Agriculture and Agri-Food Canada
Research Branch

Agriculture et Agroalimentaire Canada
Direction générale de la recherche

Canada

Research Summary

Volume 27, 1999-2000

Horticultural Research and Development Centre

Web site : http://res2.agr.ca/stjean/crdh.htm
Aussi disponible en français

GUIDE FOR CONVERTING METRIC UNITS

AGRICULTURE		
Litre per hectare (L/ha)	x 0.089	= gallon per acre
Litre per hectare (L/ha)	x 0.357	= quart per acre
Litre per hectare (L/ha)	x 0.71	= pint per acre
Millilitre per hectare (ml/ha)	x 0.014	= liquid ounce per acre
Metric ton per hectare (t/ha)	x 0.45	= ton per acre
Kilogram per hectare (kg/ha)	x 0.89	= pound per acre
Gram per hectare (g/ha)	x 0.014	= once per acre
Plant per hectare (plant/ha)	x 0.405	= plant per acre
LENGTH		
Millimeter (mm)	x 0.04	= inch
Centimeter (cm)	x 0.39	= inch
Meter (m)	x 3.28	= feet
Kilometer (km)	x 0.62	= mile
AREA		
Hectare (ha)	x 2.5	= acres
VOLUME		
Litre (L)	x 0.035	= cubic feet
Hectolitre (hl)	x 22	= gallons
Hectolitre (hl)	x 2.5	= bushels
WEIGHT		
Gram (g)	x 0.04	= ounce
Kilogram (kg)	x 2.2	= pounds
Metric ton (t)	x 1.1	= ton

NOTICE

Results reported here are preliminary. It would not be advisable to attempt to draw from them any definite conclusions.

Weather Data : Dominique Plouffe
Layout : Rick Mallett
Photographs : Thérèse Otis
Editing : Louise Paquet
Revision : Louise Paquet, Thérèse Otis

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Research Branch
Agriculture and Agri-FoodCanada

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Copies can be ordered at:

Horticultural Research & Development Centre
Agriculture and Agri-Food Canada
430, Gouin Blvd.
Saint-Jean-sur-Richelieu, Qc
Canada
J3B 3E6
Tél. (450) 346-4494
Fax. (450) 346-7740

CONTENTS

FORWORD

A SIZEABLE INTELLECTUAL PROPERTY PORTFOLIO

The years 1998 and 1999 were important ones for the HRDC in terms of marketing technologies resulting from matching investment initiatives undertaken with the private sector in horticulture. The marketing agreements are generating promising economic benefits for both the private sector and the HRDC.

For example, three strawberry cultivars, "AC L'Acadie", "AC-Yamaska'' and "L'Autenthique Orléans'', along with a columnar apple cultivar called "AC-McExcel' have been granted protection by the Plant Breeders'' Rights Office. Propagation and marketing licences have been negotiated with the firm Fraises de l'Île d'Orléans for Ile d''Orléans; with the Association des producteurs multiplicateurs de fraisiers et framboisiers certifiés du Québec for Canada; with the Ontario Berry Growers Association for Canada and the United States; and with the Chilean company PIGA S. A. for South America.

With regard to patents, the HRDC and Université Laval have filed a patent application for a new orchard spraying device; this machine called "Récup-Air'' recovers the spray liquid and prevents drift. It was developed thanks to federal funding from the R&D Matching Investment Initiative (MII), the Natural Sciences and Engineering Research Council and St Lawrence Vision 2000.

An intellectual property list will be available in the coming year on the HRDC's web site at: http://res2.agr.ca/stjean/crdh.htm

THE HRDC'S FUTURE

The HRDC team has risen to the challenge of undertaking collaborative activities with the private sector. In 1995-96, an initial sum of $500,000 was granted to develop a few joint projects with our collaborators in the private sector. Now, five years later, the figure is closer to $2.5 million, with this amount being used to fund about 70 projects.

The research being done is of high quality and the intellectual property portfolio is steadily expanding. Collaborative projects with universities have taken on considerable importance as well, allowing us to maintain links with academe by carrying out research projects upstream of application.

The HRDC's research program is articulated around the broad-scale national mandate in the market garden sector and other crops at the regional level. A number of initiatives have generated term contracts for many employees involving training and various management approaches.

The HRDC's future lies in building up its research teams. While optimal use is being made of the existing infrastructure, increased growth will make it necessary to expand the physical facilities. The R&D Matching Investment Initiative has now reached cruising speed. Given the team's vitality and the needs of the horticultural industry, the HRDC's funding envelope should stay at a level close to the present allocation of nearly $2.5 million per year.

We will also strengthen the way we operate, through improvements in the selection process for projects, the recruitment process, budgetary follow-up and the quality of reports submitted to our collaborators.

The HRDC staff is justly proud to contribute to the technical and economic advancement of the agricultural sector.

Denis Demars, Ph.D.
Director

STAFF LIST

Management
Demars Denis, Ph.D., director
Rolland Claire, executive secretary
Chagnon Roger, B.Sc.A. eng., assistant director

Commercialization
Daneau Jacques, B.A.A., new technologies
Couët Julie, LL.B., new technologies
Otis Thérèse, agr., B.Sc.A. new cultivars

Communications
Otis Thérèse, agr., B.Sc.A., commun. officer
Paquet Louise, M.Sc., assist.
Phaneuf Jacinthe, M.Sc.A., web site

Administration
Joncas Sylvie, administration officer
Audet Claire, staff clerk
Brodeur Ghyslaine, finance clerk
Charbonneau Nathalie, finance clerk
Gerderbloom Ginette, clerk
LaRocque Danièle, finance clerk
Martineau Jocelyne, receptionist
Tremblay Gilles, storekeeper
Deschamps Mathieu, trainee

Research staff
Bélair Guy, M.Sc., nematology
Fournier Yvon, D.E.T., technician
Simard Louis, [M.Sc.][1], Laval U.
Pou Thyrith*, B.Sc., research assist.
Dauphinais Nathalie, M.Sc., (NYIP)[2]
Rochon Kateryn, B.Sc., (NYIP)
Soufiane Brahim, M.Sc., (NYIP)

Bélanger André, Ph.D., analyt. org. chemistry
Boudreau, France B., D.E.C. technician
Chiasson Hélène, Ph.D., research assoc., Urgel Delisle et assoc.
Musabyimana Thaddée, Ph.D., research assoc.
Gauvin Marie-Josée, M.Sc., research assist.
Grondin Nathalie, B.Sc., research assist.
Poliquin André, M.P.M., research assistant, Urgel Delisle et associés
Sékou-Keita Moussa, [Ph.D.], UQAM
Cormier Daniel*, Ph.D., research assist.
Bérubé, Claude, B.Sc., (NYIP)
Blouin Nadine, [M.Sc.], Horizon-Sciences prog.
Boucher Véronique, (NYIP)
Landry Annick, B.Sc., Horizon-Sciences prog.
Loebe Lucia, trainee, Vienna U.
Cech Karin*, trainee, Vienna U.
Diouf Marie-Jeanne*, [B.Sc.], trainee UQAM
Kast Constantia*, trainee, Vienna U.
Katanic Sinisa*, trainee, Vienna U.
König Josef*, trainee, Vienna U.
Mongeau Luc*, [B.Sc.], trainee, UQAM
Morin Martin*, [B.Sc.], trainee, UQAM
Niepel Daniela Iris*, trainee, Vienna U.
Pichler Maria*, trainee, Vienna U.
Reding Mireille*, trainee, Vienna U.
Schwap Monika*, trainee, Vienna U.
St-Mars Karine*, B.Sc., (NYIP) and Horizon Sciences progr.

Benoit Diane L., Ph.D., weed science
Bélanger Manon, M.Sc., technician
Forest Danielle*, M.Sc, research assist.
Hotte Marie-Josée, B.Sc., research assist.
LaHovarty Christophe, [Ph.D.], U. of Guelph
Boisclair Daniel, B.Sc, techn. help
Massicotte Julie*, B.Sc, (A.-C)
Nguyen T. T. Thuy*, B.Sc, trainee U. Sherbr.

Boivin Guy, Ph.D., entomology
Thibodeau Danielle, D.T.Sc.N., technician
Pelletier Dominique, research assoc., Serv. Bio-Contrôle Inc.
Carignan Sylvie, M.Sc., research assist., Phytodata
Carrière Caroline, research assist., Phytodata
Frénette Julie, research assist.
Gauthier, Véronique, research assist., Phytodata
Gauvin Marie-Josée, M.Sc., research assist.
Godin Claude, M.Sc., research assist.
Ledoux Geneviève, research assist., Phytodata
Vaillancourt Josianne, B.Sc., research assist.
Gingras Daniel, [Ph.D.], McGill U.
Tagnan Alain, [Ph.D.], Laval U.
Handfield France, [M.Sc.], McGill U.
Poiré Thierry, [M.Sc.], Laval U.
Cournoyer Michel, [M.Sc.] McGill
Fournier François*, M.Sc., research assoc., Serv. Bio-Contrôle Inc.
Daniel Anthony*, [M.Sc.], McGill U.
Jacob, Sébastien, (NYIP), UQTR
Lachance, Lise*, [Ph.D.], McGill U.

Bostanian Noubar J., Ph.D., entomology
Racette Gaétan, M.Sc., technician
Chiasson Hélène, Ph.D., research assoc., Urgel Delisle et associés
Larocque Nancy, M.Sc., research assist.
Poliquin André, M.P.M., research assist., Urgel Delisle et associés
Trudeau Martin, M.Sc., research assist., Ag-Cord.

Bourgeois Gaétan, agr., Ph.D., agricultural systems modeling
Beaudry Nathalie, D.E.C., research assist.
Choquette Danielle, B.Sc., research assist.
Gagnon Chantal, agr., M.Sc., research assist.
Gay Geneviève, B.Sc., research assist.
Malenfant Yves, B.Sc., research assist.
Plouffe Dominique, B.Sc., research assist.
Chokmani Karem, [Ph.D.], Laval U.
Tagnan Alain, [Ph.D.], Laval U.
Leblanc Maryse, [Ph.D.] McGill U.
Laurence Hélène, [M.Sc.] McGill U.
Gagnon Sandra*, M.Sc., research assist.
Grégoire Nadia*, B.Sc., research assist.
Poliquin André*, M.Sc., research assist.
Désaulniers Julien*, M. Sc., research assist.
Fortier Anne-Marie, [B.Sc.], summer job
L'Ecuyer Marc*, [D.E.C.], trainee
Massé Daniel, [D.E.C.], trainee

Carisse Odile, Ph.D., phytopathology
Rolland, Daniel, B.Sc., technician
Bacon Réjean, B.Sc., research assoc.
Bernier Julie, M.Sc., research assoc.
Ouimet Annie, M.Sc., research assoc.
Cadieux Mélanie, D.E.C.
Lefebvre Annie, D.E.T., research assist.
El Bassam Souad, research assist.
Toussaint Vicky, [Ph.D.], McGill U.

---

* End of contract
1 Current diploma
2 National Youth Internship Program

Dewdney Megan, [M.Sc.], McGill U.
Benyagoub Mohamed*, Ph.D., assoc. rech.
Philion Vincent*, M.Sc., assoc. rech.
Bujold Isabelle, [M.Sc.], McGill U.
Charest Jolin*, [M.Sc.], McGill U.
Wellman-Desbiens Elisabeth*, [M.Sc.], U. Sherbr.
D'esteredjian Jean-François*, D.E.C., aide-technique
Tougas Sophie*, B.Sc., aide-technique
Moran Tanyan*, D.E.C., aide-technique
Gingues Sonia*, D.E.C., aide-technique
D'Esheme Bertrand*, summer job (France)
Denoncourt Patrick*, [B.Sc.], trainee, U. Sherbr.
Dionne Isabelle*, [B.Sc.], traineeU. de Sherbr.
Lahaye Isabelle*, summer job
Larivière Martin*, [B.Sc.], traineeU. Sherbr.
Tremblay Mathieu*, [B.Sc.], traineeU. Sherbr.

Chagnon Roger, eng., B.Sc.A., mechanization
Fortin Sylvain, eng., B.Sc.A., research assist.
Bisaillon Claude, D.E.S., mécanicien
Andrade Marc-David*, ing., B.Sc.A., research assist.
Ramsay Patrick*, [B.Sc.A.], summer job
Trottier Jean-François*, [B.Sc.A.], summer job

Côté Jean-Charles, Ph.D., molecular biology
Fréchette, Suzanne, B.Sc.A., technician
Boutros Saleh Mona, Ph.D., research assoc.
Xu Dong, Ph.D., postdoc fellow, research assoc.
Todorova Sylvia, Ph.D., research assist.
Bourassa Caroline, M.Sc., research assist.
Lemoyne Pierre, M.Sc., research assist.
Marcotte Chantal, M.Sc., research assist.
Joung Kwang Bo, [Ph.D.], UQAM
Jung Yong-Chul, [Ph.D.], Korea Res. Inst. of Biotechnology/University of Montreal
Wellman-Desbiens Élizabeth, [Ph.D.], UQAM
Kouassi Mathias, [Ph.D.], UQAM
Gorgeltchan Maria, [M.Sc.], UQAM
Dunn Chantal*, M.Sc., research assist.
Bolté Sébastien*, B.Sc., research assist.
Pou Thyrith*, B.Sc., research assist.
Tremblay Éléonore*, B.Sc. research assist.
Ung Muy* Y., B.Sc., research assist.
Boucher Mélanie*, D.E.C., research assist.
Kim Han-Su*, [Ph.D.], U. Montréal
Bélanger Stéphanie, B.Sc., (NYIP)
Bélanger Véronique*, [D.E.S.],
Duron Karine*, trainee (France)
Grog Grégory*, D.E.S.S., trainee, ENESAD, Dijon
Lafontaine Marielle*, Ph.D., trainee
Palaquelos Raquel*, [B.Sc.], trainee, U. Sherbr.
Rheault Jean-François*, [D.E.C.], summer job
Soufiane Brahim*, M.Sc., trainee

DeEll Jennifer, Ph.D., postharvest physiology
Roussel Dominique, B.Sc.A., technician
Gariépy Yvan, M.Sc. eng., research assoc.
Saad Fadia, Ph.D., research assoc.
Bissonnette Sylvain, B.Sc., research assist.
Demian Shereef, eng., B.Sc.A., research assist.
Martineau Robert, D.E.C., research assist.
Schofield Andrew, [M.Sc.], U. of Guelph
Barrette Maryse*, [B.Sc.], summer job
Favre Frédérique*, trainee, ENESA Dijon
Guilleux Arnaud, trainee, (France)
Kassatli Rita*, B.Sc., (NYIP)
Lemerre Stéphanie*, trainee, ENESA Dijon
Poll Samantha*, [B.Sc.], summer job
Rousseau Sophie, trainee, (France)

Jenni Sylvie, agr., Ph.D., veg. prod. physiology and management
Desrosiers Jean-Claude, D.E.T., technician
Leboeuf Nathalie, B.Sc., technical support
Dubuc Jean-François, M.Sc., research assist.
Emery Georges, Ph.D., consultant
Aziz Fahrurrozi, [Ph.D.], McGill U.
Brault Dominique, [M.Sc.], McGill U.
Côté John-Christopher, [M.Sc.], McGill U.
Tremblay Eléonore*, B.Sc., research assist.
Auclair Nicolas*, research assist.
Rioux Marie-Claude, D.E.T., (NYIP)
Fejes Anne*, [D.E.C.], summer job
Labrecque Françoise*, [D.E.C.], summer job
Marcil Nicolas*, [D.E.C.], summer job
Pinard Audrey*, [D.E.C.], summer job

Khanizadeh Shahrokh, Ph.D., plant breeding and physiology
Deschênes Martine, D.T.A., technician
Groleau Yvon, D.T.A., technician
Cousineau Johanne, Ph.D., research assoc.
Gauthier Martin, B.Sc., research assist.
Larivière Janie, M.Sc., research assist.
Levasseur Audrey, D.T.A., research assist.
Ditcham Sylvie, aide-technique
Cormier Daniel*, Ph.D., research assist.
Hakam Nadia*, Ph.D., research assist.
Saad Fadia*, Ph.D., research assist.
Thériault Bertrand, D.T.A., research assist.
Funakoshi Didier, [Ph.D.], U. McGill
Ghalavi Vida*, [Ph.D.], UQAM
Hébert Claire*, [M.Sc.], U. Laval
Beldica Elena Carmen, trainee (NYIP)
Bonneville Vicky*, summer job
Brouard Line*, trainee, UFR Sc., France
Doyon Audrey*, summer job
François Catherine*, summer job
Gaucher Pascal*, summer job
Grimard Eric*, summer job
Nguyen Ann Quan, trainee (NYIP)
Stall-Paquet Gabriel*, summer job
Trubuil Catherine*, trainee, ENITAC, France

Panneton Bernard, eng., Ph.D., engineering unit in plant production
Saint-Laurent, Gilles, D.T.I.&C., technician
Fortin Sylvain, eng., B.Sc.A., research assist.
Lacasse Benoit, eng. jr., M.Sc.A., research assistant/designer
Laurence Hélène*, B.Sc., research assist.
Piché Marlène, M.Sc.Agr., Ing., research assist.
Ramsay Patrick*, B.Sc.A.. research assist.
Thibault Eric*, B.Sc.A., research assist.
Moreau Pascal*, [M.Sc.], U. Sherbr.
Voisin Thomas*, trainee, ENITA, Bordeaux
Fontaine Véronique*, B.Sc.A., U. Laval

Piekutowski Thomas*, Eng., [Ph.D.], agricultural geomatics
Brouillard Michel, M.Sc., research assistant
Thibault Eric*, B.Sc.A., research assist.

