlings of strawberry. They have the advantages of accounting for natural variability in the fungal pathogens that cause *Botrytis*, scorch and leaf spot, and avoid high variability in results due to weather, soil and other environmental factors encountered in traditional field plot methods.

in strawberries

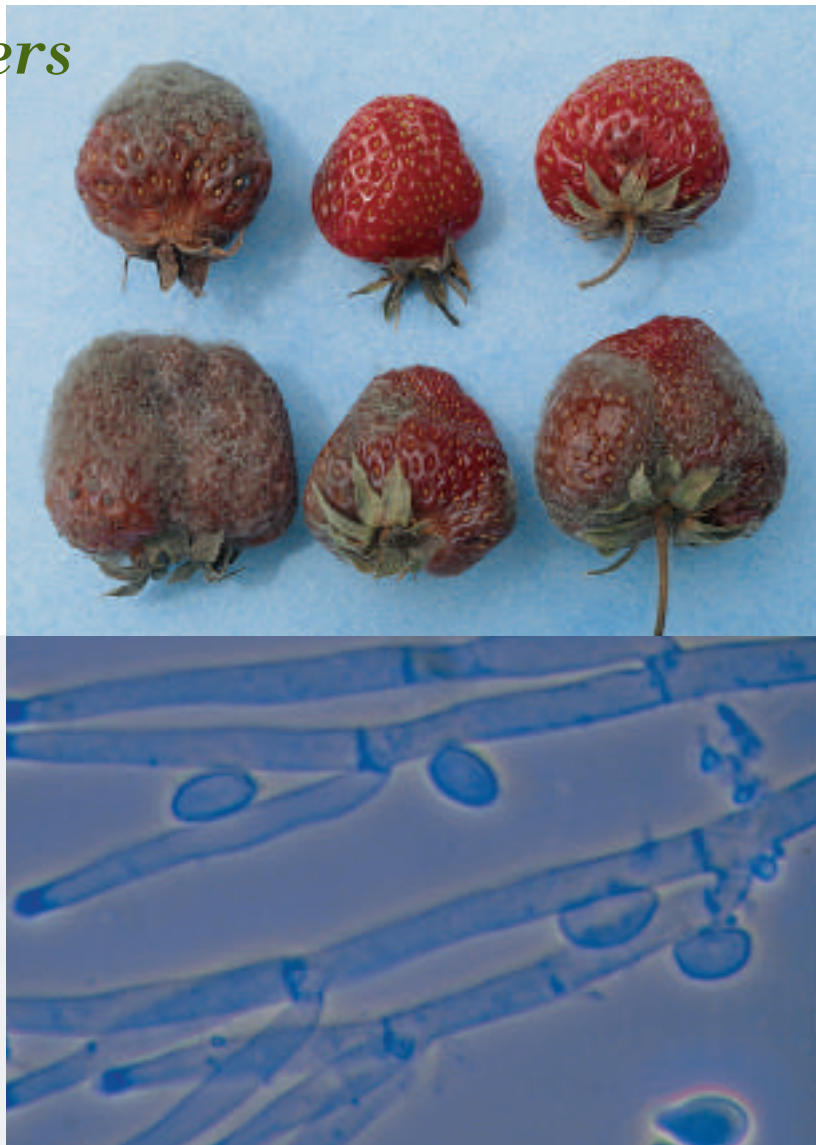
growers and consumers

Symptoms of strawberry leaf scorch. Development of this disease in the fall means few strawberries in the following year.

Further, the techniques have provided an excellent means for genetic analysis of disease resistance, which is critical for progressive research in disease resistance. Already, resistance of all strawberry cultivars grown in Ontario has been quantified – a vital step in integrated disease management.

Biological disease control involves use of microbes to suppress disease-causing organisms and thereby control disease. Prior to the present project, several thousand microbial isolates were evaluated at the University of Guelph for effectiveness in controlling *Botrytis* in strawberries. In the Food Systems 2002 program, the leading group of microbes (microfungi) were field-tested in the full range of June-bearing and day-neutral strawberries in Ontario. The selected microbes controlled *Botrytis* and, in some instances, leaf scorch, as or more effectively than recommended fungicides. Our leading microbial agent is superior to all others reported worldwide, and is now under commercial development. In nature, this agent is associated with strawberry and numerous other plants in temperate and tropical regions of the world, and is harmless to crops, mammals and other animals. The microbial agent, when registered for use in Canada, will provide an effective alternative to chemical fungicides.

In studies of diseases in strawberry transplants, several serious fungal pathogens were sometimes present, usually in the absence of disease symptoms. The disease organisms were present even in early stages of transplant production in greenhouses. The research has underscored the need to control disease-causing organisms in transplants in order to allow better disease control after the plants are set out in growers' fields.



Our critical measurement of disease resistance in strawberry cultivars, recognition of disease early in transplant production, and development of an effective biological agent allowed us to develop much improved control programs for strawberry diseases. These programs will offer growers flexibility in disease management, better yields of high quality fruit, and a realistic opportunity to reduce fungicide use. There is now a good possibility that fungicide residues will become a thing of the past. ■

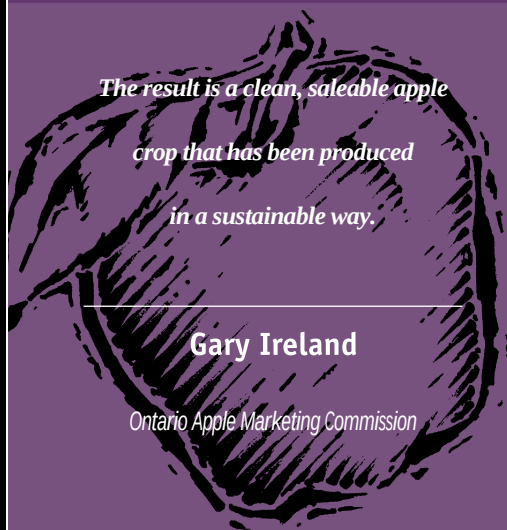
A microscopic view of a microbial bio-control agent. Spores of this agent, seen here as ellipsoid bodies, protect strawberries from *Botrytis* more effectively than recommended fungicides.

THE INDUSTRY PERSPECTIVE on Food Systems 2002

The Ontario Apple Marketing Commission, on behalf of its grower members, is pleased to comment on the success of Food Systems 2002. We have benefitted from a world-class Integrated Pest Management program that has responded to our needs.

Pesticide resistance, new pests, and changing pesticide availability have all been challenges, and FS 2002 has dealt with them all.

We have been fortunate that the Minor Use Registration program, supported in part by FS 2002, has kept us supplied with modern, effective, environmentally friendly products to use in conjunction with our on-farm management of pests.



The result is a clean, saleable apple crop that has been produced in a sustainable way.

Gary Ireland

Ontario Apple Marketing Commission

The Ontario Fruit and Vegetable Growers' Association has been monitoring the progress of the Food Systems 2002 program.

Over the years of the program's mandate, the association has seen the activities and projects that have been approved, and the results of some of this work.

In our view, it is important for this program to receive adequate funding to carry out the work that is essential to maintain the competitive edge of Ontario's fruit and vegetable industry.

It is equally important that the transfer of information be provided to the grower community. We have seen both the priority setting of projects and the information exchange from the research community to the industry.



Growers have been the direct beneficiaries of this work.

Michael Mazur

Ontario Fruit and Vegetable Growers' Association

Ontario Vegetable Growers' Marketing Board-funded research in processing vegetable crops depends to an extent on co-funding by industry and government funds such as Food Systems 2002. Crop protection in comparatively small-hectare crops like processing vegetables is a vital aspect of the production of quality crops.

The combined efforts of grower organizations, industry and government in the support of continued development of sustainable production systems is paramount in our goal to remain competitive in a global economy.



Richard Penner

Ontario Vegetable Growers' Marketing Board

The Tender Fruit Producers' Marketing Board was the first to implement Integrated Pest Management way back in 1965. In the past decade, the relevance and effectiveness of our IPM programs have come to rely very heavily on research funded by Food Systems 2002. Also, the Minor Use Program is very useful in providing our growers with valuable new materials, such as miticides for peach. FS 2002 continues to be a tremendous help in keeping our industry environmentally conscious, sustainable, and competitive.



Jim Rainforth

Tender Fruit Producers' Marketing Board

MINOR USE OF PESTICIDES PROGRAM

As documented on pages 18 and 19, the federal minor use program, which Food Systems 2002 supports in Ontario, is helping provide timely crop protection products for growers. Among the key registrations in 1996 were:

ADMIRE
potatoes and field tomatoes for Colorado potato beetle

GOVERNOR
potatoes and onions (seed treatment)

MAXIM
seed corn fungicide

AGRIMEK
miticide for apples and pears; pear psylla control

APOLLO
miticide for stone fruit

LORSBAN
oriental fruit mould — peaches

ALIETTE
*blue mould — tobacco
phytophthora rot — ginseng*

ACROBAT MZ & TATOO C
for late blight of potato

for cropping systems, is less better?

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Cash-crop growers who want some hard data on whether a lower input approach can deliver yields need look no further. In a seven-year comparative study, researchers were able to cut back on fertilizer, tillage and herbicide inputs, while maintaining good yields, improving net returns, and increasing environmental sustainability.

Can inputs for cash-cropping systems be reduced and net profitability still be improved? What would the long-term sustainability be for a reduced-input system? Could an organic cash-crop rotation work? These were some of the questions behind a long-term study at the Elora Research Station. Three cropping systems – high input, low input and near-organic – were compared, using a rotation of corn-soybean-wheat (underseeded to red clover).

High input (HI) involved moldboard ploughing, secondary tillage, OMAFRA Publication 296, *Field Crop Recommendations*, rates for fertilizers, seed

treatments, broadcast herbicides, solid-stand soybeans (rows 18 cm [7"] apart), winter wheat underseeded with red clover, and Roundup[™] when necessary.

Low input (LI) involved cutting back on inputs wherever feasible. For example, less fertilizer N was used because there were two legumes in the rotation, P and K were cut back until soil tests decreased, soybeans were grown in wide rows, and herbicide rates were reduced in corn and soybeans by banding herbicides over the rows and by using inter-row cultivation. We used a chisel plow instead of a moldboard plow. In some cases, no-till planting was also used.