Richer Claude, agr., M.Sc., ornamental plant management
Auger Michel, technician
Mottard Jean-Philippe, research assist.
Pellerin Raymond[3], technician
Constabil Caroline, Ph.D., assoc. rech.

3 Deceased August 2000

Marquis Pascale, M.Sc., research assist.
Brassard Nicole, M.Sc., research assist.
Lafond Caroline, B.Sc. research assist., (NYIP)
Renaud Brigitte, D.E.C., research assist.
Galipeau Christine, M.Sc., editing
Gauthier Chantal, D.E.C., editing
Lizée Isabelle, D.E.C., secretary
Prud'homme Nathalie*, technician
Bédard Christian*, M.Sc., assoc. rech.
Gingras Daniel*, [Ph.D.], research assist.
Janson Michel*, D.E.C., research assist.
Larivière Janie*, M.Sc., research assist.
Donaldson Cynthia, [D.E.C.], trainee
Gaillard Thomas, D.E.U.G. (France), trainee
Martineau Julie, D.E.C./I.T.A., trainee
Paquette Chantal, D.E.C., trainee (NYIP)
Tronchet Frédéric, M.S.T., trainee (France)
Arsenault Serge*, D.E.S., (NYIP)
Beaupré Etienne*, B.Sc., summer job
Bélanger Eric*, D.E.S., (NYIP)
Bourdeau Caroline*, [D.E.C.], summer job
Coquet Cédric*, M.S.T. trainee (France)
Dane Nathalie*, D.E.P., trainee
Fiset Etienne*, B.Sc., summer job
Houle Claudia*, [D.E.C.], summer job
Toupin Pénélope*, B.Sc., summer job
Turmel-Hartz Nancy*, D.E.P., (NYIP)

Tremblay Nicolas, agr., Ph.D., veg. nutrition and crop management
Dextraze, Louise, B.Sc., technician
Bélec Carl, B.Sc., research assist.
Vigneault Philippe, M.Sc., research assist.
Tétreault Marcel, B.Sc., technic. support
Badra, Abdo, [Ph.D.], Laval U.
Nkoa Roger, [Ph.D.], Laval U.
Guérette Valérie, [M.Sc.], Laval U.
Létourneau Geneviève, [M.Sc.], U. Laval
Laflamme Lucette*, M.Sc., research assist.
Laurence Hélène*, B.Sc., research assist.
Roy Geneviève*, B.Sc ., research assist.
Villeneuve Sarah, [M.Sc.], Laval U.
Boyer Mélissa*, [B.Sc.], summer job
Corriveau Julie*, [B.Sc.], summer job
Dufresne Philippe*, [D.E.C.], summer job
Hébert Jean-Michel*, [B.Sc.], summer job

Vigneault Clément, eng., Ph.D., postharvest technology
Goyette Bernard, M.Sc. eng., research assoc.
Roger Caroline, Ph.D., research assoc.
Gariépy Yvan, M.Sc., research assoc.
Bourassa Caroline, M.Sc., res. assist.
Odeogu Ike, M.Sc., res. assist.
Hui Catherine Ka Po, [M.Sc.], McGill U.
Hébert Martin, B.Sc., res. assist.
Bissonnette Sylvain, B.Sc., res. assist.
Roussel Dominique, B.Sc.A., research assist.
Tervel M. Barbara J., [Ph.D.], U. Campinas
Rennie Timothy J., eng. jr., [M.Sc.], McGill U.
Labrecque Claude, M.Sc., research assoc.
Alvo Peter*, M.Sc., research assist.
Ouimet Annie*, M.Sc., res. assist.
Martineau Robert*, D.E.C., res. assist.
Beaudry Claudia*, [B.Sc.], empl. été
Berrette Maryse*, D.E.C., empl. été
Favre Frédérique*, stag. ENESA, Dijon
Goulet Annie*, [D.E.S.], (NYIP)
Guilleux Arnaud*, stag. (France)
Kassatli Rita*, B.Sc., (.NYIP)
La Mendola Anita*, [B.Sc.], empl. été
Lemerre Stéphanie*, stag. ENESA, Dijon
Rousseau Sophie*, stag. (France)

Vincent Charles, agr., Ph.D., entomology
Rancourt Benoît, M.Sc., technician
Poliquin André, M.P.M., technician, Urgel Delisle et associés
Chiasson Hélène, Ph.D., research assoc., Urgel Delisle et associés
Joannin R., research assoc., Pomme Plus
Thomson G., research assoc., Trifolium Inc.
Lasnier Jacques, research assist., Ag Cord
Otoidobiga Lenli Claude, [Ph.D.], McGill U.
Sagara Laurent, [Ph.D.], McGill U.
Sékou Moussa Keita, [Ph.D.], UQAM
Pronier Isabelle, [Ph.D.], U. Picardie J.V. Amiens
Bellemare Julie, [M.Sc.], UQAM
Bissonnette Sylvain*, B.Sc., research assoc.
Larocque Nancy*, M.Sc., research assoc.
Asselin Mario*, research assoc.,
Grégoire Nadia*, B.Sc., research assist.
Fleury Dominique*, [M.Sc]. UQAM
Lavoie Ariane*, [M.Sc.], UQAM
Boisclair Daniel, trainee, prog. à la Source
Lemay Isabel, research assist.
Baffert Véronique*, , U. Claude-Bernard Lyon 1
Belley Mélanie*, trainee , Inst. de techn. Agric. de la Pocatière
Duquenne Rémi*, trainee, U. Claude-Bernard Lyon 1
Ménard Virginie*, trainee, Ecole Nat. Sup. d'horticulture (Anger)

Research support
Bernard Francine, M.B.S.I., librarian
Lavallée Lise, assistant
Durand Hélène, clerk
Potvin Pascale, D.E.C., trainee (NYIP)

Côté Sylvain, B.Sc., computer management
Côté Alain, D.E.C., computer management

Mercier Gaston, M.Sc. chemistry, laboratory services
Roy Yves, foreman
Lahaie Guy, maintenance
Rémillard Gérald, manoeuvre
Sauvageau David, (NYIP)
Trahan Gaétan, caretaker
Boulet Guy, greenhouse manager
Forest Carmen, greenhouse helper
Seney Sylvie, greenhouse helper

Experimental sites
Audette Monique, agr., Frelighsburg manager
Aiblinger Jean, agricultural worker
Dubé Réginald, agricultural worker / mechanic
Courchesne Éric, agricultural worker
Lagacé Lise, agricultural worker

Magnan Jocelyn, L'Acadie manager
Auclair Nicolas, B.Sc., trial plots manager
Audet Nathalie, agricultural worker
Desranleau Jacques, agricultural worker
Marin Normand, laborer
Riendeau Bertrand, agricultural worker
Rodrigue Luc, nursery man and agricultural worker
St-Martin Michel, agricultural worker
VanWijk André, agricultural worker

Fortin Michel, Ste-Clotilde manager
Desteredjian Jean-François, agricultural worker
Gervais Réal, agricultural worker
Levesque Alain, agricultural worker
Surprenant Brigitte, agricultural worker
Tremblay Jacques[4], agricultural worker

4 Retired June 2000

SPECIAL EVENTS

1999 APPLE DAY

February 2, Saint-Hyacinthe

The HRDC presented the latest research results on apple scab biological control with antagonistic fungi. This research is conducted in collaboration with Philom Bios Inc. from Saskatoon. Entomologist Charles Vincent presented the results of his research on integrated pest management of the oblique banded leafroller. Jacques Lasnier from the company AgChord Inc. of Roxton Falls outlined the collaborative project he and acarologist Noubar Bostanian are carrying out on biocontrol of mites in orchards using indigenous predatory mites.

Monique Audette, agronomist in charge of the Frelighsburg experimental orchard, visited the exhibits with François Rochon, who is an apple grower from Deux-Montagnes and an active member of the Fédération des producteurs de pommes du Québec (Federation of Quebec Apple Producers).

In charge of exhibit, from left to right, Yvon Groleau, Martine Deschênes and Benoit Rancourt, technicians.

HORTICULTURAL WEEK 1999

February 3 and 4, Saint-Hyacinthe

During the 1999 edition of horticultural week, organized by the Conseil Québecois de l'horticulture (CQH: Quebec Council for Horticulture) the HRDC presented the latest research findings on geomatic applications in agriculture. This work is being done through a matching investment initiative involving the Co-op Fédérée de Québec, Haut-Monts inc., Phytodata inc. and Société coopérative du sud-ouest de Montréal.

Many other HRDC staff members were present. For example, Marie-Josée Hotte, Éric Thibault, Guy Boivin gave presentations on weeds seedlings, geomatic and parasitoids respectively; Sylvie Jenni discussed the results of research on the effects of drip and overhead irrigation on cucumber pickles yields and revenues. Nicolas Tremblay and Thérèse Otis facilitated the morning sessions.

From left to right, the HRDC Director Denis Demars, technician Louise Dextraze, plant nutrition expert Nicolas Tremblay, agronomist Geneviève Roy, who works as a research assistant in processing vegetables and French researcher Guillaume Thomas from UNILET, who is a specialist in processing vegetables.

1999 MERITAS

MÉRITAS JEAN-DESJARDINS

The HRDC sponsored the Méritas Jean-Desjardins, an award granted by the Fédération des producteurs maraîchers du Québec (FPMQ: Québec Federation of Market Gardeners) in recognition of market garden producers' professional dedication and the key contribution they make through their enterprises.

Gilles Arsenault, a strawberry grower from Acton-Vale, received the trophy this year. He is the current president of the Association des producteurs de fraises et framboises du Québec (Quebec Strawberry and Raspberry Association) and is devoted to promoting and marketing small fruits.

Left to right: Rémy Trudel, Quebec Minister of Agriculture, Mr. Arsenault, Mr. Marian Vinet, FPMQ president and Mr. Denis Demars, HRDC Director.

MÉRITAS FRÉDÉRICK-TRUDEL

Québec market gardeners awarded the Méritas Frédérick-Trudel to Guy Boivin, an entomologist with the HRDC, in recognition of his outstanding biocontrol research on field grown vegetables over the past 15 years. Guy Boivin specializes in integrated pest management (IPM). He has helped to improve insecticide use in carrots and onions crops by establishing the first and largest IPM network in 1984, in collaboration with growers and with an Agriculture Quebec extension officer.

From left to right : Jean-Bernard Van Winden, Vice-President, FPMQ, Guy Boivin, Gilbert Normand, Secretary of State for AAFC and Denis Demars, HRDC Director

GRAP MEETING

March 10, 1999

"I am very pleased with this honour, especially since the recognition comes from the growers themselves" said Guy Boivin.

On March 10, 1999, the Groupe de recherche en agriculture de précision (GRAP: Research Group on Precision Agriculture) had a meeting at the HRDC. Fertilization, herbicide applications, soil physical properties and engineering were the topics discussed in relation to precision agriculture.

About 20 persons listened to the presentations given by European specialists, Ewald Schnug, PhD, from the Institute of Plant Nutrition and Soil Science, Braunschweig, Germany, and John V. Stafford, PhD Eng, from Silsoe Research Institute, Bedford, England. J. Brian Sanderson, MSc, from the National Centre for Research on Sustainable Potato Systems, Charlottetown, PEI, was also present.

From left to right : Nicolas Tremblay, PhD plant nutrition, Brian Sanderson, MSc (PEI, Canada), John V. Stafford, PhD Eng (Engalnd), Bernard Panneton, PhD Eng (HRDC), Ewald Schnug, PhD (Germany) and Denis Demars, PhD HRDC Director.

LAUNCHING OF "AC WILLIAM BOOTH" EXPLORERTM SERIES

The hardy rose "AC William Booth" was launched in the Explorer™ Series on Friday, May 28 at The Salvation Army Territorial Headquarters Canada and Bermuda, in Toronto. This rose was named after General Wiiliam Booth, who founded The Salvation Army in 1865.

The launch event, organised by Lieutenant-Colonel Don Ritson, in charge of Community Relations and Communications, took place in front of the main entrance of the Salvation Army Headquarters. The T.H.Q. Brass Ensemble enlivened the ceremony with music.

The HRDC donated six "AC William Booth" rosebushes, which were planted during the launch ceremony. "AC William Booth" roses can be purchased on the retail market.

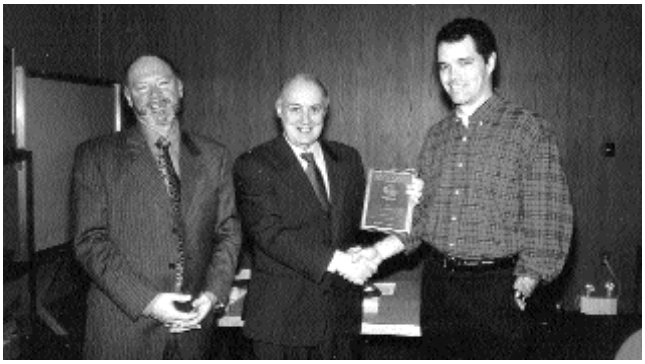
From left to right : Lieutenant-Colonel Don Ritson, in charge of the launch; John Mitchell from the Ottawa Salvation Army Recycling Centre, who chose the rose for the Salvation Army; Claude Richer, an ornemental plant specialist at the HRDC; General Arnold Brown, a retired International Leader; Denis Demars, HRDC Director and Lieutenant-Colonel Peter Wood, Secretary for Business Administration, The Salvation Army Territorial Headquarters Canada and Bermuda.

AGCELLENCE AWARDS

AgCellence awards are given by the AAFC Employee Awards Program. These awards are designed to underscore the exceptional contributions made by individual employees in the pursuit of AAFC objectives. There are several award categories, including the agri-food sector, leadership and innovation.

1998-1999: Nicolas Tremblay, a plant nutrition researcher, was awarded the Agcellence Award for his leadership in the Quebec vegetable sector. Mr. Tremblay conducts studies on fresh market and processing vegetables, medicinal plants, and remote sensing. His work on new, environmentally friendly cultural practices and crops has had a significant impact on producers and the horticultural industry. Mr. Tremblay also encourages stakeholders in the sector to tap the diversity of skills held by his colleagues at the HRDC.

1997-1998: Clément Vigneault and Bernard Goyette shared the Agcellence Award in the agri-food sector with IPL Plastique Inc. of Saint-Damien-de-Bellechasse and Laval University for the development of a new reusable container for handling fruits and vegetables.



AgCellence award. 1998-1999: with HRDC Director Denis Demars looking on, Nicolas Tremblay receives the leadership award from Yvon Martel Director General of Research, Eastern Region.

Neuville Arnold also received an Agcellence Award in the agri-food sector in recognition of the dwarf rose concept he developed for marketing miniature roses.

1996-1997: The Departmental Committee awarded an Agcellence-Leadership Award to Claude Richer, MSc, for her initiative in establishing the Réseau d'essais des plantes ligneuses ornementales du Québec (REPLOQ: Quebec Ornamental Woody Plants Testing Network). The network includes a dozen partners from the federal and provincial governments, universities, and private sector nurseries.

HRDC Director Denis Demars, PhD received the Agcellence-Innovation Award for his contribution to the team headed by Mr. P.A. O'Sullivan, PhD, of Saskatoon, for the development of a new study management system. Designed to be more efficient, more objective, and more precise than previous methods of research management, the new system will ensure optimum utilization of resources devoted to priority research.

SOCIÉTÉ DE PROTECTION DES PLANTES DU QUÉBEC

The HRDC organized the annual meeting of the Société de Protection des Plantes du Québec (SPPQ: Quebec Society for Plant Protection) in Saint-Jean-sur-Richelieu, in June 1999. During the banquet, grants up to 1500$ were awarded to students in honour of their outstanding research work or scientific communications related to plant protection.

The organising committee for the 91th annual meeting of The SPPQ. From left to right: Daniel Rolland, Annie Ouimet, Vicky Toussaint, Jollin Charest, Julie Bernier, Odile Carisse, Meagan Dewdney, Gaétan Bourgeois and Annie Lefebvre.

VISIT OF PLOTS AT L'ACADIE

August 5, 1999

On August 5, agronomist Geneviève Roy organised a visit to her trial plots devoted to processing beans. People from seed companies and processing plants where invited. Mrs. Roy is also in charge of carrying out trials for sweet peas and sweet corn for processing. According to the president of the Fédération québécoise des producteurs de fruits et de légumes de transformation (FQPFLT: Federation of Quebec Producers of Processing Fruits and Vegetables) trials of this type are essential for enhancing competitiveness. The plots are located at L'Acadie experimental farm and the costs are shared by the FQPFLT, the Quebec Food Processors Association (AMPAQ:) and the HRDC.

Center of picture, from left to right : Jacques Légaré, president and CEO of AMPAQ, Nicolas Tremblay, scientist, Léon Hébert, President of the FQPFLT and Geneviève Roy.

VISIT TO PLOTS AT FRELIGHSBURG

August 10, 1999

The Federation of Quebec Apple Producers (FPPQ) held its annual field day in the Frelisghburg area.

On August 10, apple growers and members of the Canadian Horticultural Council visited the plots of the provincial apple trial network financed jointly by the HRDC, FPPQ, and Laval and McGill universities

Agronomist Monique Audette, who manages the HRDC experimental orchard in Frelisghburg and the apple tree trial provincial network, said that the main goal was to compare the growth and yields of different cultivars at three different locations in order to introduce new apple varieties with good potential for commercial production in Québec

NEW LABORATORY AND OFFICE AREA AT FRELIGHSBURG

October 1999

A new laboratory and office area has been built at the Frelighsburg Experimental Farm.

The new building houses two roomy offices and one laboratory.