The near-organic system (ORG) initially involved manure instead of fertilizer, inter-row cultivation instead of herbicides, no seed dressings and no Roundup[™]. We expanded the organic treatments to include composted cattle manure and liquid dairy manure, along with a no-manure control.

Along the way, we calculated costs for the inputs, machinery, operating expenses and labour, and measured yields and returns. We also tried to measure non-yield effects such as grain quality, weed pressure, nitrates going to groundwater, soil fertility levels, soil erodibility, and soil microbial activity.

Yields in the HI system were no different from those in LI for corn or soybeans, but were higher in the wheat (see table). Across the seven years of study and three crops, the ORG system resulted in 30% lower yields than HI. In the LI system, net returns have been much higher than in HI, and we have lost money on our organic cash cropping venture. (NB: values shown in the table do not include price premiums for organically produced grain.)

The low yields in the ORG system were due to excessive weed competition – particularly from quackgrass – and lack of available N from the manure. A word of warning: yields with composted manure were no higher over seven years than those with no manure, because there was essentially no available N from the compost. Soil P and K levels increased sharply with the compost additions.

OTHER FINDINGS:

- groundwater nitrates in the LI system were 10 ppm, right at the allowable limit, whereas HI values were above 20 and ORG values averaged less than 10 ppm
- soils in the HI system were much more erodible than either LI or ORG soils
- wide-row (74 cm [30"] apart) soybeans with banded herbicides yielded just as well as solid stands with broadcast herbicides
- N returned to the system by plow-down red clover



Shown here are cropping systems in early August of 1996. In the near background is high input corn, followed by low input wheat and low input corn.

- was higher in LI and ORG – this helps maintain N levels in LI and ORG, but in those systems the wheat, with less available N, doesn't compete as well with the red clover, and yields decline
- there were no measurable differences among treatments in pH, organic matter, or soil microbial biomass after the first seven years.

This research shows that it is possible for producers to implement environmentally friendly cropping systems and improve financial returns at the same time. ■

CROPPING SYSTEM	GRAIN YIELDS (t/ha)			NET RETURNS (\$/ha)
	CORN	SOYBEANS	WHEAT	
HIGH INPUT	9.5 a*	2.5 a	4.0 a	+ 243 b
LOW INPUT	9.1 a	2.6 a	3.5 b	+ 402 a
ORGANIC	5.9 b	2.0 b	2.6 c	— 51 c

* values within a column followed by the same letter do not differ at $p = 0.05$

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The need for sustainable cropping systems has inspired efforts to reduce herbicide use in agriculture, and led to the development of Integrated Weed Management (IWM).

To spray or not to spray?

Determining the critical period for weed control solves growers' dilemma

IWM is a systems approach that incorporates plant breeding, fertilization, rotation, chemical weed control, mechanical weed control, competition, successional management and soil management into a method of reducing weed interference while maintaining acceptable crop yields.

"The critical period of weed control" is an important concept within this systems approach. It is defined as an interval in the life cycle of the crop when it must be kept weed-free to prevent yield loss. This concept helps in determining the most effective time for non-residual postemergence herbicides application, reduces the practice of applying season-long residual herbicides, and eliminates unnecessary late application of herbicides – all of which help in maintaining environmental sustainability as the amount of herbicide used is reduced. At the same time, crop yield is not sacrificed.

The critical period of weed control also provides a time frame for field scouting, facilitates timing for mechanical weed control, and provides information on the best time for introducing cover crops into the cropping system.

The critical periods of weed control were identified for corn, soybean and whitebean from field studies conducted in southern Ontario. Two discrete periods were identified. The first was the critical weed-free period – the maximum length of time that weeds emerging with a crop can be allowed to grow until they begin to cause unacceptable yield losses. The second was the critical weed-removal period – minimum length of time that weeds emerging after a crop must be removed so that unacceptable yield losses do not occur.

The critical periods are defined relative to crop growth stage to account for environmental variation.

The critical weed-free period was relatively short in duration and consistent across locations and years, whereas the critical time of weed removal was variable across locations and years. In general, critical periods in corn, soybean and whitebean are relatively short if the acceptable yield loss is less than 5% and approximately equivalent to the cost of weed control.

This information can be used to implement the timings of cultivations where applicable, and the use of short residual or non-residual herbicides. It also helps to show that season-long herbicides are not needed to optimize crop yields, and thus helps in reducing herbicide use. ■

CROP	CRITICAL PERIOD FOR WEED CONTROL
CORN	• excellent weed control must be achieved from the 4th leaf to the 10th leaf stage (tip of the 10th leaf emerging above the whorl)
SOYBEANS	• critical period extends from the 1st to the second trifoliolate stage of soybean growth (V2 to V3); the V4 growth stage occurs approximately 20 days after crop emergence
WHITEBEAN	• from the second trifoliolate (V2) to the first flower stage (V2-R1)

V2 = 2nd node, V3 = 3rd node, R1 = beginning bloom

Adjust the ARTILLERY

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Reduced rates of herbicides yielding better weed control? It's possible. It takes a careful match of the herbicide to the problem weed, good timing, and uniform coverage. A prototype shrouded boom sprayer promises near drift-free application.

Label rates of active ingredients are somewhat higher than are actually necessary. There is good reason for this. A slightly higher margin will compensate for the less-than-ideal weather, crop conditions, weed growth stage and sprayer performance that face most producers when they apply herbicides. In other words, a higher concentration will offset less-than-ideal management practices.

A two-part study was undertaken to determine how much less product could be used if management practices were improved. The first part considered whether active ingredient rates and overall volumes could be reduced and still provide effective control. The second part aimed at developing sprayer technology that could reduce rates when conditions were not ideal.

In the first study, three application rates (100%, 75% and 50% of active ingredient) were used with translocated and contact chemicals on corn and soybeans, respectively. In the corn trials, full control was possible with 50% active ingredient where weeds were rated as "excellent" for susceptibility, but control was reduced for weeds ranked as "good" susceptibility. At the 75% rate, all weed control was good and grain yield was not significantly different. Results followed nearly identical patterns with the

modifying boom sprayers and fine-tuning management can reduce herbicide use and raise yields

soybeans. However, in both trials it was found that the contact herbicides worked best at full volume of spray solution.

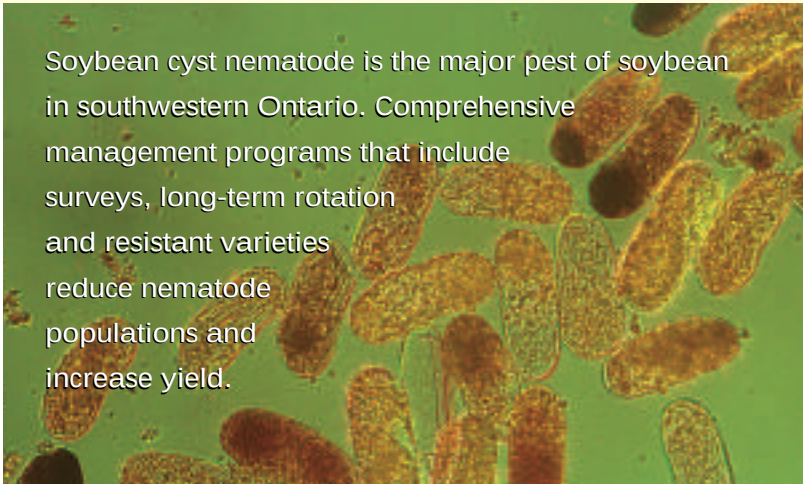
In the second study, a walk-in wind tunnel was used to design a windproof shroud for a boom sprayer. The most effective prototype developed was a porous (rather than solid) baffle or hood. The prototype was tested in the field on corn and soybeans, using the same contact and translocated products, different nozzles, reduced rates, and several volumes, but applied at moderate and high wind conditions.

The best results were with the translocated chemicals using the prototype shrouded boom sprayer under adverse conditions. There also appeared to be an unexpected benefit of reduced phytotoxicity with the lower rate shrouded boom application. Drift was minimal with the shrouded boom prototype.

To make the shrouded boom more practical, the research team plans to design a model to retrofit commercial sprayers that is lighter and easier to manufacture. It is apparent that some herbicide rates can be reduced substantially if the product selected is carefully matched to the problem weeds and steps are made to ensure good uniform coverage. The tradeoff is that the operator must be more careful about the timing and weather when spraying is done. ■

SOYBEAN CYST NEMATODE

growers armed with a battleplan are *winning in the field*



Soybean cyst nematode is the major pest of soybean in southwestern Ontario. Comprehensive management programs that include surveys, long-term rotation and resistant varieties reduce nematode populations and increase yield.

Eggs of soybean cyst nematode parasitized by fungi in field soil.

Soybeans are a major component of cash-crop farming systems in Ontario, with 2-million acres in production and a value of 600-million dollars. Soybeans have also become a major export crop for crushing world-wide and for human consumption in the Pacific Rim. Naturally, any disease or pest that threatens this expanding industry is of concern to soybean growers.

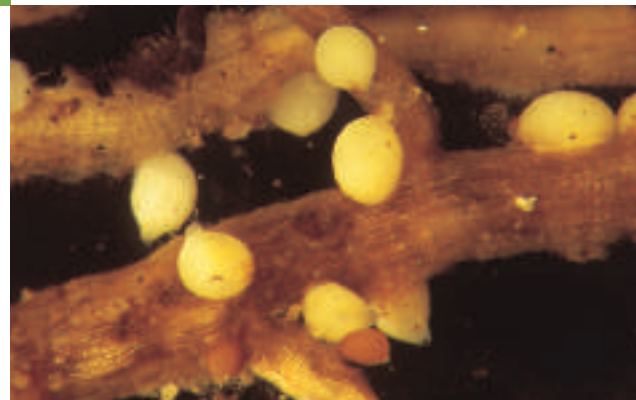
Since it was first found in Ontario 10 years ago, soybean cyst nematode (SCN) has become an important problem in southwestern Ontario. SCN continues to spread to new fields and counties in the province. To the relief of growers, research is demonstrating that with appropriate inputs, SCN is manageable.

Long-term studies funded by Food Systems 2002 and the Ontario Soybean Growers' Marketing Board on crop rotation, variety resistance, non-host crops and naturally occurring antagonistic organisms indicate that soybeans can be grown profitably – even in infested fields – if growers adopt

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Mature cysts of soybean cyst nematode that contain 200-400 eggs on soybean roots from a heavily infested field.

comprehensive control programs that include the following inputs.

Survey and detection

If SCN can be detected early, when populations are low (0-50 cysts/100 g of field soil), subsequent crop rotation strategies will be most effective, and spread of SCN to adjacent fields can be minimized.



Non-host crops appear to be useful in reducing soybean cyst nematode populations.

Corn may reduce soybean cyst nematode populations by 30-50% in one year.

Rotation with non-hosts

Although studies are incomplete, crop rotation with non-hosts such as corn, wheat, clover and alfalfa, etc. and resistant soybean varieties for 4-6 years have resulted in decreased populations of SCN and acceptable yields.

Resistant varieties

The yield potential of SCN-resistant varieties has increased dramatically in recent years. In infested fields, these varieties out-yield susceptible varieties by up to 40%.

Antagonistic organisms

Ontario soybean fields contain numerous fungi that parasitize SCN cysts, eggs and larvae. Cultural practices that promote a favourable soil environment for these fungi, such as increased organic matter and uniform moisture, should be promoted.



Symptoms of soybean cyst nematode in an infested soybean field.

Crop management programs are paying dividends to growers in Essex and Kent counties who have acknowledged their problem and committed themselves to a long-term, comprehensive SCN management plan. ■

THE BAD SEED: tracking *weed* seeds in *herbicide* evaluation plots

Traditional herbicide testing in Ontario has followed a fairly standard routine. Plots are established in fields known to have substantial weed populations. Crop performance has been monitored closely, but weed control estimates have been mostly visual. Now some new procedures for testing weed seed production and quality in herbicide trials are giving better information on exactly how weed populations can be reduced.

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The vast majority of weeds in such plots are annual and must arise from seed each year. The seeds are in the soil: they constitute the “weed seed bank”. Prior to this study, herbicide testers had not looked at the distribution of weed species in seed banks in the soil. Followup work on annual weeds that survived herbicide treatments, in terms of growth, timing and amount of seed production, had not been done. Nor were there studies on survival overwinter of seeds from such plots. We investigated each of these problems in regular herbicide tests at Centralia College.

Hundreds of soil cores from herbicide test plots were taken immediately preceding herbicide application and crop planting. We counted and removed seedlings arising from these soil cores in the greenhouse and found that this “germinable seed bank” gave a good prediction of weed densities in the test plots. None of the weed species, common or rare, was evenly distributed and there were herbicide treatments where at least one

common weed species was absent because of a lack of germinable seeds in all four replicate plots. This means that the investigator could have concluded that certain weeds were controlled by a herbicide when, in reality, there were no seeds in the plots. Good experimental design, such as plot randomization and replication, will usually minimize but not always totally overcome such effects.

Seed production was reduced for damaged plants from some treatments, but both damaged plants and escapes of lambsquarters, pale smartweed and other major weeds produced large numbers of normal-sized, viable seeds. The greatest and most consistent effect of herbicide treatment was also a delay in the ripening dates of the seeds.

Seeds produced by herbicide-damaged and control plants were left on the soil surface and 5 cm deep overwinter. There were few differences caused by herbicide treatment in the overwinter survival or in the subsequent germination patterns of the seeds. ■

Recommendations for Future Herbicide Trials

- 1 Always determine the seed bank before processing with a herbicide trial. Alternatively, plant your own weed seeds (known numbers and viability for each species).
- 2 Ensure that plants present after herbicide treatment have actually been in contact with the herbicide.
- 3 Evaluate changes in seed productivity (numbers) in each herbicide treatment.
- 4 Check for seed viability after treatment.
- 5 Based on results for two common weeds, overwintering trials using seeds from damaged plants may not be necessary.

Goodbye, GUESSWORK! Hello, ONTARIO HERB!

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Every year, many growers perform a delicate balancing act, trying to determine when herbicide treatment makes economic sense, and when it doesn't. Research is taking the guesswork out of weed control.

The goal of an Integrated Weed Management (IWM) system is to avoid exclusive reliance on herbicides for weed control – by combining cultural, mechanical, chemical and biological methods of suppressing weed growth, while maintaining crop yield. Economic thresholds are an important component of IWM. They allow growers to make decisions about the need for postemergence weed control, based on the level of weed infestation present in their fields and potential crop yield losses.

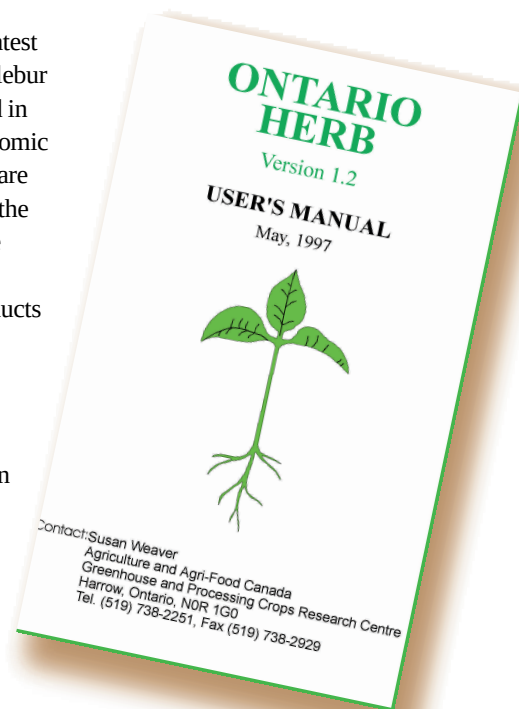
An economic threshold is defined as the weed density at which the benefit of herbicide application just equals the cost of control. Adoption of an economic threshold approach to weed management could lead to reductions in unnecessary herbicide use – a key goal in the Food Systems 2002 program – and increased profitability for growers.

Researchers determined economic threshold levels for velvetleaf, lambsquarters, common ragweed, green foxtail and cocklebur in corn and soybeans. These are all annual weeds that are very common in corn and soybean fields in southern Ontario, and often “escape” soil-applied herbicides.

The relationship between crop yield and a range of densities of each of these weeds was determined on research plots. Validation of these relationships was carried out at the commercial farm scale. An economic model has been developed to calculate economic thresholds for each weed, based on impact on yield, crop value (expected weed-free yield multiplied by commodity price), and herbicide cost and efficacy.

Lambsquarters had the greatest impact on corn yield, and cocklebur was the most competitive weed in soybeans. Calculations of economic threshold levels for each weed are complex, however, because of the assumptions that must be made about crop price and yield, the number of postemergence products available in corn and soybeans, and the multi-species nature of typical weed infestations. That's why delivery of economic threshold information to producers is best accomplished by a computerized decision-support system that can quickly perform the necessary calculations and integrate multiple databases.

Information from this study has formed the basis of *Ontario Herb*, a decision-support system that was recently released. It contains estimates of the impact of 17 annual weeds on crop yield, efficacy ratings for registered postemergence herbicides by three weed-size categories and two soil moisture conditions, and user-set herbicide prices. The program ranks available weed control options, including the option of not spraying, in terms of net benefit. ■



E is for *Electronic and Expert*

HOW EP75 IS HELPING FARM MANAGERS MAKE BETTER WEED CONTROL DECISIONS

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Farmers and industry now have a range of herbicide software options available to them via the Internet and other sources. But none of them is as complete or has as many features as the Ontario EP75 program.

For nearly 50 years, the Ontario Ministry of Agriculture, Food and Rural Affairs and the Ontario Weed Committee have produced the *Guide to Weed Control*, commonly known as Publication 75. It has been a highly valued tool for Ontario farmers. But the challenge in keeping the book up-to-date and accurate in the face of rapidly changing technologies for weed control was becoming acute. Could computer technology help the classic guide become better?

In the early 1990s, we began to develop a computer database for this information. Microsoft FoxPro 2.6 was selected to produce hard copy of the guide. At the same time, it was recognized that the decision-making process for which herbicides to use was quite complex, and programming was added to the database to develop a computer expert system to help growers select appropriately. We also decided to add a number of options to enhance the user's herbicide information resources.

Electronic Publication 75, or EP75, was first released in 1996, and updated in 1997 for use by the

industry. One of the main features of EP75 is the expert system. The user picks the crop, which weeds are in the field, sets the relative priority or importance for each weed, and then eliminates the treatments that are not appropriate to the particular field according to soil, weather or cultivar conditions. Users of the program can let the computer calculate product costs, needs for the field, and print out how much to put into each tank of spray or how many tanks will be needed for the field.

Other features include:

- the full text of Publication 75
- a complete database of about 250 product labels
- an interactive sprayer calibration calculator, and
- a computerized weed identification key.

Thus far, user feedback has been very favourable, with different users valuing different aspects of the multifaceted program. Copies of the program are available on an annual subscription basis through ORBEX Inc., 557 Massey Road, Guelph, ON N1K 1B3, or fax: (519) 837-9142. Cost is \$195 for a new version, or \$29.95 for the annual update. Also add \$15 for shipping and handling, and PST and GST. ■

EP75 helps the user plan a farm herbicide program, and takes a step-by-step approach to the many factors and questions that make herbicide selection a complex issue on the farm in the 1990s.



Cultural methods for WEED CONTROL IN LAWNS— moving *in* on PESTICIDES, TURF

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Healthy turf requires considerable knowledge about lawn establishment, maintenance and pest control. Some manual labour is often required. Many homeowners are unfamiliar with proper management practices, choosing to rely on chemical control instead. The heavy use of herbicides, combined with issues about the proper storage, handling and application of domestic-use chemicals, is a significant societal concern.

At the University of Guelph, methods of enhancing the competitive / interactive advantage of turfgrass over weeds through cultural practices are being explored. Cultural practices include:

- selection of grass species
- varying fertilization rates
- timing of fertilization
- topdressing and overseeding with various lawn seed mixes
- coring
- “verticutting” (mechanical aeration).