VISITORS FROM CHINA

November 22, 1999

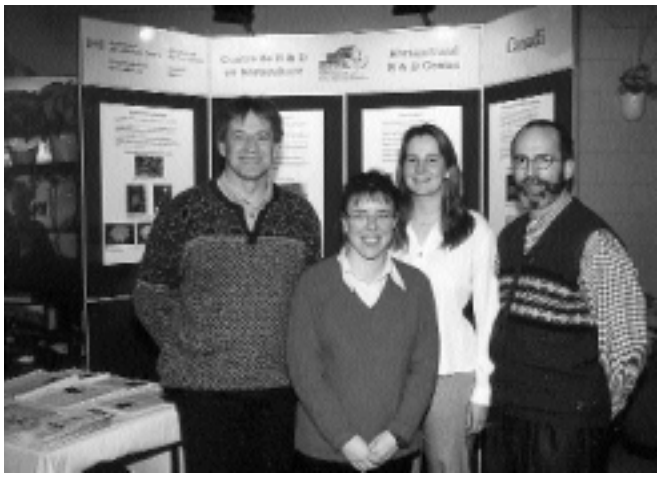
While on a business tour of Canada, seven visitors from the National Technology and Engineering Research Centre for Agricultural Products Freshness Protection, Tianjin, China, visited the HRDC postharvest quality lab.

Clément Vigneault, engineer in charge of the lab and Jennifer DeEll, postharvest physiology expert, (3rd and 4th from the left) explained their research projects during a visit of the lab.

ANNUAL REGIONAL MEETING FOR HORTICULTURAL PRODUCTION

December 2 and 3, 1999

On December 2 and 3, HRDC scientists attended the annual regional meeting on horticultural production in Saint-Rémi. As in past years, many HRDC experts gave talks at this event.



From left to right : Roger Chagnon, Acting Director, and the research team in charge of the "postharvest quality conservation" session on December 2: Mrs. Annie Ouimet, MSc and Vicky Toussaint, MSc, plant pathology, Clément Vigneault, PhD, engineer in charge of the HRDC postharvest quality lab.
Not shown: Diane Benoît, PhD, weed science and Carl Bélec, MSc, nitrogen fertilizer, gave presentations at the session on organic soil; Charles Vincent, PhD, entomology, and Monique Audette, BScA in charge of the Frelighsburg orchard attended the " apple clinic " session on December 3.

PHYSALIA 1999

December 23, 1999

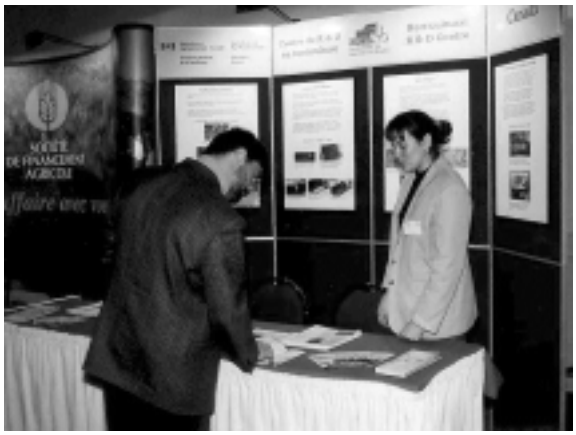
The AAFC Employees Association gives out the Physalia awards. These awards are granted in recongnition of colleagues'' personal and social qualities. The HRDC management team supports this initiative by giving a subtantial gift to each recipient.

Congratulations to our five Physalia 99 award recipients : from left to right, Gilles Tremblay, store manager; Annie Ouimet, lant pathology research associate; Mathieu Deschamps, assistant store manager; Gaétan Trahan, janitor; and Jean-Claude Desrosiers, vegetable physiology technician. Guy Bélair, nematologist, heads up the selection committee for Physalia.

HORTICULTURAL WEEK 2000

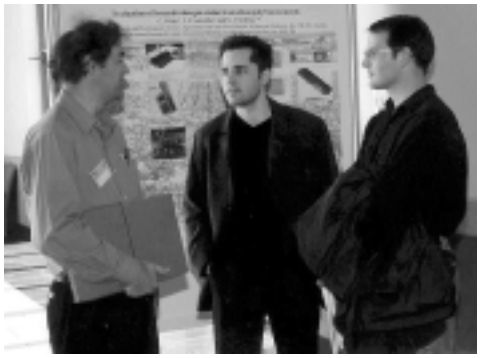
Saint-Hyacinthe - February 2 and 3, 2000

Horticultural Week 2000 was marked by a record turnout of vegetable growers. As in previous years, the HRDC made a major contribution to the success of the 7th edition of this event, which is the most important professional activity for vegetable growers in Quebec. The HRDC attended the Place d'affaires and sponsored a Méritas award and the poster session (a first this year). As well, more than 10 people from the HRDC gave talks on their research activities.



Vicky Toussaint welcoming visitors at the HRDC exhibit at the Place d'Affaires before giving talks on bacterial leaf spot of lettuce and on hygiene for fruit and vegetables warehouses.

The HRDC sponsored the scientific poster session, which was a first for the horticultural week. This gave graduate students and scientist from other centres the opportunity to describe their own research and to meet with growers and extension officers.



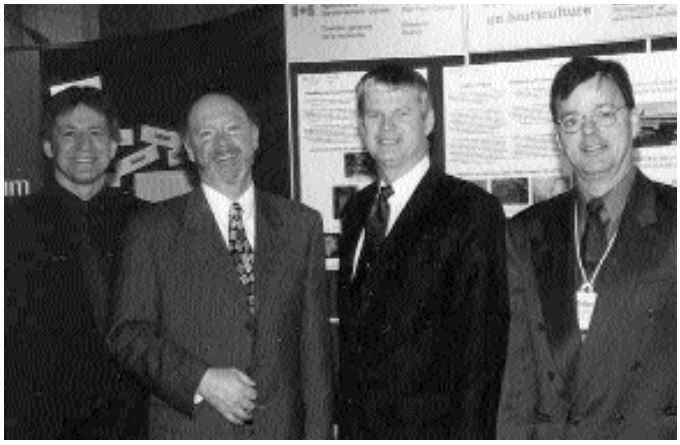
Philippe Vigneault (middle) and Carl Bélec (right), two research assitants in soil fertility, took the opportunity to explain their projects and meet with growers and extension officers durting the poster session.

Make way for the young! Catherine Hui and Tim Rennie are two promising young graduate students working on postharvest quality preservation of fruits and vegetables. They both worked at the postharvest quality preservation lab under Clément Vigneault. The two students discussed their findings on handling and transportation of fruits and vegetables and on vacuum precooling of lettuce, respectively.

ANNUAL MEETING OF THE CANADIAN HORTICULTURAL COUNCIL

Quebec city, March 8 to 11, 2000.

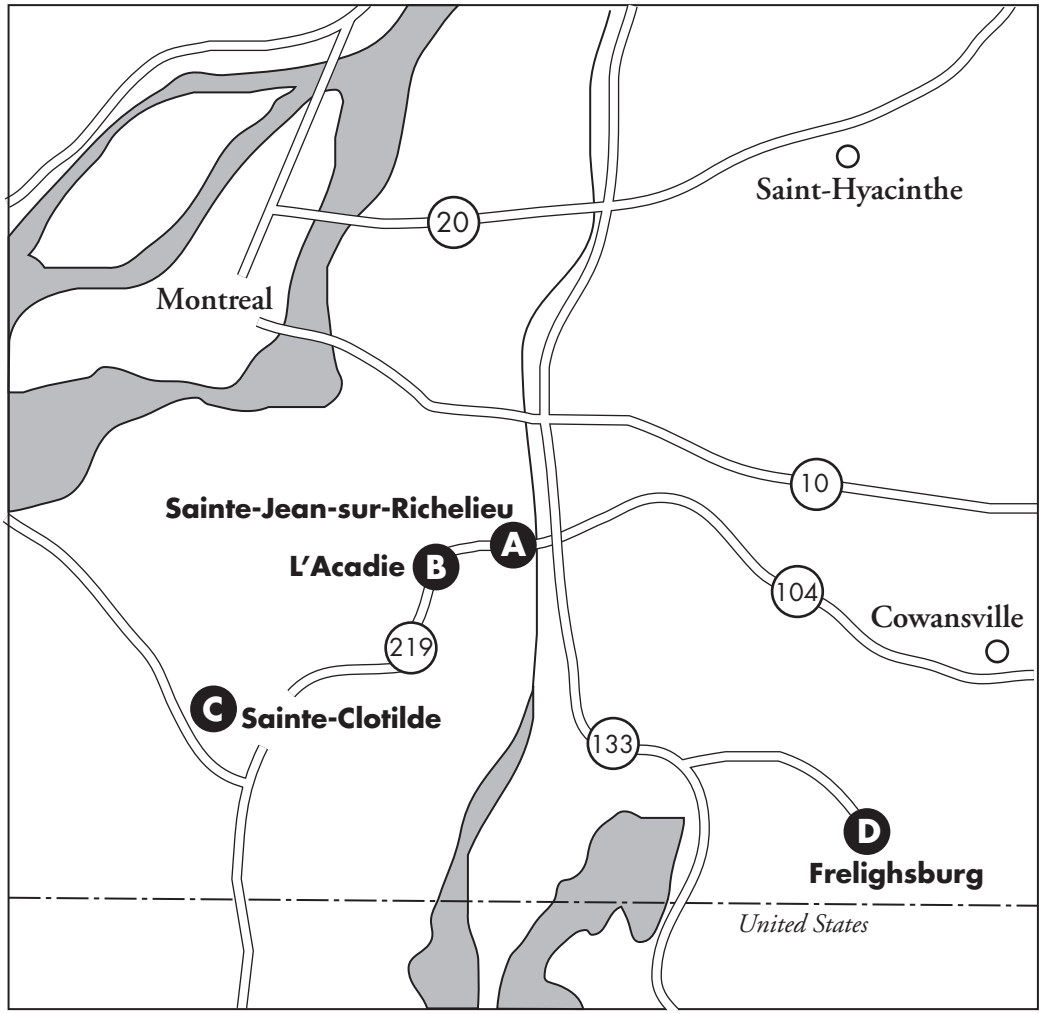
The HRDC attended the Annual Meeting of the Canadian Horticultural Council (CHC). This event was held from March 8 to 11, at the Château Frontenac in Quebec city with the theme " Challenges of the New Era ". The Honorable Lyle Vanclief, federal Minister of Agriculture, announced the injection of $1,2 million in additional funding over the next three years to help the horticultural sector seek the registration of products for limited use.



From left to right: Roger Chagnon, HRDC Assistant Director ; Denis Demars, HRDC Director ; the Honourable Lyle Vanclief ; Robert Allard, apple grower, past president of CCH.

EXPERIMENTAL SITES

Site A : the laboratories and office complex of the **Centre** situated to the west of Saint-Jean sur Richelieu.
Site B : **L'Acadie** substation, 86 ha area of loam clay soil used for vegetable, small fruit, and ornamental plants cultivation. Year of acquisition: 1964.
Site C : Ste-Clotilde substation, 26 ha area of which 14 ha of muck soil devoted to market garden crops. Year of acquisition: 1962.
Site D: Frelighsburg substation, 134 ha area of sandy soil used for growing fruit trees and small fruits. Year of acquisition: 1969.



Jocelyn Magnan, manager
L'Acadie substation
1134 route 219
L'Acadie, Quebec, Canada J2Y 1C4
Tel. and fax: (450) 346-9700;
E-mail: magnanj@em.agr.ca

Michel Fortin, foreman
Ste Clotilde substation
1815 Chemin de la Rivière,
P.O. Box 120
Ste Clotilde, Quebec J0L 1W0
Tel. and fax: (450) 826-3173;
E-mail: fortinmi@em.agr.ca

Monique Audette, agronomist., manager
Frelighsburg substation
57 Chemin St Armand,
P.O. Box 42
Frelighsburg, Quebec J0J 1C0
Tel. and fax: (450) 298-5315;
E-mail: agrifrel@acbm.qc.ca

NITROGEN INPUT FROM THE MINERALIZATION OF MARKET-GARDEN CROP RESIDUES

Valérie Guérette, Carl Bélec and Nicolas Tremblay

When residues from market-garden crops are incorporated into the soil, they can release appreciable quantities of nitrogen. The goal of this study was to determine whether the residues represent a significant source of nitrogen for the next crop, even after the winter.

Field trials were carried out at L'Acadie experimental farm in 1997 and 1998. Two crucifer crops were selected, cauliflower and red cabbage, along with a spinach crop, so that residues of various types could be ploughed under. The residues were subjected to three different modes of management. The first two were incorporation in the autumn (IA) and mulching (M) of the residues after harvest, in October 1997. The third method consisted in incorporation into the soil (IS) the following spring, as opposed to incorporation the previous fall. Following incorporation in the spring, wheat was seeded throughout the fields in order to determine the contribution made by each treatment to the nitrogen nutrition of the new crop. The soil was sampled in two horizons (0-30 cm and 30-60 cm) to permit monitoring of nitrates after the residues were ploughed under. Tissues from the residues and the wheat were likewise analysed to determine the corresponding biomass and nitrogen content.

The results indicate that during winter the practices carried out in autumn (IA and M) cause significant nitrate losses in the upper soil layer, regardless of the type of residue involved. The IS treatment, on the other hand, because it maintained nitrogen uptake by residues in fall, appears to slow down the loss of nitrogen through leaching during this period.

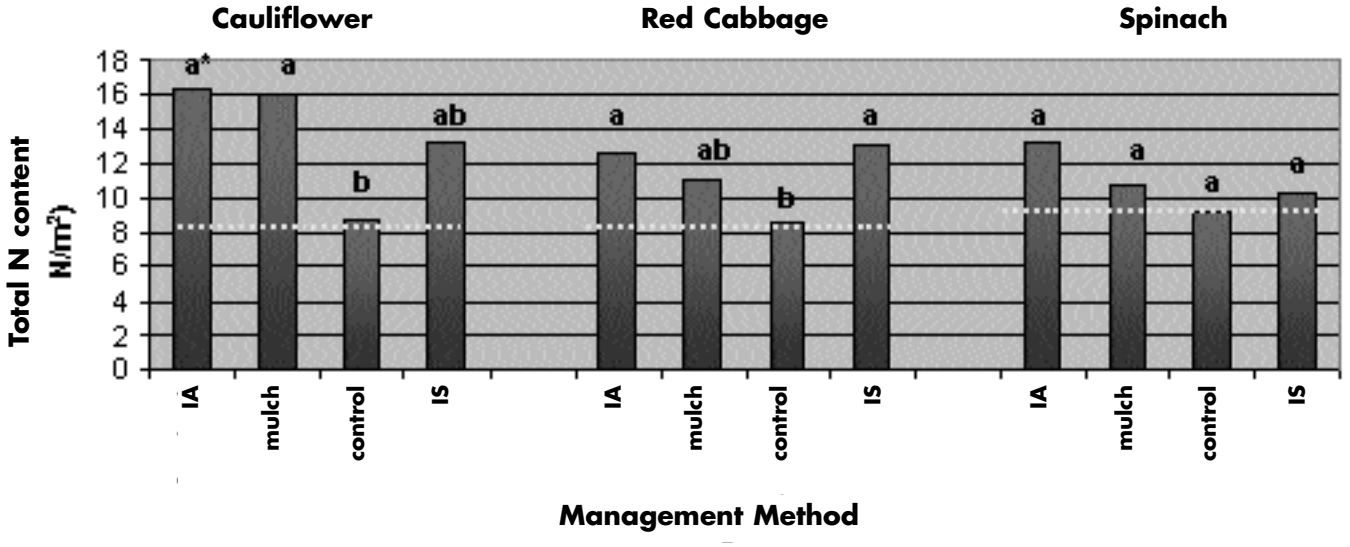
When the wheat was seeded (28-04-98), the IA treatment in the two crucifer crops was the only management method to make a significant amount of nitrogen available to the wheat (0-30 cm). With regard to the spinach, none of the treatments differed from the control (i.e. no incorporation of residues).

In July 1998, nitrogen consumption budgets were computed for the wheat. It was found to have taken up between 10 and 30% (depending on the treatment and type of crucifer) of the nitrogen content of the crucifers.

The fall management methods offer the greatest agronomic potential for cauliflower and red cabbage, because of the amount of nitrogen that the residues can transfer to the wheat crop. However, from an ecological standpoint, this approach holds the greatest risk of nitrate losses to the environment. This is because when the nitrates are released, there are no plants to take them up as the ground is bare. Hence, the unused nitrates are likely to be leached away.

Spinach appears to offer potential in terms of nitrogen inputs. The wheat crop was able to take up as much as 63% of the nitrogen content of the spinach residues. However, spinach does not appear to supply a sufficient quantity of residues to permit a significant increase in nitrogen mineralization and uptake by the wheat crop the following spring (Fig. 1).

To provide market-garden producers with a reliable tool for adding nitrogen quantities that meet the needs of their crops while respecting the environment, it will be necessary to conduct additional trials. A number of questions remain in relation to the type of nitrate losses (leaching, denitrification/volatilization, immobilization etc.). The amount of nitrogen supplied by the residues appears to be a decisive factor in the rate of uptake by the crop grown subsequently. It is also essential to examine the relationship that exists between the quality of given residues (physico-chemical characteristics) and their potential for contributing nitrogen.



*For a given crop, the means with the same letter are not significantly different at a threshold of $p<0.05$ (LSD test N=4).