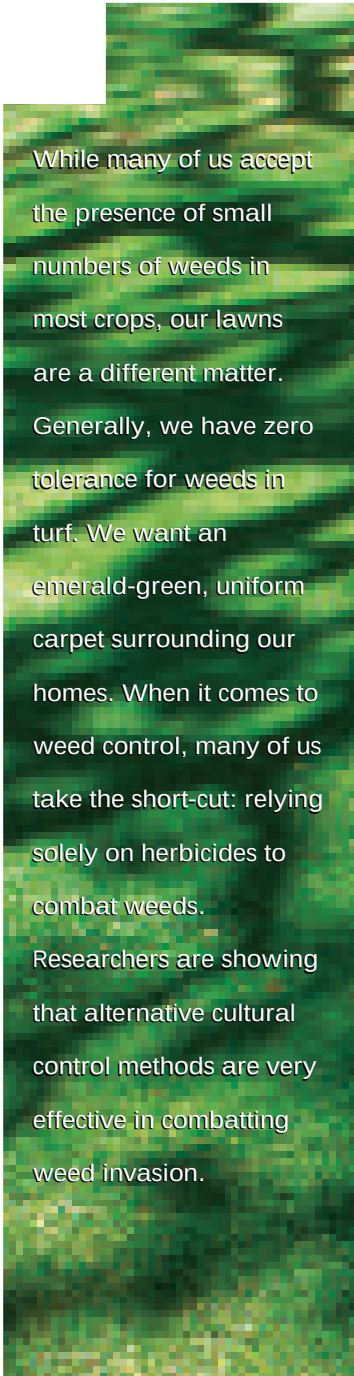
Researchers studied the effectiveness of species mixtures and fertilizer applications on weed control. Single-species and mixes of grasses included perennial ryegrass, annual ryegrass, fine fescue, tall fescue and Kentucky bluegrass. Fertilizer applications ranged from no fertilizer to an industry standard of early spring, mid-

summer and early fall. Fewest weeds were found in plots with: 20% or more perennial ryegrass; 50% or more of the creeping red fescue/ Kentucky bluegrass mix; and in plots fertilized at least twice a year.

A second trial involved the comparison of turf cultivation techniques with herbicide applications on low-maintenance turf that had not received any weed control for several years. In all cases, the herbicide applications provided the best weed control. The best cultural method was coring the turf combined with overseeding with perennial ryegrass.

In the third trial, weed competitiveness of low-cost seed mixtures and pure perennial ryegrass established from seed were compared with sod. The results showed that the commercially available seed mixes competed with weeds as well as the sod. We also determined that mowing height does not affect weed infestation. And as was shown in previous experiments, two to three fertilizer applications help turf compete against weeds better than one application of fertilizer.

These three trials have verified that appropriate, well-timed cultural methods can help turfgrass owners reduce their reliance on pesticides while enjoying high quality lawns and turf areas. ■



While many of us accept the presence of small numbers of weeds in most crops, our lawns are a different matter. Generally, we have zero tolerance for weeds in turf. We want an emerald-green, uniform carpet surrounding our homes. When it comes to weed control, many of us take the short-cut: relying solely on herbicides to combat weeds. Researchers are showing that alternative cultural control methods are very effective in combatting weed invasion.

Many golf courses in the Great Lakes Region are suffering from cool-season dieback in spring and fall. In a vain attempt to control this disease, turf managers often apply fungicides. Researchers now understand why conventional fungicides are ineffective.

the

Identifying the culprit in turfgrass

Cool-season dieback occurs in intensively managed turfgrasses during cool, wet weather in spring and fall, and is characterized by either a diffuse blighting or yellowing of turf in small patches.

Recent research in the United States has indicated that *Pythium* species, which causes root rot, may play an important role in this dieback. In our region, little is known of the identity of the causal organisms, or whether *Pythium* species are associated with root rot of turfgrass.

If indeed cool-season dieback in our region is caused by this species, then conventional fungicides that control the major turfgrass diseases would be ineffective because the *Pythium* group is highly differentiated from other groups. Therefore, this study was undertaken to determine the cause of cool-season dieback in Ontario and Quebec, to identify *Pythium* species from turf roots and crowns, and to study their pathogenicity under controlled conditions.

The study began in 1992, when we obtained 14 isolates of three *Pythium* species from diseased samples of creeping bentgrass and annual bluegrass. *Pythium* species are commonly found on turfgrass roots, but many are thought to be saprophytic, existing on dead organic matter and not causing any diseases.

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root cause

disease saves on fungicide use



Cool-season dieback of turfgrass caused by *Pythium* species.

In a tissue culture plate assay, we were able to quantify the virulence of *Pythium* isolates, and we found that they were able

to prevent seedling emergence. In general, isolates produced more severe root rot on perennial ryegrass than on creeping bentgrass, and greater virulence was found at 15 C than at 30 C. Virulence differences were confirmed in greenhouse pot tests. *Pythium* fungal structures were recovered from inoculated pot samples that showed disease symptoms.

This study showed conclusively that *Pythium* species are a cause of cool-season dieback of golf course turfgrass in Ontario and Quebec. Therefore, the use of conventional fungicides would not likely control this disease. More research is needed on other forms of management.

LES RECHERC

Cultures horticoles

Gérer la résistance de la nouvelle menace « rouge » – le tétranyque rouge du pommier

Pree, D.J., Agriculture et Agroalimentaire Canada

En alternant les familles de produits chimiques, les résistances ne se développent pas facilement et la lutte contre les ennemis des cultures reste possible. Les pomiculteurs font face à un problème de résistance dans le cas du tétranyque rouge du pommier. Faute d'information, ils étaient incapables jusqu'ici d'établir une rotation à long terme. Or, cette étude a déterminé que la résistance au dicofol était répandue, qu'il ne faut pas pulvériser la clofentézine après la troisième semaine de juin et que la fenbutatine donne de bons résultats.

Abriter l'ennemi – protéger les acariens prédateurs pour combattre les tétranyques et réduire les pulvérisations dans les cultures fruitières

Thistlewood, H.M.A., Agriculture et Agroalimentaire Canada, et R. Harmsen, Université Queen's

Les pesticides qu'on utilise dans les vergers de l'Ontario pour lutter contre les insectes nuisibles réduisent du même coup les populations de prédateurs naturels. Or sans prédateurs, la lutte contre les tétranyques nécessite un recours massif à des acaricides. Ce projet visait à élaborer une base théorique pour gérer et lâcher les prédateurs sur les fruits. La combinaison de mesures de lutte chimique et biologique a permis une maîtrise efficace des ravageurs. Il reste que les applications de pesticides ont un effet répulsif sur les

prédateurs. L'aménagement de refuges pour les auxiliaires de lutte s'est avéré utile, mais pourrait l'être plus encore s'il y avait moins de résidus de pesticides.

Examen des problèmes touchant les légumes orientaux et ethniques

Cerkauskas, R. Agriculture et Agroalimentaire Canada

Les producteurs du sud de l'Ontario produisent environ 2500 ha de légumes orientaux par année afin de répondre à la demande de plus de 500 000 consommateurs de souche asiatique de la région de Toronto-Hamilton. Une étude approfondie de l'incidence et de la gravité des maladies, des insectes, des nématodes et des problèmes abiotiques a été entreprise. L'on s'attend à ce que les résultats contribuent à faire augmenter la production destinée à l'exportation vers les États-Unis, améliorent les programmes de lutte contre les ennemis de ces cultures et aident les producteurs à se concerter pour surmonter les défis de production auxquels ils font face.

Des inoculants bactériens aident à protéger les cultures contre la maladie

Lazarovits, G., Agriculture et Agroalimentaire Canada, et J. Nowak, Nova Scotia Agricultural College

Il a été démontré qu'une bactérie *Pseudomonas* non fluorescente pouvait améliorer la croissance et le développement d'un certain nombre de cultures végétales. Dans des milieux de culture tissulaire, les explants de noeuds de pommes de terre inoculés ont produit des plantules plus



HES EN BREF

hautes et des systèmes racinaires plus développés que les plants non traités. Le PsIN a favorisé la croissance des pommes de terre et des tomates en conditions réelles lorsqu'il était appliqué aux tubercules de semence ou au substrat de repiquage. Par rapport aux plants non traités, les plants inoculés ont donné de meilleurs rendements, mais l'importance de la réaction dépendait du cultivar et variait d'un endroit à l'autre.

Recherche sur les techniques de pulvérisation pour éviter la dérive de pesticides dans les vignobles

McFadden-Smith, W. et B. Archibald, Université de Guelph

Des chercheurs ont élaboré des méthodes permettant d'évaluer le rendement des pulvérisateurs dans les vignobles, en fonction de la proportion de bouillie déposée à la surface des feuilles dans la zone cible et la proportion trouvée sur des surfaces hors de la zone cible. Ils ont évalué le rendement des buses à jet en cône creux, à jet en cône plein et à jet plat produisant différents spectres de tailles de gouttelettes avec un pulvérisateur pneumatique. Dans l'ensemble, par rapport aux autres buses, la buse à jet plat n'a pas permis d'obtenir une réduction beaucoup plus marquée de la dérive, mais elle a permis le dépôt d'une plus grande quantité du produit sur la zone cible.

Enlever les feuilles pour faire passer la lumière et vaincre la pourriture de la grappe

Fisher, K.H., Université de Guelph

Des études ont été faites sur l'enlèvement des feuilles des vignes de l'espèce vinifera dans le but de réduire l'incidence de la pourriture de la grappe et d'améliorer la qualité du fruit. On a découvert que l'enlèvement des feuilles,

soit tôt, soit tard dans la saison, réduit l'incidence de la pourriture de la grappe. Si on enlève les feuilles mécaniquement, il est recommandé de le faire tôt dans la saison, au stade des petits grains, même si, lorsque les feuilles sont enlevées à la main, cette opération se fait très souvent à un moment plus rapproché de la véraison. Les deux traitements ont été appliqués commercialement. Ils ont donné une meilleure qualité de fruits et ont réduit l'incidence de la pourriture causée par Botrytis.

Appâts pour fourmis moissonneuses dans les serres de plantules de tabac – une solution de rechange plus sûre et plus économique aux pulvérisations d'insecticides

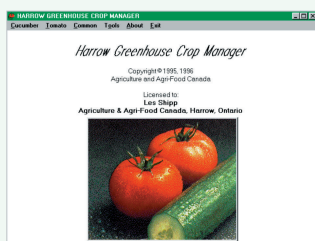
Tolman, J.H., J.J. Hanson, K.A. VanHooren, Agriculture et Agroalimentaire Canada, et G.S. Umphrey, Université Western Ontario

Depuis près de 20 ans, les fourmis moissonneuses constituent un problème de taille dans les serres de tabac. Or, le recours aux insecticides finit par coûter cher en termes de main-d'oeuvre, de ressources et d'exposition des travailleurs. Cette étude révèle qu'en offrant aux fourmis un approvisionnement constant en semoule de maïs, les producteurs diligents peuvent éviter d'utiliser des insecticides pendant les périodes critiques de la germination des semences et de l'établissement des plantules. Cette méthode leur permet aussi d'inspecter la consommation de semoule de maïs aux points d'appât et de concentrer les programmes de lutte sur les parties de la serre où un problème se pose.