Figure 1. Nitrogen content of the wheat depending on the type of residue and management method

TOOLS FOR BETTER MANAGING NITROGEN

Carl Bélec, Jean Coulombe[1], Patricia Lamy[1] and Nicolas Tremblay

Broccoli is a crop that is especially sensitive to the supply of nitrogen. Fairly high amounts of nitrogen fertilizer are normally required to ensure good yields. However, excessive nitrogen inputs resulting from natural releases of this element in the soil or from fertilizer can lead to physiological disorders, causing quality losses at harvest as well as increasing the crop's vulnerability to disease and the risk of environmental contamination.

An experimental design was developed to determine whether assessing the nitrogen content in broccoli using quick tests during the growing season could be an approach for determining the appropriate rate of nitrogen fertilizer to be applied 5 weeks after planting. This experiment involved three different nitrogen fertilization regimes i.e. poor, moderate and rich. A first application of fertilizer was made at planting. After two weeks, a second application was made. The object of the experiment was to assess the nitrogen status of broccoli five weeks after planting and to use this information to adjust the amount of nitrogen to be used as the third application. The nitrogen content of the plants was measured using two different instruments. A Nitrachek® reflectometer equipped with Merckoquant® strips was used to measure the nitrate content in leafstalk sap. Secondly, an N-tester was employed, which is essentially a chlorophyll meter. The measurements were made directly in the field, on the broccoli leaf blades. The trial took place simultaneously at two sites, Agriculture and Agri-Food Canada's L'Acadie experimental substation and Laval University's Ferme Joseph-Rhéaume (Ste-Croix-de-Lotbinière). Two broccoli cultivars were tested, Arcadia at both stations, and Windsor at Ste-Croix only.

Nitrate content in the sap and chlorophyll readings

Before the fertilizer application was made in the fifth week, we evaluated the effect of the different nitrogen fertilizer treatments on the sap nitrate content and the chlorophyll readings. The statistical analysis of the results obtained for the L'Acadie site indicated that the relationship between nitrogen fertilization and sap nitrate content was very close to that obtained with the chlorophyll readings. At the Ste-Croix site, no significant relationship was found between sap nitrate content and nitrogen fertilizer regime, whereas the chlorophyll reading showed a significant linear relationship with the fertilizer regime.

In order to estimate the nitrogen fertilizer application rates necessary to meet the needs of broccoli plants at five weeks, a "sufficiency index" was established for each fertilizer regime. The mean value of the nitrate concentrations in the sap at five weeks for each treatment was compared with that obtained in reference plots (saturated with nitrogen) : the relationship between these two measures corresponds to the sufficiency index, which indicates the nitrogen status of the broccoli. The sufficiency indices at the L'Acadie site, for the poor, moderate and rich regimes, were 82, 95 and 88% respectively, which translated into application rates of 100, 50 and 50 nitrogen units. At the Ste-Croix site, the indices were 87, 96 and 96%, which translated into rates of 100, 50 and 50 nitrogen units. Yields were then evaluated for each rate tested

Validation of the "sufficiency index" concept

First, the "sufficency index" concept was validated by varying the tested doses for the two cultivars that were treated with a moderate nitrogen fertilization regime. This procedure made it possible to obtain a yield response curve. We found that, for the *Arcadia* cultivar, the yield response curve was curvilinear for both the L'Acadie and Ste-Croix sites.(Figure 1. Moderate regime) This indicates that the theoritically ideal rate of 50 kg/ha is indeed sufficient to obtain maximum yields. However, in the case of the cultivar *Windsor*, tested solely in the Ste-Croix design, no relationship was found between the yields and decreasing rates of nitrogen fertilizer application (Figure 1b). It should be noted that the calculation of the sufficiency index for the *Windsor* cultivar was done by assuming that the nitrogen nutrition status would follow the same trend as for the *Arcadia* cultivar. The nitrogen sufficiency indices were thus computed on the basis of the reference plots (saturated with nitrogen) planted with the *Arcadia* cultivar. This could have brought errors in calculations since the two cultivars seem to have different needs for nitrogen fertilization.

Second, no nitrogen fertilizer was employed during the application at two weeks. This was done in order to simulate a nitrogen deficiency. The dose to be applied at five weeks (100kg/ha) was therefore determined based on the sufficiency index measured from the sap nitrate content at five weeks. The yields obtained were compared with those obtained with the moderate fertilization treatment of 50 kg/ha at 5 weeks. Statistical analysis showed that there was no difference between the yields, and this was true for both sites. This suggests that the nitrogen deficiency was suitably corrected through the fertilizer rate determined using the calibration curve.

A supplemental treatment was used in the design at the L'Acadie site in order to simulate a situation of overfertilization. During the application at two weeks, 100 units of nitrogen were applied. Application rate used at five weeks (50 kg/ha) was therefore determined based on the sap test and the calibration curve. The yields obtained with rate y were compared with those obtained with 100kg/ha(maximal rate of the moderate regime : both treatments received a total of 200 nitrogen units). Statistical analysis shows that there is no difference between the treatments.

We were therefore able to determine the nitrogen status of broccoli during the last split application and to apply fertilizer by taking into account the sufficiency index, which made it possible to adjust the application rate of nitrogen fertilizer and obtain optimal yields while limiting the risk of environmental contamination.

1 Centre de recherche en horticulture, Pavillon de l'Envirotron, Laval University

EFFECT OF FERTILIZATION AND IRRIGATION ON YIELD AND DOWNGRADING OF PROCESSING CUCUMBERS

Sylvie Jenni, Nicolas Tremblay, Mike Bleho[1] and Katrine Stewart[1]

In Quebec, 26,000 tonnes of cucumbers used for processing are produced annually by 66 growers in the Lanaudière, St-Hyacinthe, Nicolet and Laurentian regions. Tests carried out over two years have shown that sprinkler irrigation increases gross

revenues by as much as 20%. However, irrigation, which may be done up to nine times during the growing season, may also promote the leaching of nutrients provided by fertilizers and thus reduce yield. Sprinkler-irrigated and fertilized study plots were compared with non-irrigated plots to evaluate the effects of irrigation and foliar nitrogen fertilizer on yields, gross revenues and downgrading of processing cucumbers.

The experiment, conducted at the Horticultural Field Station of McGill University in Sainte-Anne-de-Bellevue, involved four blocks, in which eight fertilized treatments were randomly situated. Treatments are described in Tables 1 and 2.

The summer when the tests were conducted was fairly hot and there were two periods of water stress: one lasting 15 days (6 mm of rainfall) which occurred when the plants were undergoing vegetative growth, and another lasting 22 days (23 mm of rainfall), during flowering and the first three harvests (Fig. 1). From the end of the vegetative growth stage to the onset of flowering, the plants received adequate rain (83 mm in 12 days). Although differences were not significant, increases in the weight and number of fruits belonging to categories 1, 2 and 3 were observed in the sprinkler-irrigated plots, although not among the largest fruits (category 4), along with a slight decrease in deformed fruits (Table 1) and an 18% increase in gross revenues in comparison with non-irrigated plots (Table 2). The basic fertilizer treatment of 80 kg/ha of nitrogen appears to have been sufficient for the 1999 crop. The addition of 24, 40 or 60 kg/ha after the first week of harvest, the application of 40 kg/ha of granular fertilizer after seeding or overfertilization (40 kg/ha of granular fertilizer plus 60 kg/ha of slow-release fertilizer) did not increase yields (Tables 1 and 2).

1 Plant Science Department, McGill University

Table 1: Effect of sprinkler irrigation and nitrogen fertilization on the yield (T/ha) of processing cucumbers

Treatment	Total	Marketable	No. 1	No. 2	No. 3	No. 4	Rejected
Irrigation + 0 kg/ha N	69.8	56.0	7.9	9.2	23.1	15.8	13.8
Irrigation + 20 kg/ha N foliar	68.8	55.7	7.5	9.5	22.2	16.5	13.2
Irrigation + 40 kg/ha N foliar	71.8	55.7	7.9	9.3	22.1	16.4	16.1
Irrigation + 60 kg/ha N foliar	71.1	54.7	7.8	8.8	20.2	17.8	16.4
Irrigation + 40 kg/ha N granular	68.8	56.3	6.9	8.4	23.6	17.4	12.5
Irrigation + 40 kg/ha N granular + 60 kg/ha N slow-release	70.3	54.9	7.6	9.8	23.0	14.6	15.4
Control (no irrigation)	61.2	48.3	6.3	8.6	18.6	14.8	12.8
Average	*68.8*	*54.5*	*7.4*	*9.1*	*21.8*	*16.2*	*14.3*
Effect of treatments	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Table 2. Effect of sprinkler irrigation and nitrogen fertilization on gross revenues ($/ha) obtained from processing cucumber production.

Treatment	No. 1	No. 2	No. 3	No. 4	Total
Irrigation + 0 Kg/ha N	5134	3555	6142	1651	16481
Irrigation + 20 Kg/ha N foliar	4891	3671	5911	1717	16190
Irrigation + 40 Kg/ha N foliar	5175	3596	5882	1706	16359
Irrigation + 60 Kg/ha N foliar	5108	3428	5380	1851	15768
Irrigation + 40 Kg/ha N granular	4475	3262	6289	1809	15836
Irrigation + 40Kg/ha N granular + 60Kg/ha N slow-release	4934	3785	6121	1518	16357
Control (no irrigation)	4139	3348	4946	1538	13971
Average	*4771*	*3498*	*5774*	*1666*	*15710*
Effect of treatments	*NS*	*NS*	*NS*	*NS*	*NS*

VARIETAL TESTS OF CRISPHEAD LETTUCE IN MINERAL SOIL IN THE LANAUDIÈRE REGION

Sylvie Jenni and Jean-Francois Dubuc

The Quebec market for processed crisphead lettuce is expanding rapidly. Despite this, production here is limited almost exclusively to the 'Ithaca' variety, which is grown in organic soil in the Montégérie region. The potential for growing crisphead lettuce in mineral soil should therefore be assessed in terms of both quality and yield.

The quality and yield at harvest and in storage of four varieties of crisphead lettuce grown in mineral soil were evaluated at two commercial sites in the Lanaudière region. The experiment included two seedings (May 25 and June 7) of four blocks with randomly laid out plots. Lettuce was harvested during the hottest time of the summer, from July 29 to August 27.

When each variety reached optimum maturity, a dozen heads per plot were harvested and sampled to determine the fresh weight, density and core length (Table 1). Another dozen heads were harvested and packed in cartons and then vacuum cooled and stored at 2EC for one to two weeks. A visual quality index was then assigned to the heads based on physical damage, browning, the presence of disease and physiological disorders, colour and shape.

Heads from the second seeding had a higher fresh weight and were firmer despite a tendency to bolt. The difference in results between the seedings in storage shows that storage quality decreases rapidly after more than a week in storage. The ''Ithaca'' and especially the "Emperor'' varieties were the heaviest and firmest, and had the shortest cores. However, "Ithaca'' was susceptible to rib blight and "Emperor'' to tip burn. The two other varieties had a number of defects: 'Igloo' and 'Salinas 88 Supreme' were not firm enough and were prone to bolting. Results for the lettuce grown at St-Paul in sandy loam soil were different from those for lettuce grown at St-Jacques in clay loam soil. Several aspects of the production management of crisphead lettuce in mineral soil still need to be improved in order to obtain lettuce of sufficient quality to meet current market standards.

Table 1. Number of days to maturity, fresh weight, density, stem lenght and post-storage visual quality, for 4 varieties of crisp lettuce cultivated on two sites in mineral soil (from 2 seedings during 1999 season).

Treatment	Transplant at maturity (days)	Fresh weight[x] (g)	Density[x] (g/cm³)	Stem lenght[x] (mm)	Post-storage visual quality[y] (1-5)
St-Paul-de-Joliette seeding 1					
Igloo	41	454	0.32c	72b	2.4
Ithaca	41	523	0.50a	53bc	3.3
Emperor	42	555	0.40b	47c	2.9
Salinas 88 supreme	42	536	0.33c	114a	2.3
Variety effect[z]	-	NS	***	***	-
St-Paul-de-Joliette seeding 2					
Igloo	53	648	0.46c	125.3ab	2.4
Ithaca	53	760	0.68a	84.2bc	2.1
Emperor	53	888	0.65a	63.0c	2.5
Salinas 88 Supreme	53	814	0.53b	172.6a	2.3
Variety effect[z]	-	NS	***	**	-
St-Jacques-de-Montcalm seeding 1					
Igloo	46	331	0.32b	69.0b	2.4
Ithaca	47	371	0.43a	43.5c	2.3
Emperor	47	315	0.35b	38.3c	2.4
Salinas 88 Supreme	46	359	0.31b	96.7a	2.1
Variety effect[z]	-	NS	*	***	-
St-Jacques-de-Montcalm seeding 2					
Igloo	50	637	0.49	140.9b	2.0
Ithaca	51	546	0.69	71.0c	2.4
Emperor	51	687	0.66	75.8c	2.4
Salinas 88 Supreme	50	711	0.64	173.7a	2.0
Variety effect[z]	-	NS	NS	***	-

x The different letters denote statistically significant differences (LSD test)
y Visual quality: 1=poor, 5=excellent
z where *: = p<0.05; ** = p<0.01;*** = p<0.001 and NS = non significant p>0.05

YIELD SENSOR FOR BROCCOLI

Bernard Panneton

The objective of this project is to develop a yield mapping system for broccoli. The equipment has been selected and assembled. The system is based on the use of an industrial PC computer with a VGA touch screen. The data are recorded on a hard drive, with data transfer done using diskettes. The computer is equipped with an interface card linking the different sensors. Meter boxes have been installed on the harvester along with sensors that record conveyor start-up and the movement of the machine; a DGPS system has also been installed. A software program has been designed to record yield data. In addition, several harvest management tools, which have been incorporated into the software program, provide statistics on harvesting while it is under way. Following successful testing of this system in the fall of 1998, improvements were made to the equipment and software. A software program has been developed that can be used to produce maps from the recorded data as well as generate yield and harvest statistics.

GÉOPHYTE

Bernard Panneton

A number of tools have been developed for the *a posteriori* analysis of yield maps (corn, soybeans, carrots, onions). These include an automated processing method for annual yield data, a method for dividing fields into management zones based on multi-year series of yield maps and the use of colour infrared aerial photos for assessing yield. Work was also undertaken to assess the usefulness of existing tools, including soils maps, topographic maps and maps of fertility based on systematic sampling. The tools found to be most useful for diagnostic purposes include the management zones map, colour infrared aerial photos of bare and wet soils showing differences in soil moisture content, the soils map and the topographic map. The next most useful tools are maps of soil pH, compaction and organic matter, followed by maps of various minerals. Information on physical soil characteristics and moisture content appears to be of greatest importance in explaining yield variations in Quebec. This project also included a weed science component, leading to the development of effective methods for scouting weeds in corn crops.

Prepared in collaboration with the Coopérative Fédérée du Québec, Hauts-Monts Inc., Phytodata Inc. and SCA

USING MODELLING AND REMOTE SENSING FOR CROP MONITORING

Philippe Vigneault, Gaétan Bourgeois, Sylvie Jenni, Geneviève Roy and Nicolas Tremblay

Forecasting of yields and the harvest date of crops is essential for effectively managing the supply of raw materials required by processing plants. Plant managers and producers use their knowledge of specific cultivars (average yield, accumulated degree-days, etc.) and their experience to come up with forecasts.

The goal of this research is to improve predictions of the maturity dates and yields of processing vegetables by using modelling and remote sensing. In the course of experiments conducted on an experimental farm, during the 1996 to 1999 growing seasons, normalized difference vegetation index (NDVA) data and leaf area indices (LAI) were derived using a spectroradiometer and a LAI 2000 respectively. A spectroradiometer is an instrument that measures the reflectance from surfaces in several spectral bands, whereas the LAI-2000 computes the biomass index for a given surface. The measurements were made during the vegetative and reproductive periods of beans (Matador) and sweet corn (Empire).

For the sweet corn, we found an increase in NDVI values during the growing period, a plateau from flowering until a few weeks before harvest, and then a downtrend. In beans, we observed a curve that rose steadily right until harvest. The NDVI curves show variations from one year to the next.

The estimated LAI readings were quite consistent with field observations, and were positively correlated with the NDVI. It is difficult to establish a reliable link between the NDVI measurements and the yields computed at harvest. We noted that the isolated use of NDVI values does not permit satisfactory yield predictions. However, by superimposing the mean growth curves on the annual curves and comparing them with raingauge and evapotranspiration data, we observed that episodes of rain coincided with a rise in the NDVI curve and hence values that were generally greater than the mean. When evapotranspiration exceeds precipitation, NDVI values show a decline relative to the mean. Even during periods of extreme drought when irrigation is carried out, the effects of the poor moisture conditions on the NDVI values are very noticeable. Our findings also show that, the farther it is into the vegetative season, the less closely the NDVI values and climatic parameters are related. Based on the analyses done on grain corn (CV Empire), the curves that showed above-average values gave superior yields. The opposite effect occurs when the NDVI values remain below average. The addition of climatic parameters does not suffice to explain the variations in NDVI for beans or to show a positive relationship with the yield computed at harvest.

The introduction of new known parameters: cumulative solar radiation, soil texture and moisture readings, combined with the raingauge, evapotranspiration, NDVI and LAI values, will make it possible to develop a model of growth and eventually a tool that can aid in improving the order of harvest operations and yield predictions.

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1 HRDC and Centre de technologie en agro-environnement

2 Productions en Régie Intégrée du Sud de Montréal (PRISME)

USE OF *RHIZOBACTERIA* TO STIMULATE CARROT GROWTH AND REDUCE THE DAMAGE CAUSED BY MELOIDOGYNE HAPLA

***Guy Bélair, Brahim Soufiane and Chantal Beauchamp*[1].**

The objective of this study was to select rhizobacteria with the potential to stimulate root growth in carrots and reduce the damage caused by the root-knot nematode *Meloidogyne hapla* (Chitwood). Rhizosphere bacteria were isolated from a carrot field infested with *M. hapla*. Sterile carrot seeds were coated with 150 rhizobacteria in a 0.75% alginate solution and placed in petri dishes. After a week of growth at room temperature, the length of the roots was measured. Of all the bacteria tested, 12 isolates were found to have stimulated the root growth of the carrots significantly. The seeds coated with the 12 selected bacteria were tested in the greenhouse for 2 months in organic and mineral soils, without nematodes. In the organic soil, increases in the weight of the roots and leaves and in the length of the carrots were observed in the case of seeds treated with the isolate 2F15. By contrast, in mineral soil this isolate has did not cause any increase in the above-mentioned parameters. The isolate 3B15 promoted an increase in the weight, diameter and length of the carrots grown in mineral soil. The coated carrot seeds were tested in a sandy soil in the presence of 1200 nematode larvae. After two months of growth, the isolates 2F15 and 3B15 reduced the damage caused by *M. hapla* by 10 and 23% respectively, whereas all the untreated carrots were seriously damaged. The number of nodules on the secondary roots indicated that the rhizobacteria strains did not reduce the nematode's ability to establish itself and to reproduce on secondary roots of carrots. When the nematode larvae were placed in direct contact with each of the strains, the rhizobacteria had no direct effect on them.

1 Laval University

EFFECTS OF SEED AND BACTERICIDE TREATMENTS AND CULTIVAR SUSCEPTIBILITY ON THE DEVELOPMENT OF BACTERIAL LEAF SPOT ON LETTUCE

Odile Carisse, Annie Ouimet and Vicky Toussaint

Bacterial leaf spot, caused by the bacterium *Xanthomonas campestris* pv. *Vitians,* is a new disease of lettuce in Quebec. The first manifest symptoms are oily looking water-soaked spots on the edge of leaves, which result in leaf necrosis a few days after they appear. Later in the season, the spots coalesce and, under conditions favourable to development of the disease, they spread to the core leaves. Seed treatments and bactericide application in the greenhouse were carried out in an effort to limit the damage caused by this disease. In addition, cultivars were evaluated to determine their tolerance to the disease. Seeds inoculated artificially with bacteria were subjected to treatments with various chemical products (bactericides) as well as hot water treatments and dry heat treatments, and then assessed for germination and contamination rates. The application of sodium hypochlorite (1%, 5 or 20 min.) resulted in a 90% reduction of the contamination rate in seeds without affecting germination. Treatments with dry heat (1 hour), hot water (50EC, 2 hours) and Lonlife, however, significantly reduced the germination rate of seeds. Given the incidence of contamination and rate of germination in seeds, the best treatments were those using 1% sodium hypochlorite for 5 or 20 minutes. Bactericide treatments in the greenhouse had a significant effect in reducing the disease except when copper sulphate alone or copper sulphate combined with Zineb or Dithane was used. These treatments caused symptoms of phytotoxicity on the lettuce leaves. However, treatments of Kocide alone or Kocide combined with Zineb or Dithane and copper sulphate reduced the severity of the disease by 78-87%.

The evaluation of cultivars, done over a two-year period, showed that there was no significant difference among cultivars in the expression of the severity of the disease (Table 1). In terms of incidence, the most susceptible cultivar was Bellagreen (a Boston lettuce type), while leaf lettuce types such as Waldmann's and Grand Rapids were the least susceptible. No cultivar was found to be tolerant to the disease. The results of the study show that using a single control method against bacterial leaf spot is insufficient. An integrated control program should include the use of less susceptible cultivars, seed treatments and greenhouse treatments on seedlings with Kocide alone or Kocide combined with Dithane.

Table 1. Bacterial leaf spot severity and incidence in lettuce cultivars inoculated with *X. campestris* pv. *vitians*.

Cultivar	Type of lettuce	Severity [1]	Incidence [2]
Bella Green	Butterhead	2.18 a[3]	80.04 a[3]
Ideal cos	Romaine (cos)	1.94 a	67.72 b
Grand Teton	Romaine (cos)	2.06 a	67.51 b
Great Lakes	Crisphead	2.22 a	60.14 bc
Paris Island	Romaine (cos)	1.79 a	59.81bc
Ithaca	Crisphead	1.95 a	50.07 cd
Optima	Butterhead	1.77 a	48.01 cd
Waldmann's	Leaf	1.83 a	42.88 d
Grand Rapids	Leaf	1.72 a	42.07 d
LSD		0.66	12.14

1 The severity index for the disease was based on the average of nine repetitions performed in 1997 and 1998. Severity was measured at harvest, on a scale of 0 to 5 where 0 = no symptoms, 1 = 1 to 5 distinct spots on the edge of the leaf, 2 = several spots that coalesce, 3 = spots scattered over the entire surface of the leaf, 4 = yellowing and slight wilting of the leaf, 5= dead leaf. Severity was calculated by adding up the scores for each leaf on a plant.

2 Incidence of the disease at harvest based on the average of nine repetitions.

3 The values in the same column assigned the same letter(s) are not significantly different according to the Least Significant Difference test (LSD) (P=0.05).

SURVEY OF APHID SPECIES IN MARKET-GARDEN CROPS AND ON WILD PLANTS

Claude Godin and Guy Boivin

In collaboration with Phytodata and producers belonging to Prisme, we carried out a qualitative survey of the aphid species in 8 market-garden crops and 23 wild plants that abound in the proximity of areas under cultivation. Sampling of each plant species was done from May through October for one to three years, between 1997 and 1999. The aphids were identified with a magnifying glass or a compound binocular microscope using existing keys and characteristics derived from data collected during this project. Each plant species studied was monitored every year in 4 insecticide-free plots with an area of 100 to 200 m^2. The sites visited were located in an agricultural zone within 200 km of the town of Sherrington.

The survey of aphids on wild plants provided a means of differentiating potential hosts of pest aphids in market-garden crops from hosts containing either innocuous or beneficial aphids. An aphid species may be considered beneficial if it is not a crop pest and it is abundant and may thus harbour populations of parasitoids that prey on harmful aphid species.

Of the over 21 species and groups of aphid species identified, 12 were found in at least one of the 5 crops (Table 1). Of this number, only *A. lactucae*, *A. gossypii*, *B. brassicae*, *L. erysimi*, *M. euphorbiae*, *M. persicae* and *N. ribisnigri* showed potential for having an adverse effect on one or more of the crops. Harmful aphids therefore make up less than one third of the species that are abundant on the wild plants. Furthermore, none of the aphids that occurred on 14 of the 23 wild plants were likewise found in the crops. In the case of poison ivy, yellow rocket and wild parsnip, the aphid species that were concurrently found on the cultivated plants did not damage the crops. This suggests that only 5 wild plant species are potential hosts of pest aphids, ie. pigweed, chicory, sow-thistle, prickly lettuce and wild mustard.

With regard to beneficial parasitoids, two wild plants had sizeable populations of parasitized aphids, namely lamb's-quarters and tufted vetch (denoted by a 'p' in Table 1). The aphids found on those plants did not affect the crops, but they have potential for increasing the populations of beneficial parasitoids. The identification of these parasitoids and those found in crops will permit a more precise assessment of this positive interaction between wild plants and cultivated plants.

Table 1. Main aphid species found on wild plants and cultivated plants (in bold).

Common Name	Family / Group	*1*	2	3	4	5	6	7	*8*	9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	21
Redroot pigweed	Amaranthaeae				x													x				
Milkweed	Asclepiadaceae							x														
Spotted jewelweed	Balsaminaceae																					
Lamb's-quarters	Chenopodiaceae				p									p								
Burdock	Compositae				x																	
Nodding beggarticks	Compositae					x		x														x
Bull thistle	Compositae												x									
Chicory	Compositae																			x	x	
Poison-ivy	Compositae																				x	
Perennial sow-thistle	Compositae	x														x						x
Lettuce	**Compositae**	x							x									x	x	x	x	
Prickly lettuce	Compositae	x														x						x
Canada goldenrod	Compositae																					x
Yellow rocket	Crucifers						x															
Cultivated crucifers*	**Crucifers**									x							x	x	x			
Wild mustard	Crucifers																x	x	x			
Wild cucumber	Cucurbitaceae																					
Tufted vetch	Leguminosae		x	p																		
Celery	**Umbelliferae**				x	x	x				x							x	x			
Wild parsnip	Umbelliferae						x			x	x			x								
Broad-leaved plantain	Plantaginaceae																					
Lady's-thumb	Polygonaceae												x									
Sulphur cinquefoil	Rosaceae																					
Sweet pepper	**Solanaceae**					x	x											x	x			
Potato	**Solanaceae**					x	x		x									x	x			
Stinging nettle	Urticaceae																					
Frost grape	Vitaceae																					
Virginia creeper	Vitaceae																					

* Cultivated crucifers include the following varieties: broccoli, cabbage, cauliflower and Chinese cabbage.

1: Acyrthosiphon lactucae
2: Acyrthosiphon pisum
3: Aphis craccae
4: Aphis faba
5: *Aphis gossypii*
6: Aphis nasturtii
7: Aphis spp.
8: Aulacorthum solani
9: Brevicoryne brassicae
10: Cavariella aegopodii
11: Cavariella theobaldi
12: Capidophorus spp.
13: Hayhurstia deformans
14: Hyadaphis foeniculi
15: Hyperomyzus lactucae
16: Lipaphis erysimi
17: Macrosiphum euphorbiae
18: Myzus persicae
19: Nasonovia ribisnigri
20: Uroleucon ambrosiae
21: Uroleucon spp

WINTER MORTALITY OF YELLOW NUTSEDGE TUBERCLES USING DIFFERENT FALL TILLAGE REGIMES IN ORGANIC SOIL

Marie-Josée Hotte, Diane Lyse Benoit, Christophe LaHovary[1] and François Tardif

Yellow nutsedge (*Cyperus esculentus* L.) is the most prevalent perennial weed found in onion crops in organic soils when no herbicides are used to control it. This plant reproduces both sexually and vegetatively by seeds and tubercles respectively. The latter are responsible for yellow nutsedge populations persistance and growth.A research project was carried out from 1997 to 2000 to identify a fall tillage practice that could affect winter mortality of yellow nutsedge tubercles. The approaches studied included plots where the soil was not disturbed after harvest (control) and plots subjected to different types of tillage in the fall (barley seeding, chisel plough, conventional tillage).

Winter mortality was measured at two depths (0-10 cm and 10-20 cm) by evaluating tubercle density in the autumn following cultivation and the following spring.

The tubercle density data collected in the fall and spring of the 1997-1998 season were highly variable (Fig. 1). This variability may be attributable to the layer of ice that covered the plots during the winter and served to insulate the tubercles from temperature fluctuations. No difference was observed between the treatments. Barley seeding was the only treatment in which tubercle mortality (31%) was recorded in the first 10 cm of soil.

Considerable variability was observed during winter 1998-1999 (Fig. 2). In the control plot, where the soil was not disturbed, 74% mortality was recorded in the first 10 cm of soil and 43%

Figure 1. Tubercle density in yellow nutsedge harvested in fall 1997 and spring 1998 using different tillage regimes in the fall

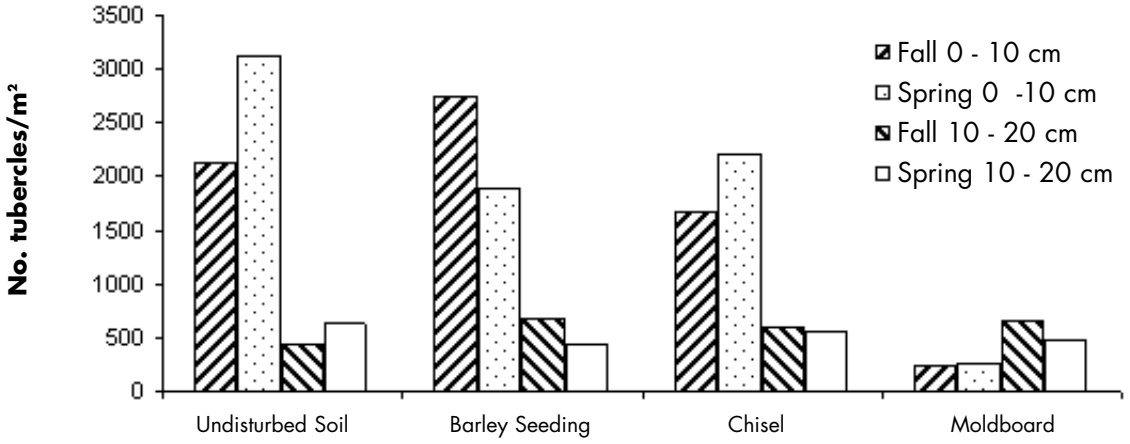
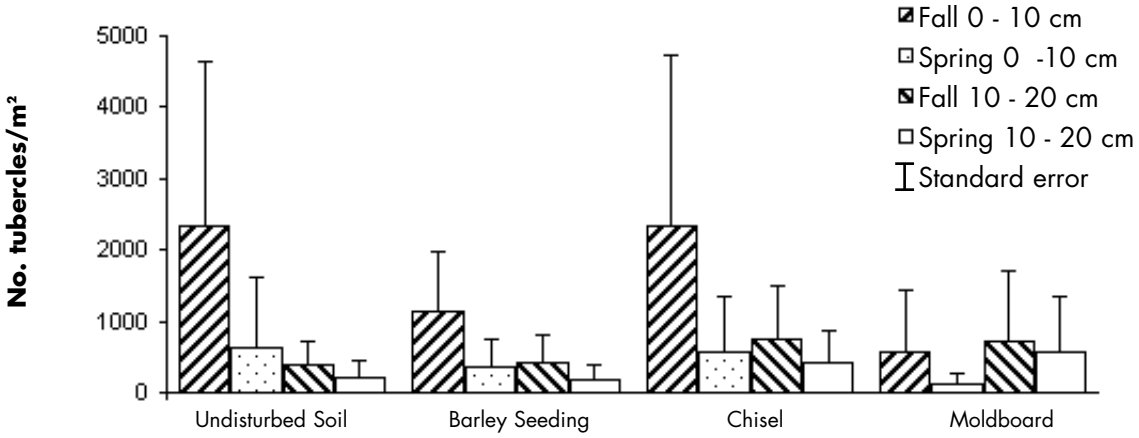


Figure 2. Tubercle density in yellow nutsedge harvested in fall 1998 and spring 1999 using different tillage regimes



mortality in the 10-20 cm layer of soil. The winter tubercle mortality recorded at both depths in all treatments was comparable to that in the control plot.

During the winters 1997-1998 and 1998-1999, winter mortality of tubercles varied greatly. Consequently, none of the fall tillage regimes tested resulted in increased winter mortality of yellow nutsedge tubercles. The practice of sowing barley in autumn, which is widely used, is therefore useful since in addition it protects the soil from wind erosion.

1 Department of Plant Agriculture, Crop Science Division, University of Guelph

EFFECTS OF DELAYED EMERGENCE AND GROWTH INTERRUPTION ON THE PRODUCTION OF NUTSEDGE TUBERCLES

Marie-Josée Hotte, Diane Lyse Benoit, Christophe LaHovary[1] and François Tardif

Over a period of two years (1997-1998), the effect of delayed emergence and interruptions in the growth of yellow nutsedge (*Cyperus esculentus)* on tubercle production was monitored to determine the appropriate timing of measures to suppress yellow nutsedge prior to field testing. The treatments consisted in delays of 15, 30, 45 and 60 days after the emergence of nutsedge and single or continuous growth interruptions after the nutsedge had been growing for 15, 30, 45 and 60 days. The control situation involved suppression and uninterrupted growth throughout the season (Fig.1). Delayed emergence and growth interruptions were performed by applying diquat repeatedly to destroy the foliage before it could reach 5 to 10 cm in height.

In 1997, the treatment whereby emergence was delayed during the first 30 days made it possible to maintain nutsedge tubercle density at the same level as in the spring, whereas emergence delayed for the first 45 and 60 days led to decreases in density of 80% and 85% respectively (Fig. 2). These decreases are comparable to that obtained in the control situation, where nutsedge growth was suppressed throughout the season (decrease of 88%). The only single growth interruption treatment that produced a reduction in tubercle density similar to the season-long suppression was the single interruption on the 30th day after nutsedge emergence (decline of 77%)(Fig. 3). Continuous interruptions after the nutsedge had been growing for 15, 30 and 45 days resulted in density declines of 93%, 82% and 64% respectively (Fig. 4). However, interruptions in nutsedge growth after 60 days caused a 207% increase in tubercle density.