Un système de soutien à la prise de décision aide les producteurs de tomates de serres à réduire leur utilisation de pesticides

Shipp, L., Agriculture et Agroalimentaire Canada



Un système de soutien à la prise de décision a été élaboré à Harrow pour pratiquer la lutte intégrée contre les ennemis des cultures dans les tomates de serres. Ce programme aide le producteur à intégrer à ses activités les plus récentes pratiques de lutte et de production. Le système facilite le diagnostic des infestations et identifie les recommandations de lutte incompatibles. Une base de données est également incluse pour aider les producteurs à évaluer tous les aspects de leurs activités.

Solution de rechange plus douce à l'éclaircissage des pommes

Cline, J., Université de Guelph

Pour améliorer le calibre des fruits et minimiser le phénomène de l'alternance, les pomiculteurs doivent intervenir chaque année, au moment de la floraison ou peu de temps après, pour limiter le nombre de fruits que portent leurs pommiers. Des études ont été menées dans les vergers pour évaluer les nouveaux produits chimiques offerts en remplacement du carbaryl utilisé comme agent d'éclaircissage des pommes. Les résultats laissent entrevoir des solutions de rechange. L'agent d'éclaircissage des fleurs Wilthin a eu un effet comparable au carbaryl lorsqu'on l'a utilisé sur des Red Delicious, mais a été inefficace sur les Idared et Empire. Les agents d'éclaircissage chimiques ANA et BA se sont révélés efficaces pour éclaircir chimiquement les pommiers Idared et Empire.

La tordeuse orientale du pêcher et les insecticides de rechange

Pree, D.J., Agriculture et Agroalimentaire Canada

Selon les producteurs de pêches, la tordeuse orientale du pêcher serait résistante à plusieurs insecticides clés. L'étude en cours se penche sur l'évaluation de la résistance et l'élaboration de méthodes de lutte de remplacement. Pour le moment, on conseille aux producteurs d'utiliser en rotation l'acéphate, le chlorpyrifos et les pyréthrinoides afin de réduire au minimum les risques d'apparition d'une résistance aux pyréthrinoides.

L'homologation rapide de nouveaux herbicides bonne pour les producteurs et l'environnement

O'Sullivan, J., Université de Guelph

Les producteurs de légumes de l'Ontario ont de moins en moins de produits phytosanitaires à leur disposition. Pour remédier à cette situation, attribuable au fait que la taille du marché ne justifie pas la recherche nécessaire de la part des fabricants, le Programme d'extension du profil d'emploi pour usages limités demandés par les utilisateurs (URMULE) donne aux producteurs accès à de nouveaux herbicides plus sûrs et plus efficaces. Des chercheurs ont fait l'essai d'un certain nombre d'herbicides avec pour résultat que des demandes d'homologation de pesticides à usage limité sont en cours.

Des systèmes d'alerte rapide pour informer les producteurs de la manifestation d'une résistance aux insecticides

Sears, M.K. et S. Hilton, Université de Guelph

Il a été démontré que le doryphore de la pomme de terre affiche un degré élevé de résistance aux insecticides. Un système d'alerte rapide serait utile pour informer les producteurs d'une résistance et leur éviter des pertes au niveau des insecticides avant qu'une résistance ne se manifeste au champ. La technique d'essai biologique discriminatoire, la cartographie informatisée et le procédé de tenue de registres élaborés dans ce projet permettront aux producteurs de surveiller et de prévoir les manifestations de résistance aux insecticides.

Gestion phytosanitaire des fraisiers—des rendements élevés et des fruits exempts de fongicides satisfont producteurs et consommateurs

Sutton, J.C., Université de Guelph

Des méthodes ont été élaborées pour mieux gérer la maladie chez les fraisiers en recourant le moins possible aux fongicides et en évitant que les fruits ne renferment des résidus de fongicides. On a misé essentiellement sur la résistance à la maladie et de meilleures façons de mesurer cette résistance, des méthodes de lutte biologique à l'aide de microchampignons, et l'amélioration de la condition phytosanitaire des fraisiers repiqués.

Grandes cultures

Comparaison de différents systèmes de culture commerciale

Hume, D., Université de Guelph

Une comparaison à long terme des trois systèmes culturaux suivants a été entreprise en 1990 : agriculture très exigeante en facteurs de production, peu exigeante en facteurs de production et presque biologique. La comparaison portait sur la rotation maïs-soya-blé (contre-ensemencés de trèfle rouge) dans chacun des trois systèmes. Dans le système peu exigeant en facteurs de production, nous avons pu réduire les apports d'engrais et d'herbicides et le travail du sol tout en maintenant des rendements proches de ceux des systèmes exigeants en facteurs de production, nous avons amélioré le bénéfice net et avons pratiqué une agriculture plus durable sur le plan de l'environnement. Le chiendent a constitué un problème majeur là où l'on a soumis la rotation des cultures commerciales sur trois ans aux méthodes d'agriculture biologique sans culture destinée à l'étouffer.



Résoudre le dilemme des producteurs en déterminant des périodes critiques pour les pulvérisations

Swanton, C.J., Université de Guelph

De la nécessité d'élaborer des systèmes de culture durables, sont nées des initiatives destinées à réduire l'utilisation des herbicides en agriculture et à mettre au point des méthodes de lutte intégrée contre les mauvaises herbes. Or, un aspect clé de cette lutte intégrée est l'établissement du moment précis où chaque

culture doit être maintenue exempte de mauvaises herbes afin de prévenir les pertes de rendement. Ce projet précise les périodes critiques pour la lutte contre les mauvaises herbes dans le maïs, le soya et les haricots blancs. L'un des avantages du projet réside dans la réduction de l'utilisation des herbicides.

Faire plus avec moins – la modification des pulvérisateurs à rampe et une gestion fine peuvent réduire l'utilisation des herbicides et augmenter les rendements

Brown, R., Université de Guelph

Deux années d'essais démontrent qu'il est possible de réduire la dose de matière active de certains herbicides largement utilisés pour peu que les conditions d'application soient idéales. Si l'on choisit bien les herbicides en fonction des mauvaises herbes à combattre, on peut réduire les doses des herbicides de contact et des herbicides systémiques. Par temps venteux, des doses réduites d'herbicides appliqués à l'aide de pulvérisateurs à rampe à écran protecteur ont permis une lutte efficace contre les mauvaises herbes et procuré de meilleurs rendements en grains que les pleines doses traditionnelles lorsque l'herbicide était appliqué sans écran protecteur.

Nématode à kyste du soya – les producteurs armés d'un plan de bataille gagnent le combat sur le terrain

Anderson, T.R., et T.W. Welacky, Agriculture et Agroalimentaire Canada, et A.U. Tenuta, Collège de Ridgeway

Le nématode à kyste du soya est le principal ennemi du soya dans le sud-ouest de l'Ontario. Les programmes de lutte complets qui

comprennent des inspections sur le terrain, une rotation à long terme et des cultivars résistants amènent une réduction des populations de nématodes et une augmentation des rendements.

Repérage des graines de mauvaises herbes dans des parcelles servant à l'évaluation d'herbicides

Cavers, P.B. et M. Kane, Université Western Ontario

Aucune étude portant sur l'évaluation d'herbicides ne s'était auparavant penchée sur la distribution des espèces de mauvaises herbes parmi les semences qui se trouvent dans le sol. On n'avait jamais fait le suivi des mauvaises herbes annuelles qui survivent aux traitements herbicides, ni d'études sur la survie à l'hiver des semences provenant de ces parcelles. Cette étude a débouché sur un certain nombre de recommandations visant de futurs essais d'herbicides.

ONTARIO HERB : Fin du désherbage à l'aveuglette

Weaver, S.E., Agriculture et Agroalimentaire Canada

On a établi les seuils de nuisibilité économique de l'abutilon, du chénopode blanc, de la petite herbe à poux, de la lampourde et de la sétaire verte dans les cultures de maïs et de soya du sud de l'Ontario. À partir de cette information, on a élaboré un système de soutien à la prise de décision, appelé ONTARIO HERB. Ce système classe les méthodes de lutte contre les mauvaises herbes envisageables, y compris la possibilité de ne faire aucune pulvérisation par souci de rentabilité.



E pour électronique et expert – comment la PE75 aide les exploitants à prendre de meilleures décisions de lutte contre les mauvaises herbes

Martin, H., ministère de l'Agriculture, de l'Alimentation et des Affaires rurales de l'Ontario

La Publication électronique 75, ou PE75, est une version informatisée de la publication 75F. La PE75 comprend un système expert qui aide l'utilisateur à concevoir un programme d'herbicides sur mesure. Elle comprend aussi une banque de données complète sur 250 étiquettes de produits, une calculatrice interactive pour la calibration du pulvérisateur et une clé d'identification informatisée des mauvaises herbes.

Gazon

Méthodes culturelles visant à réduire l'usage de pesticides dans la production de gazon

Hall, J.C., K.L. Sagan et T. Tripp, Département de biologie environnementale, Université de Guelph

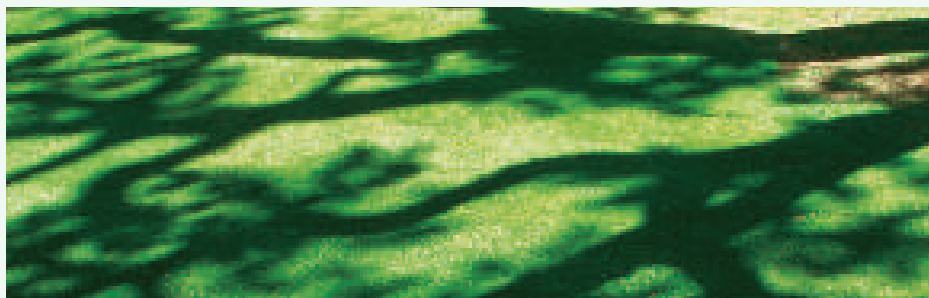
Les chercheurs ont élaboré des méthodes pour réduire l'utilisation d'herbicides sur les semis de gazon en pleine surface. Ils ont amélioré l'avantage concurrentiel du gazon sur les mauvaises herbes par des pratiques culturelles telles que le sursemis, la tonte verticale, le carottage, le traitement en couverture et la fertilisation. Dans l'ensemble, il y a eu moins de mauvaises herbes dans les parcelles où l'on trouvait soit 20 % ou plus de ray-grass vivace, soit 50 % ou plus de féтуque rouge traçante, en combinaison avec du pâturin des prés, et dans les parcelles recevant de l'azote au moins deux fois l'an à raison de 2 kg par hectare. Dans les gazons

déjà infestés de mauvaises herbes, l'utilisation combinée du carottage, du sursemis et du ray-grass vivace a donné les meilleurs résultats. Les mélanges à pelouse bon marché ont donné des résultats comparables aux pelouses de pâturin des prés. La hauteur de tonte n'a pas eu d'influence sur les infestations.