Figure 2. Yellow nutsedge tubercle density before and after the delayed emergence treatments in 1997

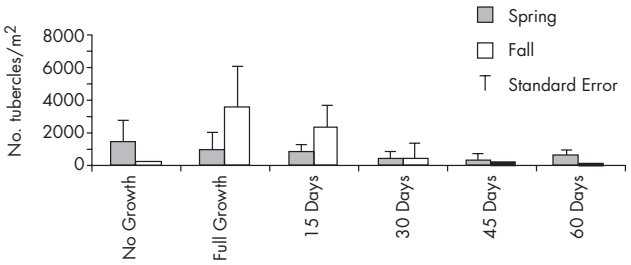


Figure 3. Yellow nutsedge tubercle density before and after single growth interruptions in 1997

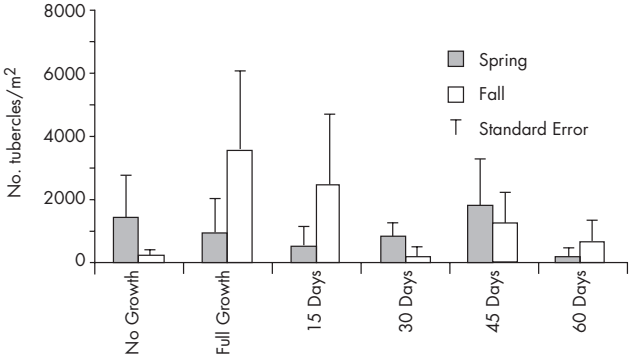
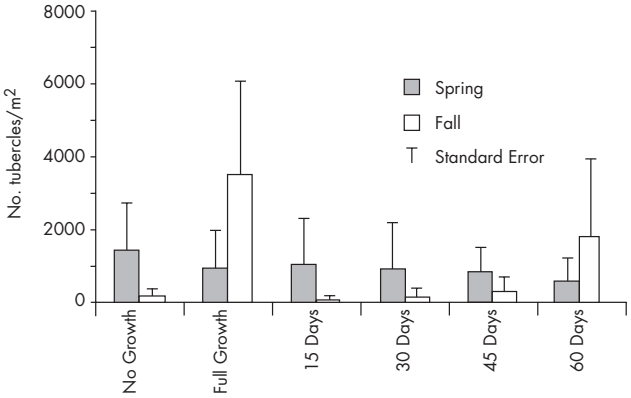


Figure 4. Yellow nutsedge tubercle density before and after continuous growth interruptions in 1997



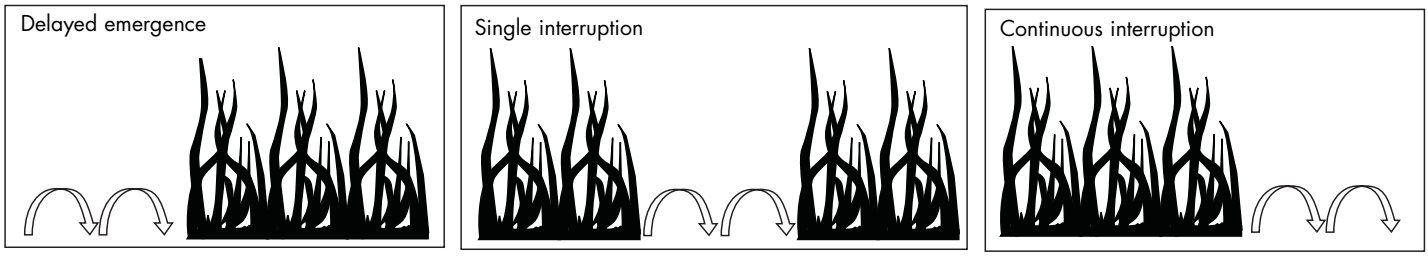


Figure 1. Diagram of the effect of delayed emergence and growth interruptions on yellow nutsedge

In 1998, the early start to the season combined with the hot, dry growing conditions promoted tubercle production, with densities reaching over 13 000 tubercles/m^2 in the control situation, in which growth was not interrupted. None of the treatments to delay emergence or interrupt with growth caused decreases in tubercle density.

When the results for 1997 and 1998 are compared, it can be seen that the treatments that caused the biggest declines in tubercle density were delaying emergence for 45 and 60 days, continuous interruption after 30 days of growth and a single interruption on the 30th day after emergence. Tubercle density measured in the fall is thus strongly influenced by the actions taken between the 30th and 45th day after the nutsedge emerges. This period corresponds to the time when the tubercles are forming.

Integrated control programs for yellow nutsedge should take into account the period when the tubercles are forming with a view to reducing tubercle density in the soil. Measures such as delaying nutsedge emergence for 45 days or suppression between the 30th and 45th day after emergence may have a major impact on the density of nutsedge tubercles at the end of the season.

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1 Department of Plant Agriculture, Crop Science Division, University of Guelph

FORECASTING MODEL FOR CERCOSPORA BLIGHT OF CARROT IN MINERAL SOIL

Gaétan Bourgeois, Dominique Plouffe, Danielle Choquette, Odile Carisse and Charles Audette

Cercospora blight, caused by the fungus *Cercospora carotae* (Pass) Solh., is one of the main diseases affecting carrots; it necessitates several fungicide applications during the growing season. When severe, this foliage disease can greatly increase the losses that result from carrots being left in the ground at harvest. Although fungicide treatment is effective, conditions favouring disease development are not taken into consideration, thus sometimes resulting in applications that are unnecessary or not timed for optimum impact based on the target pathogen's life cycle. Epidemiological studies have permitted determination of the weather conditions conducive to development of the fungus. This information has been used in developing a forecasting system for incorporation into the CIPRA software. The model can be used to identify infection periods and their severity, thereby allowing recommendations to be made about fungicidal treatments based on the real risk of disease development. Testing of the model in organic soil has been going on since 1995, and the infection forecasts are considered to be accurate.

Theoretically, the system should be reliable for carrots grown in mineral soil as well, since the infection prediction model and the infection criteria were developed on the basis of experiments conducted under controlled conditions. Interpretation of the infection risk predictions may differ for carrots grown in mineral soil because of their differing growth. Carrots grow faster in organic soil, which makes them more immune to the disease, because their new foliage compensates photosynthetically for the leaves attacked by the fungus. In mineral soil, however, carrot growth is slower and this may allow the fungus to establish itself more effectively. The goal of this project was to validate the criteria used by the cercospora blight model to assess the infection risk in a carrot crop in mineral soil.

The experimentation phase of the project was spread over two years. In 1997, this work was carried out at the farm of *Lidom et fils enr* located at Saint-Lin in the Lanaudière region, and in 1998, the experimental site was another farm, namely *Les Maraîchers du Ruisseau* in Saint-Lin. Three carrot varieties were used in the tests, two in 1997 (Berlanda and Orange-Pak) and one in 1998 (Orange Appeal "Germ Plus'').

The following parameters were measured on 10 selected and identified plants in each plot every 7 to 14 days: phenological stage, number of green leaves present on the plant and extent of disease development on each of the live leaves on the 10 plants. The latter was assessed by using the improved Horsfall-Barratt scale, which describes the disease in terms of how much leaf area is affected (0 to 100%).

Twice during the 1997 season and six times in 1998, leaf area index measurements were made. At the end of the growing season, the 10 plants monitored throughout the summer were harvested and their length, diameter and weight values were computed. In addition, harvesting was carried out in 5 sections 2 linear meters long per plot in order to evaluate the following parameters: number of carrots, total fresh weight of roots, total fresh weight of rejected parts and total biomass. These data were then used to determine the yield per square metre.

Meteorological data were recorded by a weather station installed near the experimental site. The instruments for measuring temperature and relative humidity were placed a few metres away from the station. The leaf wetness index was determined by means of a probe installed in the middle of one of the experimental plots some 25 metres from the station.

During the two years of research, the disease situation was not very serious. In 1997, the percentage of infection ranged from 0 to 3.5%, and in 1998 the level of infection was almost nil until August 15 (range of 0 to 1.5% per plot). From August 22 to September 17, the level of infection fluctuated between 2.4 and 9.8%. According to the model, a sporulation period occurs 10 to 14 days after the start of an infection period. At the beginning of the season, when the *Cercospora* inoculum is present at a low level, the conditions most conducive to disease development occur when an infection coincides with a sporulation period. Later in the season, when the carrot plants have produced more foliage and the concentration of inoculum is not a limiting factor, the disease may increase in severity, even if the infection period does not coincide with a sporulation period (Figure 1). In 1997, the model predicted 5 infection periods (one in June, two in July and two in August), two of which coincided with a sporulation period. These two infection periods were followed by an increase in the disease. In 1998, the model predicted 6 periods of infection (two in July and four in August), with only one of these periods coinciding with a sporulation period (Figure 1). An increase in disease severity was observed at the end of the season; however, this situation may have been linked to the substantial presence of *Alternaria dauci*.

To interpret the changes in the incidence of cercospora blight in mineral soil, the phenology of the carrots in the present experiment was compared with that of the carrots grown on organic soil, in plots located at Agriculture and Agri-Food Canada's

experimental farm at Sainte-Clotilde. The parameters that were compared consisted of the phenological stage and leaf area index. The analysis of the average phenological stage indicated that the same progression occurred at Sainte-Clotilde and Saint-Lin; however, the LAI was lower at Saint-Lin. The difference therefore cannot be linked to the number of leaves on the plants but rather to the leaf area itself, which was smaller at Saint-Lin. As a result of the denser foliage, the rows of carrots at Sainte-Clotilde were more closed, creating a microclimate favourable to disease development. The lower disease severity at Saint-Lin, combined with the low inoculum present from year to year, may partly explain the limited incidence of cercospora blight during the two observation seasons.

From these two years of study, it can be concluded that the cercospora blight forecasting model appears to be applicable to mineral soil as well as organic soil. However, in the Saint-Lin region, this disease does not appear to be very severe and it did not cause substantial losses in 1997 or 1998. The 1997 season was not conducive to disease development at either Sainte-Clotilde or Saint-Lin, and the dry summer conditions partly explain this situation. Nonetheless, the large amount of rain that fell as of mid-June in summer 1998 caused a serious outbreak of the disease at Sainte-Clotilde and weekly fungicide applications were required in order to protect the foliage. During this same season at Saint-Lin, the action threshold (50% of intermediate leaves with at least one spot) was never reached.

A collaborative project between Agriculture and Agri-Food Canada and Agro-Production Lanaudière inc.

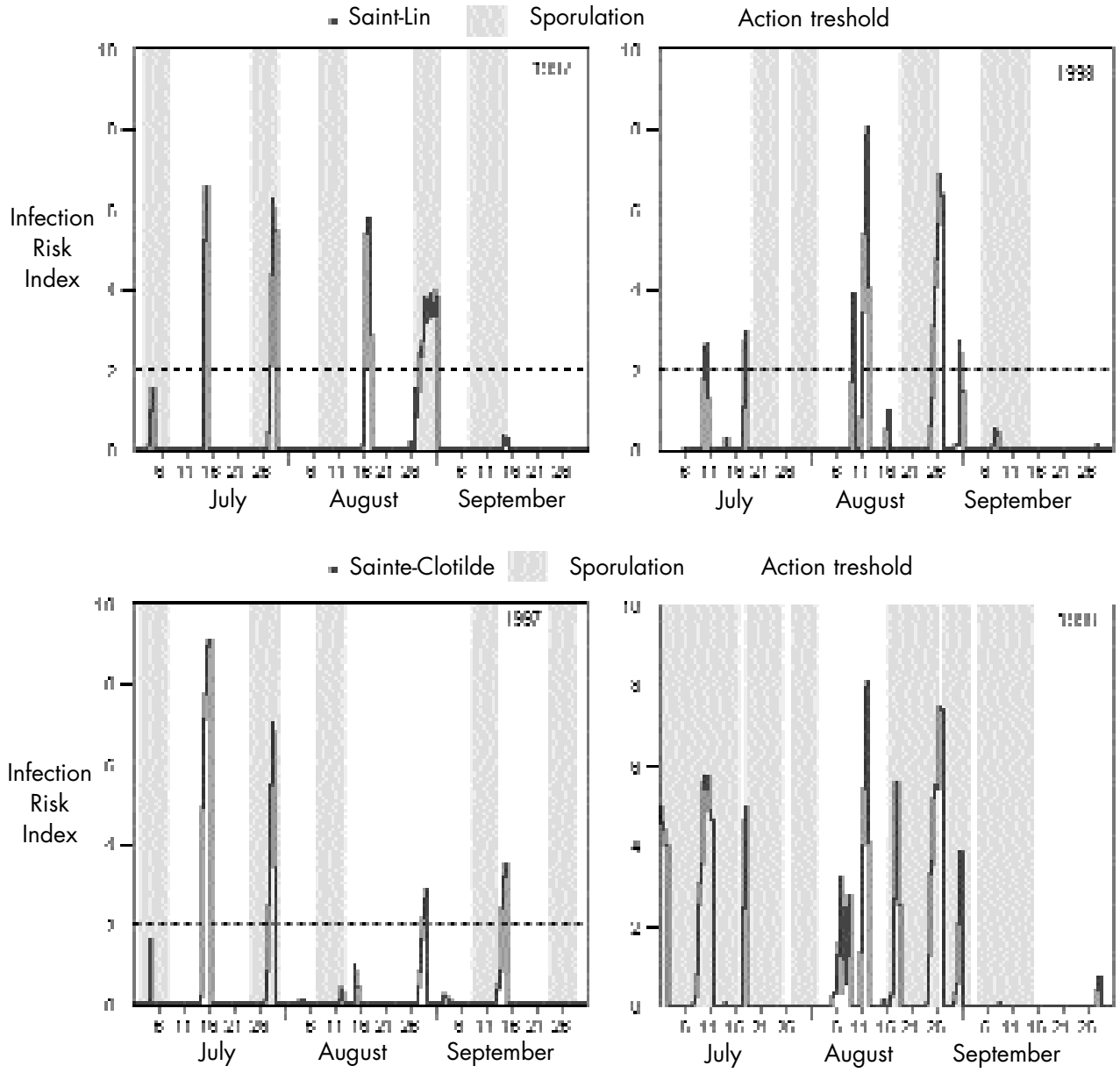

Figure 1. Curves in the infection risk index for cercospora blight at Saint-Lin and Sainte-Clotilde during the two years of observation, 1997 and 1998, according to the forecasting model and as presented by CIPRA.

MODELLING EGG ECLOSION IN THE COLORADO POTATO BEETLE

Julien Desaulniers, Gaétan Bourgeois, Mario Asselin and Gilles Hamel.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, is the main pest of potato crops in Quebec, like everywhere else in North America. This insect causes severe defoliation and its activity inevitably leads to reduced potato yields.

The goal of this study was to determine the number of degree-days (DD) that it takes the beetle to go through certain stages in its development that are important in terms of controlling the pest. The chronology of events in the beetle's life cycle enabled us to develop a mathematical model, using weather forecasts, which will supplement field scouting and provide producers with an informative and predictive tool. The targeted events in the beetle's life cycle are as follows: emergence of adults in spring, start of egg-laying, appearance of the first small larvae (L1L2) and large larvae (L3L4) and observation of an action threshold consisting of about 85% small larvae out of the total number of larvae present. The 85% threshold for L1L2 was set as a means of effectively timing insecticide treatment.

This research was conducted during the 1997 and 1998 growing seasons but also incorporated data collected by two monitoring networks between 1990 and 1996. For all of these years, the biological data for the Colorado potato beetle came from regions located in southern Quebec. The fields that were monitored belong to commercial potato growers; they were monitored by two agricultural scouting companies, Phytodata and Agréco.

Each field was visited at least twice a week and counts of beetle densities were done from adult emergence in spring to the establishment of massive numbers of L3 and L4l larvae. Each of the fields included an untreated section in which insect density surveys were conducted after the first insecticide applications were made in the rest of the field. The producers made these applications in keeping with the recommendations of agricultural scouting firms. This involved taking into account the larval densities present on the plants and percent eclosion of the egg masses, in accordance with the method used by the scouting networks participating in the project.

The relationship between the different life cycle events observed and the degree-days was studied by using data from automated weather stations located near the experimental fields. These weather stations provided mean daily temperatures computed from readings recorded several times every hour. The degree-day calculation was done by using a base temperature of 10°C and starting the DD accumulation on April 1. We decided to incorporate the seeding date into our degree-day calculations. This was done to give us a fixed starting point that we could link to the weather conditions and thus use in predicting adult emergence; hence, we did not only use a date with no connection to the insect's biology.

We computed the DD values for all identified stages as of April 1, and noted a lot of interannual variation and a fairly high standard deviation for the yearly values. Snow depth, proximity of a wooded area (overwintering site for potato beetles) and crop rotation are factors that may explain the variability in DD calculations based on the use of a fixed date. However, the between-event values were similar from one year to the next, and less variability was noted within individual years. The standard deviation was nonetheless high; however, despite this variation the mean values were very similar from one year to the next, regardless of the source of the data. When the sowing date was used as a starting point, the DD values were more stable than with the fixed date of April 1. Sowing and plant emergence dates have an effect on the presence of potato beetles in fields in spring. The sowing date depends on annual and local weather patterns and that is why it is a more reliable date for starting DD accumulation than a fixed calendar date

Table 1: Mean degree-day values (DD) base 10°C, for all years, obtained from the companies Agréco and Phytodata, along with the general means comprising all fields (where **n** is the number of fields monitored during the year, **mean** is the mean of the values for all fields monitored during the year and **S.D.** is the standard deviation of the mean) .

	Degree Days										
	April to sowing	**Avril to emerg.**	**Sowing to emerg.**	**April to egg laying**	**Emerg. to egg laying**	**April to L1L2**	**Egg laying to L1L2**	**April to 85% L1L2**	**Egg laying 85% L1L2**	**April to L3L4**	**L1+L2 to L3L4**
Agréco											
N: '92-98	114	96	94	99	100	122	122	121	104	121	120
Mean	28.57	122.06	110.03	161.45	46.34	239.83	85.33	319.95	173.99	298.56	68.86
St. Dev.	36.76	60.20	26.73	59.97	22.13	66.57	33.55	70.97	27.63	74.06	31.01
Phytodata											
N: 90-98	21	61	13	103	58	99	99	103	95	89	85
Mean	55.90	195.61	106.43	222.03	50.50	309.34	94.79	374.02	172.23	365.31	76.55
St. Dev.	27.36	77.29	35.45	77.83	22.22	74.49	35.29	74.72	30.56	78.58	33.52
Total											
N	135	157	107	202	158	221	221	224	199	210	205
Mean	32.82	150.64	109.6	192.34	47.99	270.97	89.56	344.81	173.15	326.85	72.05
St. Dev.	36.74	76.15	27.76	75.82	22.20	78.16	34.59	77.42	29.01	82.72	32.

The consistency observed in the between-event values coverng several years is a key element. It is likewise interesting to note how similar the mean values are for all years, including those for all fields monitored for each partner when the number of observations is equivalent (Table 1). This enabled us to compute, for all the fields, a single set of reliable DD values delimiting the different beetle development stages, with a view to effective control of this insect (Table 1). In view of the valuable results obtained, we were able to develop a predictive model based on degree-days. After the producers confirm their sowing dates, the model combines the weather forecasts with the following data to determine the optimal timing of control measures for the larvae and to alert all the stakeholders: the required DD values between the sowing date and adult emergence in spring (110 DD), between emergence and egg-laying (48 DD), between egg-laying and the appearance of L1L2 larvae (90 DD), between egg-laying and observation of the 85% threshold for L1L2 (173 DD) and between the observed appearance of L1L2 larvae and L3L4 larvae (72 DD). This model was incorporated into the CIPRA forecasting software in September 1999 and is now available to users.

Collaborative project with AAFC, Phytodata and Agréco.

POSTHARVEST CONSERVATION

CHLOROPHYLL FLUORESCENCE AS A NONDESTRUCTIVE INDICATOR OF QUALITY

Jennifer R. DeEll and Peter M. A. Toivonen1

Modified atmosphere packaging (MAP) has become popular for extending the storage life of broccoli (Brassica oleracea L., Italica group) although maintaining optimum gas concentrations in MAP throughout handling and transport is often difficult. When the gas concentrations of MAP become extreme for broccoli (<2 kPa O_2 and >10 kPa CO_2), off-odors and off-flavors may develop via anaerobic respiration, rendering it unmarketable. No simple and rapid method is available to determine this without opening the bag and disrupting the atmospheric conditions. The appearance of broccoli heads held in optimum MAP is generally similar to that of those held in unsuitable MAP, but off-odors and/or off-flavors have developed in the latter group.

The objective of this study was to determine if chlorophyll fluorescence could be used as an indicator of anaerobic respiration in broccoli during MAP. Two types of packages were used, PD-941 bags, which provided optimum MAP conditions for broccoli (~3 kPa O_2 plus 5 kPa CO_2), and PD-961EZ bags, which allowed the CO_2 to accumulate (~11 kPa CO_2). After 28 d in MAP at 1 °C, the broccoli from both types of bag had similar appearances and weight losses (Table 1).

However, broccoli held in the PD-961EZ bags had developed slight to moderate alcoholic off-odors and had higher ethanol, acetaldehyde, and ethyl acetate content, as compared with broccoli in PD-941 bags. Chlorophyll fluorescence parameters were lower for broccoli held in the PD-961EZ bags than in the optimum bags (PD-941), and these differences increased with storage duration

These results indicate that chlorophyll fluorescence is a reliable, rapid, nondestructive indicator of broccoli quality during MAP, and that it could be used to determine if broccoli has developed off-odors without opening the bag and disrupting the package atmosphere.

1 AAFC-PARC, Summerland, BC

Table 1. Effects of bag type on broccoli characteristics and weight loss after 28 d in MAP at 1 °C.

					Concentration (µL/L)		
Bag type	**Appearance[1]**	**Black speck[1]**	**Weight loss (%)**	**Odor[1]**	**Acetaldehyde**	**Ethanol**	**Ethyl acetate**
PD-941	3.2	2.7	0.92	1.067	0.18	2.9	0.32
PD-961EZ	3.2	4.4	0.94	3.40	0.47	16.7	0.85
SIGNIFICANCE	NS	NS	NS	***	***	***	***

1 1-5 scale: appearance 1 = poor color and major defects, 5 = green, no defects; black speck 1 = severe, 5 = none; odor 1 = no off-odors, 5 = strong alcoholic odor.
NS: Not significant at P # 0.05.
***: significant at P<0.001

EFFECTS OF VACUUM COOLING AND STORAGE TEMPERATURE ON THE QUALITY OF BEAN SPROUTS

Jennifer R. DeEll, Clément Vigneault, Frédérique Favre [1], Tim Rennie et Shahrokh Khanizadeh

Bean sprouts (*Vigna radiata* L. Wilczek) are highly perishable and thus have rapid quality loss during storage, even at low temperatures, emphasizing the critical need for immediate cooling. Vacuum cooling, which is achieved by evaporation of water from the product at very low air pressure, is used commercially in some areas to precool bean sprouts. However, little information exists in the scientific literature on the benefits or the optimum cooling temperature.

The objective of this study was to evaluate the effects of vacuum cooling and temperature on the quality and storage life of fresh bean sprouts. Sprouts in micro-perforated bags were either not precooled or vacuum cooled to 9, 6, or 3C, and stored for 7days at 1, 3, or 6C. Vacuum-cooled bean sprouts lost more weight than sprouts not precooled, and the weight loss was greater when the sprouts were cooled to lower temperatures. However, the total loss never exceeded 5% and no apparent signs of shrivel were observed. Vacuum cooling resulted in greater product freshness after 4 days of storage, although the final precooling temperature had no effect (Table 1).

Storage temperature had greater influence on bean sprout quality than did cooling temperature, with greater freshness and whiter hypocotyls at the lower temperatures. On the other hand, blackening of cotyledons increased as the storage temperature decreased. However, a storage temperature of 1 C is recommended, to maintain greater freshness and whiter hypocotyls even though the cotyledons may eventually become black. It is important to note that any subsequent room cooling in commercial operations would probably be slower than in this study and therefore, more research is needed to determine if final precooling temperature influences sprout quality under commercial conditions.

1 ENESAD, France

OPTIMUM HYDROCOOLING TEMPERATURE FOR CUCUMBERS

Jennifer R. DeEll, Clément Vigneault and Stéphanie Lemerre[1]

Cucumbers are chilling sensitive and thus should not be stored long-term at temperatures below 7-10°C. Chilling injury may develop if cucumbers are stored at lower temperatures, as characterized by surface pitting and dark watery patches. This injury is generally followed by an increased tendency to decay, particularly when the temperature is raised. It is generally accepted that the temperature of the water used for hydrocooling is the same as the recommended storage temperature for the produce being cooled. Therefore, a water temperature near 10°C is generally used for cucumbers. Lower water temperature would result in faster cooling, however, due to the chilling sensitive nature of cucumber it is often assumed that this would result in visual damage.

The objective of this research was to test the hypothesis that water temperatures less than the lowest recommended storage temperature (10°C) for cucumbers could be used for hydrocooling field cucumbers without inducing chilling injury or negatively affecting storage-life. Freshly harvested cucumbers (cv. 'Speedway') were hydrocooled with water at 1.5, 3.5, 6, 8 or 10.5°C until the internal cucumber temperature reached 12°C (expt. 1), or were precooled with water at 1.5°C until the internal temperature of the cucumber reached 1.7, 8 or 12°C (expt. 2). Cucumber quality was then evaluated after 10 or 12 days of storage at 12°C and 95% relative humidity.

The temperature of the cucumbers at harvest was ~20°C and the time taken to cool the cucumbers to 12°C using water at 1.5, 3.5, 6, 8 or 10.5°C was 21.5, 24, 27, 37 and 50 min, respectively. This demonstrates the rate advantage in using colder water. In the second experiment, in which water at 1.5°C was used, cucumbers reached temperatures of 1.7, 7.5 and 12.4°C in 61, 26 and 15 min. respectively. Little or no chilling injury was observed in the precooled cucumbers after 10 or 12 days of storage at 12°C. In addition, there were no significant differences in weight loss and % marketable cucumbers. However, chlorophyll fluorescence (CF) measurements indicated some chilling stress at the membrane level in cucumbers hydrocooled with

Table 1. Main effect of vacuum cooling on the freshness, cotyledon color, and hypocotyl color of bean sprouts after storage for 4 d.

Vacuum cooled Temperature (°C)	Freshness (5-1)[Y]		Cotyledon color (4-1)[Y]		Hypocotyl color (4-1)[Y]	
	Expt. 1	Expt. 2	Expt. 1	Expt. 2	Expt. 1	Expt. 2
No vacuum	3.8	3.8 b[z]	3.5	3.9	3.0	3.1 b
3	4.1	4.4 a	3.1	3.7	3.3	3.6 a
6	4.3	4.3 a	3.4	3.9	3.3	3.4 a
9	4.2	4.4 a	3.3	32.8	3.2	3.5 a
	NS	*	NS	NS	NS	*

Y Freshness: 5 = excellent to 1 = poor; cotyledon color: 4 = excellent to 1 = poor; hypocotyl color: 4 = excellent to 1 = poor.
Exp.1: storage temperatures at 1 and 6°C.
Exp. 2: storage temperatures at 1, 3 and 6°C.
z Mean separation within columns and treatments by Least Square Means
NS: differences not significant.
* significant at P#0.05

water at temperatures below 6°C (expt. 1) and in cucumbers precooled with water at 1.5°C until internal temperatures reached 1.7°C (expt. 2), as indicated by low values of the CF parameter Fv/Fm (Figure 1).

These results suggest that cucumbers could be hydrocooled using water temperatures below the recommended storage temperature of 10°C. However, when water below 6°C was used and/or cucumbers were cooled to 1.7°C there was sufficient chilling stress to affect CF. This indicates that some chilling stress at the membrane level was present in the cucumbers, although it was not enough to result in visual symptoms during storage at 12°C. Therefore, it is not recommended that water temperatures below 6°C be used for hydrocooling cucumbers or that the product is cooled down to 1.7°C, due to increased risk of chilling injury development. However, there is no need for the latter situation since the recommended storage temperature for cucumber is much warmer than this (10°C).

1 ENESAD, France

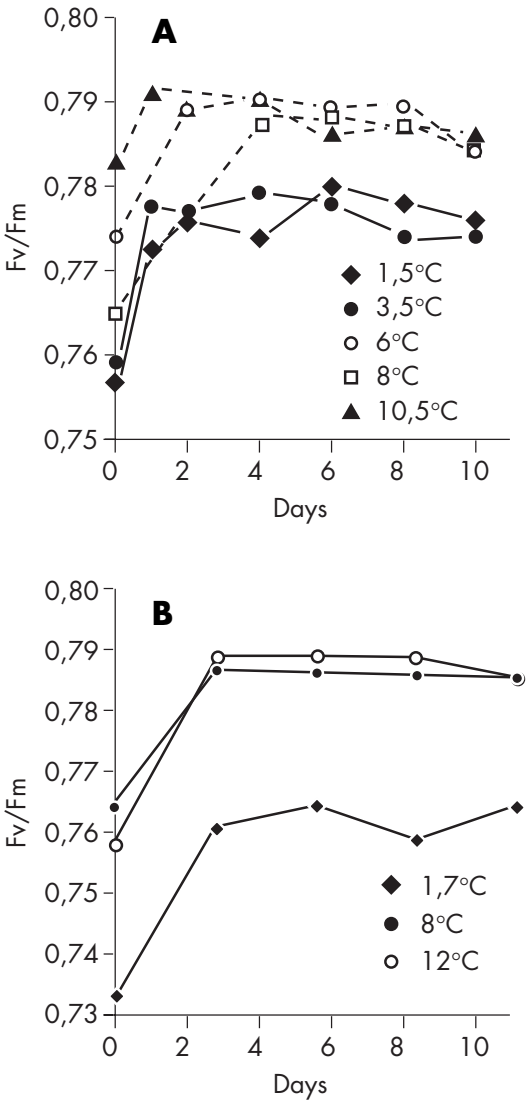

Figure 1. Chlorophyll fluorescence (Fv/Fm) of cucumbers after hydrocooling with: A) water at 1.5, 3.5, 6, 8, or 10.5°C until the internal temperature of the cucumbers reached 12°C, and during 10 days of storage at 12°C (expt. 1) and B) water at 1.5°C until the internal temperature of the cucumbers reached 1.7, 8 or 12°C, and during 10 days of storage at 12°C (expt. 2).

COMPUTERIZED CONTROLLED ATMOSPHERE STORAGE FOR FRUITS AND VEGETABLES

Yvan Gariépy, Bernard Goyette, Claudia Beaudry, Clément Vigneault, Jacques-André Landry[1], G.S.V. Raghavan[1] and Jennifer DeEll

Controlled atmosphere (CA) storage systems are used commercially for the long-term storage of fresh horticultural crops. Recent research has shown the potential advantages of this method in short-term (a few days) and medium-term (a few weeks) storage of certain types of produce. Optimizing storage conditions requires facilities that allow the temperature and the composition of gases in storage rooms to be controlled precisely. Each product reacts in different ways to different concentrations of gases. Therefore, the objective of the study was to design and test an automated system for mini-warehouses for fruits and vegetables allowing temperature, oxygen (O_2) and carbon dioxide (CO_2) to be controlled.

Initially, a series of airtight mini-storage chambers with flexible walls were developed and tested. Each mini-chamber consisted of a rigid base on which products in their original containers can be stored, covered with a 150-ìm polyethylene film. A system of tubing and solenoid values linked the mini-chambers to the air inlet, carbon dioxide control and sampling systems. Each mini-chamber was controlled individually by the automated control system.

Next, a completely automated control system was designed and built. This system allows gas samples to be taken every six hours, information which is used by the control system to adjust the period of air or N_2 injection or CO_2 scrubbing. The short interval between each control action allows relatively stable gas concentrations to be maintained. The control system uses recursive correction algorithms to take account of the history of previous control actions in each mini-chamber to calculate the correction to be applied. The parameters for this type of algorithm also allow the speed at which the system acts to be adjusted and were determined based on research needs on the use of CA on new horticultural crops. The control system was used successfully with mini-chambers ranging from 110 L to 500 L in volume, containing products with highly variable respiration rates. The current system can control 41 CA mini-chambers simultaneously.

1 Macdonald Campus of McGill University and HRDC

IMPACT OF ROOM DIMENSIONS ON THE COOLING OF PRODUCE

Yvan Gariépy, Clément Vigneault and Jennifer DeEll

In Quebec, a large proportion of fruit and vegetables are stored for short- or long-term periods before being sent to market. This practice is used to regulate supplies, stabilize prices, increase areas under production and encourage exports. To preserve freshness, after harvest, these products must be cooled rapidly and stored under optimal conditions. Cooling systems adapted to products and/or cold storage rooms using mechanical systems or cold air from the outside are used for this purpose.

The effect of the room size and relative importance of the various heat sources on the refrigeration system capacity were calculated and compared. Refrigeration loads for two facilities holding 1800 t of carrots were calculated: a warehouse consisting of a single cold storage room with a capacity of 1800 t (warehouse A),

or a warehouse with four cold storage rooms with a capacity of 450 t each (warehouse B). Storage, loading and marketing conditions were identical for both facilities. The carrots were harvested at a rate of 500 t a week, beginning in mid-September, and were sold at a rate of 50-125 t a week between mid-September and late February. The factors used to calculate the capacity of the refrigeration system included the field heat of products to be stored, respiration heat, heat infiltration, heat transmitted by the walls, ceiling and floors of the warehouse, load related to handling, the ventilation and lighting system and the weather conditions at the Ste-Clotide, Quebec, station (1996). For the calculations of heat load, it was assumed that the temperature of the carrots when they arrived at the warehouse corresponded to the mean outside daytime temperature, and that it took 48 hours for the carrots to reach the desired temperature (0°C).

The temporal distribution of refrigeration demand for warehouse A is shown in Figure 1.

The maximum load was close to 75 t of refrigeration capacity, corresponding to the end of the period when the warehouse was being filled (mid-October). Subsequently, the demand decreased progressively as exterior temperatures cooled and the carrots were taken out of the warehouse. For warehouse B, the maximum load was 74 t, reached at the same period. The load calculations carried out for the period when the last loads of carrots were being brought into the warehouse showed that in both cases, close to 50% of refrigeration capacity was used to remove respiration heat while the cooling of the products represented close to 30% of the total load (Figure 2).

Interestingly, the two factors related to the design of the cold storage rooms (transmission and infiltration) only made up 8.3% of

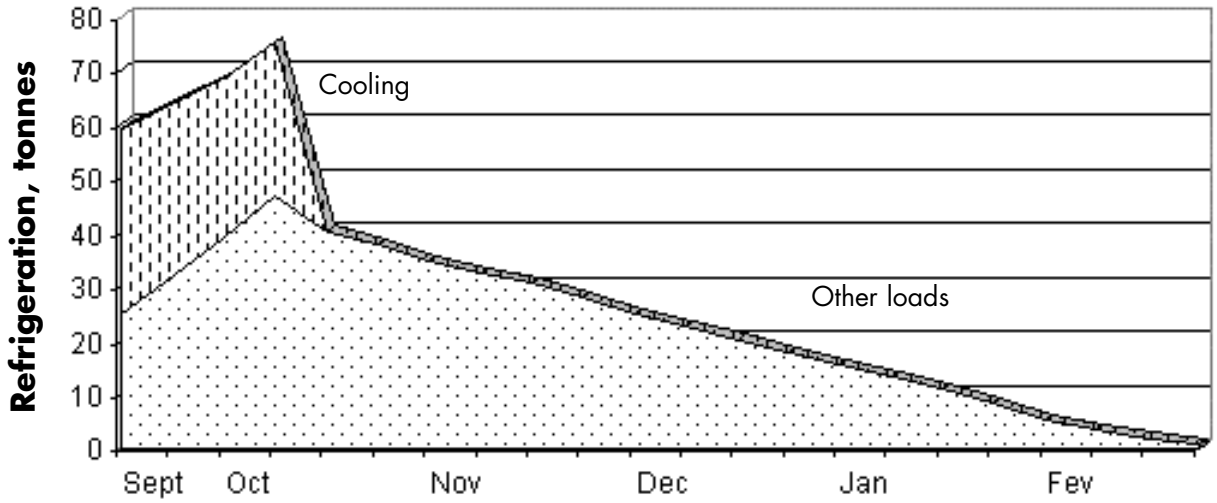

Figure 1. Temporal distribution of mechanical refrigeration demand for warehouse A, for 1800 t of carrots.