Réduire l'emploi de fongicides dans les gazons par une bonne identification de l'agent pathogène

Hsiang, T. et C. Wu, Université de Guelph

Le dépérissement des gazons les saisons de temps frais se voit de plus en plus dans la région des Grands Lacs. Dans les échantillons prélevés en Ontario, des espèces du champignon *Pythium* sont la principale cause de cette maladie. Comme *Pythium* est assez différent des autres groupes de champignons, l'utilisation des fongicides traditionnels ne permet pas de venir à bout du problème. Il faut approfondir la recherche sur d'autres formes de lutte.



FOOD SYSTEMS 2002

horticulture

Fruit



APPLICATION OF STYLET-OIL TO REDUCE FUNGICIDE USE ON GRAPES TO CONTROL POWDERY MILDEW AND BOTRYTIS BUNCH ROT
J. Northover, AAFC, Vineland Station

ASSESSMENT OF ALTERNATIVE INSECTICIDES FOR CONTROL OF RESISTANT ORIENTAL FRUIT MOTH AND EVALUATION OF POTENTIAL RESISTANCE MANAGEMENT SYSTEMS FOR ONTARIO
David Pree, AAFC, Vineland Station

CONTROL OF SAN JOSE SCALE ON ONTARIO GROWN APPLES BY LOW OXYGEN CONTROLLED ATMOSPHERE STORAGE
G. Chu, HRIO

DEVELOPMENT AND EVALUATION OF A SAMPLING STRATEGY FOR TENTIFORM LEAFMINER PRIVATE
Howard Thistlewood, AAFC, Vineland Station

DEVELOPMENT AND VALIDATION OF FIELD BIOASSAY METHODOLOGIES FOR THE DETECTION OF RESISTANCE IN POPULATIONS OF EUROPEAN RED MITES IN ONTARIO ORCHARDS
D.J. Pree, AAFC, Vineland Station

DEVELOPMENT OF PEST MANAGEMENT SYSTEMS FOR FRUIT CROPS
Gordon E. Riddle, HRIO

EFFECTIVENESS AND ENVIRONMENTAL IMPACT OF THE GRANULOSIS VIRUS IN MANAGEMENT OF THE CODLING MOTH IN APPLE ORCHARDS
Robert P. Jaques, AAFC, Harrow

EFFECTS OF GROUND COVER, THINNING AGENTS AND PESTICIDES ON MITES IN APPLE ORCHARDS
Howard Thistlewood, AAFC, Vineland Station

EPIDEMIOLOGY AND CONTROL OF BLACK KNOT OF SOUR CHERRY AND PLUM
Wendy McFadden-Smith, HRIO



EPIDEMIOLOGY AND CONTROL OF BLACK KNOT OF SOUR CHERRY AND PLUM
John Northover, AAFC, Vineland Station

EPIDEMIOLOGY OF JUNIPER TWIG BLIGHT IN ONTARIO
T. Hsiang, Dept. of Environmental Biology, UofG

EVALUATION OF ALTERNATIVE CHEMICAL THINNING MATERIALS TO REPLACE CARBARYL AS A CHEMICAL THINNER FOR APPLE
Don Elfving, HRIO

EVALUATION OF FIELD SPRAYER PERFORMANCE AND ENVIRONMENTAL IMPACT USING IMAGE ANALYSIS AND OTHER TECHNIQUES
Bruce Archibald, Agriculture and Food Laboratory Services Branch, OMAFRA

EVALUATION OF MASS-REARED PREDATORY MITES AMBLYSEIUS FALLACIS IN ONTARIO FRUIT CROPS PHASE 1 - APPLE
Howard Thistlewood, AAFC, Vineland Station

EVALUATION OF SUMMER OILS FOR INTEGRATED MITE MANAGEMENT ON APPLES
Fred Vaughn, Vaughn Agricultural Research Services

EVALUATION OF VINEYARD SPRAYER PERFORMANCE AND ENVIRONMENTAL IMPACT USING IMAGE ANALYSIS AND OTHER TECHNIQUES
Wendy McFadden-Smith, HRIO

HEALTH MANAGEMENT OF STRAWBERRIES FOR HIGH PRODUCTIVITY OF FUNGICIDE-FREE FRUIT
J.C. Sutton, Dept. of Environmental Biology, UofG

IMPROVED TIMING OF FUNGICIDES AND REDUCED PESTICIDE USE FOR CONTROL OF DOWNY MILDEW OF GRAPE USING PREDICTIVE MODELS
W. McFadden-Smith, HRIO

INCIDENCE AND IMPACT OF JUNIPER TWIG BLIGHT IN ONTARIO
T. Hsiang, Dept. of Environmental Biology, UofG

INTEGRATED CONTROL OF BROWN ROT OF STONE FRUITS
John Northover, AAFC, Vineland Station

LEAF REMOVAL OF VINIFERA GRAPES TO REDUCE BOTRYTIS BUNCH ROT AND IMPROVE FRUIT QUALITY
Helen Fisher, HRIO

MANAGEMENT OF ACARICIDE RESISTANCE IN THE EUROPEAN RED MITE PANONYCHUS ULMI (KOCH)
D.J. Pree, AAFC, Vineland Station

MINOR USE HERBICIDES AND NEW REGISTRATIONS FOR BERRY CROPS
J.A. Sullivan, Dept. of Horticultural Science, UofG

MONITORING AND CONTROL OF APPLE SCAB WITH MINIMAL FUNGICIDE RESIDUES
John Warner, AAFC, Trenton

MANAGEMENT OF PREDATORY AND TARSONEMID MITES FOR BIOLOGICAL CONTROL OF PEST MITES IN ONTARIO FRUIT CROPS
Howard Thistlewood, AAFC, Vineland Station

MODIFIED SUMMER PROGRAMME USING BORDER SPRAYS FOR MANAGING THE CODLING MOTH AND THE APPLE MAGGOT
R.M. Trimble, AAFC, Vineland Station

ABBREVIATIONS LEGEND

AAFC	— Agriculture and Agri-Food Canada
HRIO	— Horticultural Research Institute of Ontario (University of Guelph)
OMAFRA	— Ontario Ministry of Agriculture, Food and Rural Affairs
RCAT	— Ridgetown College of Agricultural Technology
UofG	— University of Guelph

APPROVED PROJECTS

REDUCED PESTICIDE USE AND IMPROVED CONTROL OF GRAPEVINE FUNGAL DISEASES THROUGH TRELLIS DESIGN, CANOPY MANAGEMENT AND IMPROVED SPRAY APPLICATION USING VINE/ROW VOLUME
W. McFadden-Smith and H. Fisher, HRIO

STATUS OF STREPTOMYCIN RESISTANCE IN ERWINIA AMYLOVORA AND THE NEED FOR ALTERNATIVE FIRE BLIGHT CONTROL STRATEGIES
Gordon Bonn, AAFC, Harrow

Greenhouse and Protected Crops

AN EXPERT SYSTEM FOR INTEGRATED CROP MANAGEMENT OF GREENHOUSE TOMATO
Les Shipp, AAFC, Harrow

BIOLOGICAL CONTROL OF BOTRYTIS GREY MOLD (BOTRYTIS CINEREA) IN GREENHOUSE ORNAMENTALS AND VEGETABLES
John Sutton, Dept. of Environmental Biology, UofG

BIOLOGICAL CONTROL OF MUSHROOM FLIES WITH ENTOMOPATHOGENIC NEMATODES AND MICROBIAL INSECTICIDES
Dan Rinker, HRIO

EXPOSURE STUDIES IN THE USE OF PESTICIDES IN GREENHOUSE CHRYSANTHEMUM PRODUCTION USING FLUORESCENT TRACERS AND VIDEO IMAGING
Bruce Archibald, Agriculture and Food Laboratory Services Branch, OMAFRA

INTEGRATED DISEASE MANAGEMENT FOR VERTICILLIUM DISEASE OF THE CULTIVATED COMMERCIAL MUSHROOM
Dan Rinker, HRIO

INTEGRATED PEST MANAGEMENT OF INSECTS AND DISEASES IN GREENHOUSE CROPS: A LITERATURE REVIEW
G.J. Boland, Dept. of Environmental Biology, UofG

INVESTIGATION OF AGGRESSIVE TRICHODERMA ISOLATES CAUSING MUSHROOM LOSS IN ONTARIO
Dan Rinker, HRIO

MANIPULATION OF THE GREENHOUSE MICROCLIMATE TO IMPROVE THE EFFICACY OF ENTOMOPATHOGENS FOR CONTROL OF GREENHOUSE PESTS
J.L. Shipp, AAFC, Harrow

REDUCING PESTICIDE USAGE BY CONTROLLING WHITEFLIES AND THRIPS WITH HIGH CO₂ WHILE ENHANCING YIELD AND QUALITY OF VALUABLE VEGETABLE AND ORNAMENTAL GREENHOUSE CROPS
Bernard Grodzinski and Michael Dixon, Dept. of Horticultural Science, and Jon Schmidt, Dept. of Environmental Biology, UofG

STUDIES ON THE ADAPTATION FOR SURVIVAL OF VERTICILLIUM DAHLIAE MICROSCLEROTIA AND THE EFFECT OF SPECIFIC INHIBITORS AND BIOLOGICAL CONTROL AGENTS ON THEIR LONGEVITY
George Lazarovits, AAFC

TO DETERMINE THE ECONOMIC INJURY LEVEL AND IMPACT OF WESTERN FLOWER THRIPS ON GREENHOUSE CUCUMBERS
J.L. Shipp, AAFC, Harrow

TO DETERMINE THE ECONOMIC INJURY LEVEL AND IMPACT OF WESTERN FLOWER THRIPS ON GREENHOUSE SWEET PEPPER
Les Shipp and Tom Papadopoulos, AAFC, Harrow and Michael Binns, AAFC, Ottawa

TO DEVELOP STRATEGIES FOR CONTROL OF THRIPS ON GREENHOUSE PEPPERS
Les Shipp and Gary Whitfield, AAFC, Harrow

Vegetables

ALTERNATIVE MANAGEMENT STRATEGY FOR THE EUROPEAN CORN BORER IN FIELD PEPPERS
Dr. D. Hunt, AAFC, Harrow

AN ASSESSMENT OF THE SIGNIFICANCE OF PLANT PARASITIC NEMATODES IN PROCESSING TOMATOES THROUGHOUT THE COUNTIES OF ESSEX AND KENT
Ron Pitblado, RCAT

ASSESSMENT OF THE RELATIONSHIP BETWEEN BACTERIAL SPECK INFESTATION OF TOMATO TRANSPLANT SEEDLINGS AND INCIDENCE USING A DIAGNOSTIC DNA PROBE SPECIFIC FOR THE BACTERIAL SPECK PATHOGEN
Diane Cuppels, AAFC, London

BACTERIAL SPECK OF TOMATO: CHARACTERIZATION OF PATHOGENICITY AND VIRULENCE FACTORS
V.L. Morris, Dept. of Microbiology and Immunology, Univ. of Western Ontario and Dr. D.A. Cuppels, AAFC

BIOLOGY AND MANAGEMENT OF WHITE ROT OF ONION IN ONTARIO
Mary Ruth McDonald, HRIO, and Greg Boland, Dept. of Environmental Biology, UofG

COMPLETION OF THE DEVELOPMENT OF A DNA PROBE TO ASSAY THE ASTER YELLOWS MYCOPLASMA
Paul Goodwin, Dept. of Environmental Biology, UofG

CONTROL OF ROOT DISEASES WITH CHITOSAN, A BIODEGRADABLE, NATURAL COMPOUND: CASE STUDY 1: FUSARIUM CROWN AND ROOT ROT OF TOMATO
V.J. Higgins, Dept. of Botany, Univ. of Toronto

CONTROL STRATEGIES FOR PROBLEM WEEDS (NIGHTSHADE, GALINSOGA, PROSO MILLET) IN VEGETABLE CROPS
Dr. John O'Sullivan, HRIO

DESIGN AND EVALUATION OF A MECHANICAL TRENCH DIGGING / MULCH LAYING DEVICE FOR CONSTRUCTION OF PLASTIC-LINED TRENCHES FOR CONTROL OF COLORADO POTATO BEETLES
Mark Sears, Dept. of Environmental Biology, UofG

DEVELOPMENT OF BIOLOGICAL CONTROLS FOR FOLIAR DISEASES OF TOMATO, POTATO, BEAN AND GINSENG
Rick Reeleder, AAFC, Delhi

DEVELOPMENT OF AN INTEGRATED REDUCED TILLAGE CROPPING SYSTEM FOR GROWING PROCESSING TOMATOES WITH REDUCED PESTICIDE INPUT
David Hunt, AAFC, Harrow





DEVELOPMENT OF INSECTICIDE RESISTANCE MANAGEMENT (IRM) STRATEGIES FOR COLORADO POTATO BEETLE (CPB): RELATIVE RESIDUAL ACTIVITY OF CONTROL AGENTS
J.H. Tolman, AAFC, London

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Bill Jarvis, AAFC, Harrow

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V. Souza Machado, Dept. of Horticultural Science, UofG

EVALUATION OF CALCIUM AND PHOSPHOROUS ACID FOR DISEASE ON MUCK VEGETABLES
Mary Ruth McDonald, HRIO

EVALUATION OF SUMMER AND WINTER COVER CROPS FOR THE CONTROL OF ROOT KNOT NEMATODES ON CARROTS
Mary Ruth McDonald, HRIO

EVALUATION OF WEAKLY VIRULENT STRAINS OF VERTICILLIUM SPP. FOR THE PROTECTION OF SOLANACEOUS CROP PLANTS AGAINST VERTICILLIUM WILT
George Lazarovits, AAFC, London

FACTORS INFLUENCING THE EFFECTIVENESS OF THE ONION PEST MANAGEMENT PROGRAM IN ONTARIO
Ron Harris, Dept. of Environmental Biology, UofG

FEASIBILITY STUDY ON THE CONTROL OF SLUGS IN COMMERCIAL CROPS
C.R. Ellis, Dept. of Environmental Biology, UofG

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M.R. McDonald, HRIO

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J. O'Sullivan, HRIO

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Ray Cerkauskas, AAFC, Vineland Station

IDENTIFICATION OF WEEDS AND NATIVE PLANTS OR RESERVOIR HOSTS FOR THE TOMATO SPOTTED WILT VIRUS AND THE WESTERN FLOWER THRIPS
Lorne W. Stobbs, AAC

INSECTICIDE RESISTANCE MANAGEMENT STRATEGIES FOR COLORADO POTATO BEETLE - EVALUATION AND VALIDATION OF QUICK FIELD BIOASSAY AND GIS MAPPING TECHNIQUES FOR DETECTION AND DOCUMENTATION OF INSECTICIDE RESISTANCE
Mark Sears, Dept. of Environmental Biology, UofG

INTEGRATED PEST AND DISEASE MANAGEMENT OF THE WESTERN FLOWER THRIPS - TOMATO SPOTTED WILT VIRUS COMPLEX
Wayne Allen, AAFC, Vineland Station

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Guy Boivin, Dept. of Entymology, Macdonald College of McGill University

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Ron Brammall, HRIO

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A. Liptay, AAFC, Harrow

MANAGEMENT OF COLORADO POTATO BEETLE AND OTHER PESTS OF POTATOES
Mark Sears, Dept. of Environmental Biology, UofG

MANAGEMENT OF INSECTICIDE RESISTANT INSECT PESTS ATTACKING ONIONS
Ron Harris, Dept. of Environmental Biology, UofG

MANAGEMENT OF THE NEMATODE COMPONENT OF POTATO EARLY DYING WITH ORGANIC SOIL AMENDMENTS
John Potter, AAFC, Vineland Station and George Lazarovits, AAFC, London

MANAGEMENT OF INSECTICIDE RESISTANT INSECT PESTS ATTACKING ONIONS
C.R. Harris, Dept. of Environmental Biology, UofG

NEMATODE DIAGNOSTIC SERVICES
C. Blaser, Ontario Fruit and Vegetable Growers' Association

OPTIMIZATION OF IMMUNODIAGNOSTIC TEST SPECIFIC FOR TOMATO SPOTTED WILT VIRUS
M. McDermott, McMaster University

SEED TREATMENT FOR BACTERIAL DISEASES OF TOMATO AND PEPPER
B.N. Dhanvantari, AAFC, Harrow

SOIL PEST REDUCTION USING SOLAR ENERGY: AN APPRAISAL OF ITS EFFICACY IN TEMPERATE CLIMATES USING A POTATO PRODUCTION SYSTEM
George Lazarovits, AAFC, London

STRATEGIES FOR CONTROL OF SEPTORIA LEAF SPOT, FUSARIUM YELLOWS AND TARNISHED PLANT BUG ON CELERY
R. Cerkauskas, AAFC

STUDY OF YELLOW NUTSEDGE AGRO-ECOLOGY TO DEVELOP AN INTEGRATED MANAGEMENT PROGRAM FOR ONIONS GROWN IN MUCK SOIL
F. Tardif, Dept. of Crop Science, UofG

SURVEY OF INSECTICIDE RESISTANCE IN SELECTED POPULATIONS OF COLORADO POTATO BEETLE, LEPTINOTARSA DECEMLINEATA, ATTACKING POTATOES AND TOMATOES
Jeff Tolman, AAFC, London

THE BIOLOGY AND CONTROL OF PERENNIAL NIGHTSHADE SPECIES IN FIELD AND HORTICULTURAL CROPS - PART A
Rudy Brown, RCAT



THE BIOLOGY AND CONTROL OF PERENNIAL NIGHTSHADE SPECIES IN FIELD AND HORTICULTURAL CROPS - PART B

Paul Cavers, Dept. of Plant Sciences, University of Western Ontario

THE CONTROL OF POWDERY MILDEW ON ONTARIO-GROWN RUTABAGAS

V.I. Shattuck, Dept. of Horticultural Science, UofG

TRANSFER OF DISEASE AND STRESS TOLERANCE INTO TOMATO BY CELL FUSION

Stephen Gleddie, AAFC

TRANSGENIC POTATO PLANTS RESISTANT TO VIRUSES: AN ALTERNATIVE TO REDUCE CHEMICAL PESTICIDES FOR THE CONTROL OF INSECT VECTORS OF POTATO VIRUSES

M.G. AbouHaidar, Dept. of Botany, Univ. of Toronto

WEED CONTROL STRATEGIES FOR ASPARAGUS USING FALL-SEEDED RYE STRATEGIES FOR CONTROL OF SEPTORIA LEAF SPOT, FUSARIUM YELLOW AND TARNISHED PLANT BUG ON CELERY

R. Cerkauskas, AAFC, Harrow

WORKSHOP ON FUTURE DIRECTIONS OF POTATO IPM IN ONTARIO

Mark Sears, Dept. of Environmental Biology, UofG

field

A COMPARISON OF LOW CHEMICAL INPUT AND CONVENTIONAL PRACTICES IN CORN AND SOYBEAN PRODUCTION

G. Hofstra, Dept. of Environmental Biology, UofG

BIOLOGICAL AND CULTURAL CONTROL OF SOYBEAN CYST NEMATODE

Terry Anderson, AAFC, Harrow

BIOLOGICAL CONTROL OF SCLEROTINIA AND SCLEROTIUM WITH FUNGAL VIRUSES AND ANTAGONISTIC FUNGI

G. Boland, Dept. of Environmental Biology, UofG

BIOLOGICAL CONTROL OF WEEDS OF ROW CROPS

Jack Alex, Dept. of Environmental Biology, UofG

BIOLOGY AND CONTROL OF PROBLEM WEEDS

Jim Shaw, RCAT

COMPARISON OF LOW-INPUT, NO-TILL, CONVENTIONAL AND NO-SYNTHETIC CASH CROPPING SYSTEMS

Dave Hume, Dept. of Crop Science, UofG

CONTROLLING INSECT PESTS OF CORN USING ENTOMOGENOUS NEMATODES

E. Riga and J. Potter, AAFC, Vineland Station

CORN ROOT WORM CONTROL WITH BACILLUS LATEROSPORUS A NATURALLY OCCURRING BIOPESTICIDE

J.P. Insell, Microbe Inc., London

CRITICAL PERIOD OF WEED CONTROL IN NO-TILL SOYBEAN AND CORN

Jianhua Zhang, AAFC, Harrow

CROP WEED MODELS FOR CORN AND SOYBEANS

M. Tollenaar, Dept. of Crop Science, UofG

DAMAGE THRESHOLD FOR POTATO LEAFHOPPERS

Art Schaafsma, RCAT

DETERMINATION OF THE CRITICAL PERIOD OF WEED INTERFERENCE IN CORN (ZEA MAYS L.) AND SOYBEANS (GLYCINE MAX L.)

Clarence J. Swanton, Dept. of Crop Science, UofG

DEVELOP MONITORING METHODS FOR OVIPOSITION BY CORN ROOTWORMS IN FIELD CORN AND MEASURE EGG QUALITY AND OVERWINTERING SUCCESS FOR IPM PURPOSES

C.R. Ellis, Dept. of Environmental Biology, UofG

DEVELOPING AND ANALYZING A DATABASE ON BELOW LABEL RATES OF HERBICIDES

Jianhua Zhang, AAFC, Harrow

DEVELOPMENT AND APPLICATION OF A DNA PROBE FOR SPECIFIC DETECTION OF COMMON AND FUSCOUS BLIGHT BACTERIA IN FIELD BEAN SEED

B.N. Dhanvantari, AAFC, Harrow

DEVELOPMENT OF AN EXPERT SYSTEM TO DELIVER INFORMATION ON WEED ECONOMIC THRESHOLDS TO CORN AND SOYBEAN GROWERS IN ONTARIO

Susan Weaver, AAC, Harrow

DEVELOPMENT OF DECISION SUPPORT SOFTWARE FOR WEED MANAGEMENT IN CORN AND SOYBEANS IN ONTARIO

Susan Weaver, AAC, Harrow

DEVELOPMENT OF WEED CONTROL STRATEGIES FOR REDUCED TILLAGE CROP PRODUCTION

Clarence Swanton, Dept. of Crop Science, UofG

ECONOMIC THRESHOLDS OF WEEDS IN SOYBEANS AND CORN IN ONTARIO

Susan Weaver, AAFC, Harrow

ECONOMICS OF LOW-INPUT AGRICULTURE AND ALTERNATIVE SYSTEMS FOR THE MANAGEMENT OF WEEDS IN ONTARIO FIELD CROPS

D.P. Stonehouse, Dept. of Ag. Economics & Business, UofG

EFFECT OF POTATO LEAFHOPPER FEEDING AND MANUAL DEFOLIATION AT VARIOUS STAGES OF DRY EDIBLE BEAN GROWTH AND VALIDATION OF AN ENHANCED CROP RESISTANCE TO PLANT DISEASE USING BACTERIAL INOCULANTS

G. Lazarovits, AAFC, London

EFFICIENT SPRAY APPLICATION TECHNOLOGY TO REDUCE HERBICIDE USE IN FIELD CROP PRODUCTION

Ralph Brown, School of Engineering, UofG

EVALUATION OF ALTERNATIVE MATERIALS FOR THE CONTROL OF THE INDIAN MEAL MOTH IN GRAIN STORAGE BINS IN ONTARIO

Art Schaafsma, RCAT

EVALUATION OF MANAGEMENT TECHNIQUES TO PREDICT AND CONTROL WHITE MOLD IN AN EDIBLE COLOURED BEAN SYSTEM

J.J. O'Toole, Vaughn Agricultural Research Services





EVALUATION OF RESISTANCE TO MALATHION IN POPULATIONS OF INDIAN MEAL MOTH, *PLODIA INTERPUNCTELLA*, FOUND IN SOUTHERN ONTARIO

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J.C. Sutton, Dept. of Environmental Biology, UofG

INTEGRATED WEED MANAGEMENT DECISION RULES FOR POSTEMERGENCE CONTROL OF BARNYARDGRASS (*ECHINOCHLOA CRUS-GALLI*) IN CORN (*ZEA MAYS*)

Clarence Swanton, Dept. of Crop Science, UofG

INTEGRATED WEED MANAGEMENT IN CORN AND SOYBEANS: PHASE I - LITERATURE SEARCH

Clarence Swanton, Dept. of Crop Science, UofG

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John Heard, New Liskeard College of Agricultural Technology

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A.W. Schaafsma and J.A. Underwood, RCAT

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David Hume, Dept. of Crop Science, UofG

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J.T. Arnason, Ottawa-Carleton Institute of Biology, Dept. of Biology, Univ. of Ottawa

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R. Hall, Dept. of Environmental Biology, UofG

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C.R. Ellis, Dept. of Environmental Biology, UofG

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THE INFLUENCE OF CROP ROTATION AND REDUCED TILLAGE ON WHITE MOLD OF SOYBEAN

G. Boland, Dept. of Environmental Biology, UofG

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Al Hamill, AAFC, Harrow

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R.C. Roy, AAFC, Delhi

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Bruce Bowman, AAFC, London

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J.C. Tu, AAFC, Harrow

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CONTROL OF EUROPEAN CHAFER, *RHIZOTROGUS MAJALIS*, IN TURF

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CONTROL OF WHITE GRUBS AND EUROPEAN CHAFER ON TURF

F.C. Vaughn, Vaughn Agricultural Research Services Ltd.

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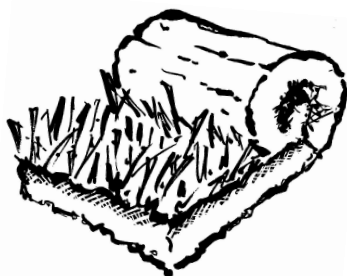
C.A. Levesque, AAFC, Vancouver

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J.C. Hall, Dept. of Environmental Biology, UofG

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J.C. Hall, Dept. of Environmental Biology, UofG



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Tom Hsiang, Dept. of Environmental Biology, UofG

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Wayne Barton, Vaughn Agricultural Research Services Ltd.

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Chris Hall, Dept. of Environmental Biology, UofG

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Tom Hsiang, Dept. of Environmental Biology, UofG

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Tom Hsiang, Dept. of Environmental Biology, UofG

SUBSURFACE INJECTION SYSTEMS FOR PLACEMENT OF INSECTICIDES BELOW TURFGRASS THATCH FOR CONTROL OF EUROPEAN CHAFERS

Mark Sears, Dept. of Environmental Biology, UofG

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G. Hofstra, Dept. of Environmental Biology, UofG

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F.D. Sumsion, Ontario Centre for Farm Machinery & Food Processing Technology

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B. Ripley, Lab Services Div., UofG

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Gord Surgeoner, Dept. of Environmental Biology, UofG

ECONOMIC EVALUATION OF FOOD SYSTEMS 2002

A. Weersink, Dept. of Ag. Economics and Business, UofG

ENVIRONMENTAL IMPACT OF ONTARIO'S PESTICIDE REDUCTION PROGRAM FOOD SYSTEMS 2002

G.A. Surgeoner, Dept. of Environmental Biology, UofG

EVALUATION OF THE BENZOYLPHENYL UREA, LUFENURON7 FOR CONTROL OF THE NORTHERN FOWL MITE, ORNITHONYSSUS SYLVIARUM

G. Surgeoner, Dept. of Environmental Biology, UofG

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Fred Vaughn, Vaughn Agricultural Research Services

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Gord Surgeoner, Dept. of Environmental Biology, UofG

PESTICIDE APPLICATION TECHNOLOGY RESEARCH

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R.G. Winfield and J.A. Underwood, RCAT

TO DETERMINE THE SPRAY PATTERN OF 80E AND 110E SPRAY NOZZLES UNDER SIMULATED FIELD CONDITIONS

Jack Underwood, RCAT

WEED CONTROL RECOMMENDATION SYSTEM

John Schleihauf, Plant Industry Br., OMAFRA

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Dr. J.A. Traquair, AAFC

BIOLOGY OF HARVESTING ANTS IN TOBACCO SEEDLING GREENHOUSES

Jeff Tolman, AAC, London

DEVELOPMENT OF AN INTEGRATED BIOLOGICAL AND CHEMICAL CONTROL PROGRAM FOR TOBACCO

Rick Reeleder, AAFC, Delhi

MARIGOLD ROTATION CROP EFFECTS ON SOIL NEMATODE POPULATIONS AND ON TOBACCO YIELD AND QUALITY

L.B. Reynolds, AAFC, Delhi

PART A: DEVELOPMENT OF AN INTEGRATED BIOLOGICAL AND CHEMICAL CONTROL PROGRAM FOR TOBACCO SEEDLING (GREENHOUSE) DISEASES CAUSED BY RHIZOCTONIA SOLANI AND PART B: CHEMICAL AND BIOLOGICAL CONTROL OF RHIZOCTONIA DAMPING-OFF OF GINSENG

Rick Reeleder, AAFC, Delhi

POTENTIAL OF REDUCED QUINTOZENE RATES AND OTHER PRODUCTS TO CONTROL RHIZOCTONIA SOLANI DAMPING-OFF OF GINSENG SEEDLINGS

Rick Reeleder, AAFC, Delhi

TOBACCO CULTIVARS WITH MULTIPLE INSECT RESISTANCE USING A COMBINATION OF GENETIC TRANSFORMATION AND CONVENTIONAL BREEDING TECHNIQUES

Jim Brandle, AAFC, Delhi

USE OF BIOWASTES AND CULTURAL PRACTICES FOR IMPROVED MANAGEMENT OF SOILBORNE DISEASES OF GINSENG

Rick Reeleder, AAFC, Delhi