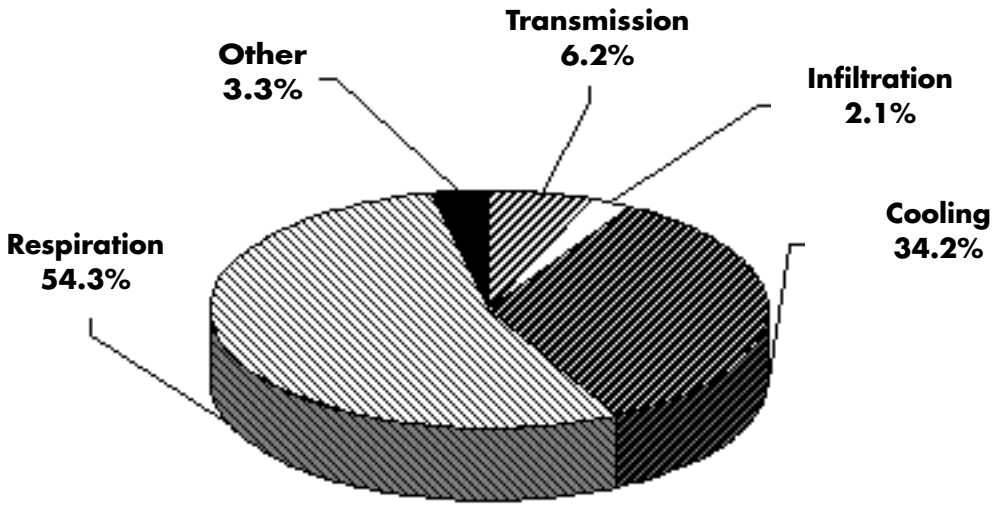

Figure 2. Relative importance of loads for the mechanical refrigeration system for warehouse filled with 1800 t of carrots. The load calculations were done when the last loads of carrots arrived at the warehouse.

demand. This observation explains why there is so little difference between the loads calculated for warehouses A and B. The configuration of warehouse B allows for more versatility, however, since it allows storage rooms to be operated at different temperatures and to use only the space required for the amount of products stored.

The study also confirmed the importance of the loading rate and the temperature of the product when it arrives at the warehouse in relation to the capacity of the refrigeration system. An increase in the loading rate from 100 t to 110 t per day resulted in an increase of 4 t in the refrigeration demand. In addition, an increase in the temperature of the product when it arrived from 16 to 17°C resulted in an extra load of 2.5 t. Therefore, it is essential to monitor the temperature of the air and the products stored in order to regulate the volume of arrivals and avoid overloading the refrigeration system.

EFFECT OF PRECOOLING OF HORTICULTURAL CROPS ON REFRIGERATION DURING TRANSPORT

Catherine K. P. Hui, Clément Vigneault, G.S.Vijaya Raghavan[1] and Jennifer DeEll

In Canada, refrigerated semitrailers are commonly used to transport fresh fruit and vegetables. The trailers are equipped with a mechanical refrigeration system and forced-air circulation system to keep products cool during transport. A theoretical study was carried out to assess the effect of precooling on refrigeration requirements for semitrailers. A typical load was used to determine the quantity of heat generated by each heat source and their relative importance depending on whether the products were precooled or not.

The theoretical load consisted of 17,160 kg of Iceberg lettuce transported in a new precooled semitrailer with an internal height of 2.59 m. The walls and ceiling were composed of 22 mm of aluminium amalgam, 63.5 mm of polyurethane foam and 3.175 mm of fibreglass. The floor was composed of 3 mm of steel, 63.5 mm of polyurethane foam and 3 mm of aluminium amalgam. Cold air (1°C) continuously circulated inside the trailer, which was on the road throughout the night (mean ambient temperature of 30°C) travelling at a speed of 100 km/h.

The field heat of products that were not precooled increased the load on the refrigeration system considerably compared with precooled products. The heat generated by respiration was also greater in products that were not precooled. Infiltration heat was relatively insignificant but may increase considerably with the use and age of the semitrailer. It should be noted that radiation heat was omitted from the calculations since the truck travelled at night. Residual heat was also omitted because the semitrailer was thoroughly precooled before the products were loaded. Lastly, in the case of the non- precooled product, respiration and field heat together accounted for over 80% of the total heat load, which was close to four times greater than for precooled products.

Based on this example, it is clear that the amount of heat in products directly from the field is so great that in many cases, semitrailers' refrigeration systems cannot extract this heat. The product will remain hot throughout transport and significant product losses will occur.

1 Macdonald Campus of McGill University

Table 1: Heat sources involved and their relative importance in the transport of non-precooled and precooled lettuce

Heat source	Non-precooled		Precooled	
	KW	(%)	kW	(%)
Conduction	1.69	(17.8)	1.69	(74.0)
Infiltration	0.0348	(0.4)	0.0348	(1.5)
Field heat	6.39	(67.1)	0	(0.0)
Respiration	1.40	(14.7)	0.56	(24.5)
Total	9.51	(100)	2.28	(100)

EFFECT OF VACUUM COOLING ON PRECOOLING OF LETTUCE

Timothy J. Rennie[1], Clément Vigneault, G.S. Vijaya Raghavan[1], Yves Amesse[2] and Jennifer DeEll

Vacuum cooling is particularly well suited to precooling vegetables with a high surface to volume ratio, in particular leafy vegetables such as lettuce, endives, and spinach. Other very porous produce such as sweet corn and cauliflower may also be successfully vacuum cooled since they allow the water vapour formed to easily escape. Vacuum cooling works by forcing a portion of the water found in the product to evaporate at a low temperature, simply by lowering the atmospheric pressure around the product. Under low pressure, the energy required to evaporate the water comes from the product itself, thus reducing the temperature of the product.

The major disadvantage of vacuum cooling is the high cost of purchasing and installing the equipment required. Therefore, commercial use of this process is limited to large agricultural firms, to coops that sell a wide range of products and to concerns operating year round.

In the beginning, vacuum cooling devices were designed to cool products as quickly as possible since it was commonly believed that only an extremely rapid drop in pressure would provide sufficiently uniform cooling. Relatively slow decreases in pressure were thought to result in highly variable cooling rates, causing freezing problems and significant losses. This conclusion was a little premature, however, and resulted in the development of high performance systems designed mainly to reduce pressure as quickly as possible. Vacuum cooling systems producing a more gradual decrease in pressure should not need components with such a high capacity, and therefore should be cheaper to manufacture and should be better adapted to the needs of local producers.

The main objective of this project was to asses the effect of the duration of treatment on the quality of the product treated - in this case, lettuce - using a completely airtight experimental vacuum system. In addition, the project aimed to determine the maximum time in which a vacuum can be produced without compromising product quality.

Tests were carried out using vacuum production durations ranging from 15 to 120 minutes. The results showed that the temperature distribution in the head, loss of water mass during treatment, quality and shelf life were not affected by changes in cooling rates associated with the different vacuum production durations.

A mathematical relationship linking the time in which a vacuum is produced and the maximum refrigeration demand was developed and validated. This relationship can be used to determine the optimum dimensions of the different components of cooling systems and the volume capacity of the vacuum pump based on the cooling speed desired.

1 Macdonald Campus of McGill University and HRDC
2 Réfrigération Amesse Inc., Beauharnois

DEVELOPMENT OF AN EXPERIMENTAL VACUUM PRECOOLING SYSTEM

Clément Vigneault, Yves Amesse[1], Bernard Goyette and Jennifer DeEll

Vacuum cooling, which has been used for years, is particularly well suited to cooling products such as leafy vegetables that have a high surface to volume ratio. Vacuum cooling is based on the evaporation of water at very high pressure. It is by far the best system for precooling prepackaged products, but requires packaging (plastic bags or other containers) that allows water vapour to escape. New products, called HydroVac systems, have recently appeared on the market, incorporating both vacuum cooling and hydrocooling technology. However, there is a paucity of information in the scientific literature on the operation and design criteria for these devices, since almost all of the research has been conducted in the private sector.

Consequently, a research project was established with the primary objective of designing, constructing and creating instrumentation for an experimental prototype for a vacuum precooling system so that the effects of the different parameters affecting performance (both vacuum cooling alone and vacuum cooling with water) can be measured.

The first phase of the project has been completed. The prototype consists of a vacuum cooler with a precooling chamber with a capacity for up to 65 kg of produce in different types of packing, vacuum pump, piping, refrigeration system, spray/mist system, control panel and instrumentation. The chamber has 46 cm by 66 cm by 125 cm (high) available space. The chamber is sufficiently airtight to be operated at absolute pressures as low as 3 mm mercury. The chamber is equipped with a spray/mist system that allows products to be sprayed or moistened before or during the cooling operations. The vacuum pump and piping generate the desired pressure for 15 to 120 minutes. The refrigeration system has the capacity for cooling 65 kg of products (including packaging weight) from 30EC. Switches, controls and indicators are located on a conventional control panel easily accessed by the operator and each component is clearly identified. The instrumentation making up an integral part of the system comprises eight temperature probes, a flow meter for the water circulating in the spray/mist system and two pressure probes (one for the vacuum and one for water). The control system allows a set of parameters to be adjusted for experimental or demonstration purposes, such as the period required to generate a vacuum; the distribution of droplets generated by the spray/mist system; type of product, packaging and stacking; and the location of products with respect to the water source.

1 Réfrigération Amesse Inc., Beauharnois

'AC-YAMASKA' AND 'AC-L'ACADIE' STRAWBERRIES

Shahrokh Khanizadeh, Bertrand Thériault, Odile Carisse and Deborah Buszard1

'AC-Yamaska' is a new June-bearing strawberry cultivar (*Fragaria* x *ananassa* Duch.) bred for Eastern Central Canada and more specifically for Quebec growing conditions. 'AC-Yamaska' was released because of its very large, dark red, glossy fruit, its late ripening season (five to seven days after Bounty) which extends the strawberry harvest (Khanizadeh, 1994), and after receiving requests for propagation licences from Canadian and European nurseries.

The Prefix 'AC' in the name is the abbreviation for "Agriculture and Agri-Food Canada'". The name "Yamaska" refers to a town located near the shore of Lake Saint-Peter, a widening of the St. Lawrence River between Richelieu and Nicolet counties: Yamaska located in a rich agricultural county where farming and market gardening are the main occupations. The name Yamaska is an native indian word meaning "where there is grass under the water" and it probably refers to the extensive marshes in the area.

'AC-Yamaska', tested as SJ89700-1, is a progeny from a cross between two late season cultivars, 'Pandora' and 'Bogota', made in 1989 by S. Khanizadeh. "Pandora" was originally tested as 'Jilla 33' and released by D. Simpson from East Malling, UK in 1989. It is noted for its moderate resistance to verticillium wilt (*Verticillium albo-atrum* Reinke & Berth.), powdery mildew (*Sphaerotheca macularis* Wallr. ex Fr.) and grey mold (*Botrytis cinerea* Pers. ex Fr.). 'Bogota' was released in 1978 by the Institute for Horticulture, Plant Breeding, in Wageningen, Holland. It was used as a parent because it produces orange-red colored fruit late in the season and it is moderately resistant to red stele (*Phytophthora fragariae* Hickman), verticillium wilt and powdery mildew.

'AC-Yamaska' has been tested at the Agriculture and Agri-Food Canada substation in L'Acadie, Quebec since 1990, and at the Macdonald Campus of McGill University in Ste-Anne-de-Bellevue during 1992-1994. It was also evaluated during 1996-1998 in controlled semi-commercial sites by our private partners Lareault Inc. and Les Fraises de l'Ile d'Orleans Inc. in Quebec and also in Europe by Kraege Gbr (Postfach 266, 48284 Telgte, Germany).

"AC-L'Acadie" is a new June-bearing strawberry cultivar (*Fragaria* x *ananassa* Duch.) bred for Eastern Central Canada and more specifically for Quebec growing conditions. "AC-L'Acadie" was released because of its large, firm fruit, its moderate resistance to leaf diseases and partial resistance to red stele (*Phytophthora fragariae* Hickman), its keeping quality of several days after picking or maturity in the field, and after receiving requests for propagation licences from nurseries in Quebec. It is ideal for shipping or for growers who need to store fresh fruit several days before marketing. It is recommended for pick your own and/or fresh market.

The Prefix 'AC' in the name stands for "Agriculture and Agri-Food Canada" and the name "L'Acadie" was chosen because the selection was selected and tested several years at L'Acadie the location of the Agriculture and Agri-Food Canada substation where most of the strawberry research and breeding are being conducted in the province of Quebec.

"AC-L'Acadie", tested as SJ8916-50, is a progeny from a cross between 'Glooscap' and 'Guardian' made in 1989 by S. Khanizadeh. 'Glooscap' is a popular commercial cultivar in Eastern Central Canada. It has high yields of high quality, glossy, dark red fruit with a raised calyx. 'Guardian' was released by the Agricultural Research Station, Maryland and the Crops Research Division of the U.S. Department of Agriculture. It was used as a parent because of its large, firm, pale red fruit, and its known resistance to five races of red stele, verticillium wilt, leaf scorch and powdery mildew.

1 Department of Plant Science, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada, H9X 1C0.

L'AUTHENTIQUE ORLÉANS: A NEW STRAWBERRY CULTIVAR WITH HIGH LEVELS OF ANTIOXIDANT

Shahrokh Khanizadeh, Louis Gauthier[1], Deborah Buszard[2]

A new project was started in 1996 by Agriculture and Agri-Food Canada, Les Fraises de l'Île d'Orleans Inc. and McGill University to develop firm strawberry cultivars with a long shelf life suitable for transportation. Initially, five selections (FIO-9623-55, FIO-9524-74, FIO-968-1, FIO-9624-11, FIO-9623-40) were retained and entered into advanced trials. FIO-9623-55 was re-selected for its good shelf life, high yields, and firm, large fruit. Chemical analysis of the fruit revealed high levels of proanthocyanidins. In a separate project, proanthocyanidins were shown to enhance fruit preservation because of their antifungal properties and a correlation was found between the level of proanthocyanidins in cultivars and shelf life. Selection FIO-9623-55 is being released under the name "L'Authentique Orléans". It is a June-bearing strawberry cultivar (*Fragaria* x *ananassa* Duch.) bred for Eastern Central Canada and more specifically for Île d'Orleans growing conditions. ' L'Authentique Orléans ' is a progeny resulting from a cross between two recently released cultivars from our station, 'AC-L'Acadie' and 'AC-Yamaska', made in 1993 by S. Khanizadeh. 'L'Authentique Orléans' has been tested at the Agriculture and Agri-Food Canada substation in L'Acadie, Quebec and at Île d'Orleans, Quebec, since 1994. It out yielded 'Annapolis' and 'Kent' in both trials and had the highest level of the antioxidant ellagic acid compared to 23 other strawberry cultivars tested including 'Kent' and 'Annapolis'. Additional information on this new cultivar can be obtained from Les Fraises de l' Île d'Orleans Inc. (LG) or from Agriculture and Agri-Food Canada (SK). For more information visit: http://www.pgris.com/partners/cultivar/fio/index.html

1 Les Fraises de l' Île d'Orleans Inc., St-Laurent, Île d'Orleans, Quebec, Canada, G0A 3Z0

2 Department of Plant Science, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada, H9X 1C0.

NEW HARDY, DAY-NEUTRAL RED FLOWERING STRAWBERRY CULTIVARS

Shahrokh Khanizadeh

Many attempts have been made to develop hardy, disease and pest resistant June-bearing strawberry cultivars for the Quebec climate. Many of these attempts have been successful in improving hardiness and in several cases in controlling various fungal diseases such as leaf spot, mildew, anthracnose, red stele and verticillium wilt and in achieving resistance to the tarnished plant bug. Several cultivars with diverse agronomic characteristics have been named so far from our breeding program (Chambly, Oka, Joliette, L'Acadie and Yamaska). Since there was some interest from growers and home gardeners in growing day-neutral strawberry cultivars in Quebec, we added a new objective to our breeding program: the development of hardy, day-neutral cultivars for Quebec growing conditions. Of the seedlings produced so far, over 80 were hardy and day-neutral and also produced red flowers. We selected and backcrossed the most promising red-flowering seedlings with our advanced or semi-advanced lines and re-selected the ones which had the most interesting agronomic characteristics. There are presently a total of 10 advanced, hardy, day-neutral selections with improved fruit quality which are under evaluation in Quebec including:

SJO9620-146

Day-neutral, hardy, numerous large flowers, multiple crowns, good production of medium to small fruit which taste like wild strawberries, produces a few stolons at our farm in L'Acadie.

SJO9611-30

Day-neutral, hardy, very dwarf plant with dark red flowers and small fruit which taste like wild strawberries, very few or no stolons produced, excellent for home gardeners since no runners are produced and the plants are easy to manage.

SJO9620-76

Day-neutral, hardy, large fruit, firm with excellent wild taste.

SJO9611-23

Day-neutral, hardy, produces few or no stolons, excellent for home gardens, resistant to leaf diseases (two years data), fruit medium to large, produces many flowers, very productive.

NEW HARDY LEAF SPOT RESISTANT STRAWBERRY SELECTIONS

Shahrokh Khanizadeh, Olivier Champigny [1], and Odile Carisse.

Twenty advanced strawberry selections were compared to four known cultivars for susceptibility to leaf spot (*Mycosphaerella fragariae* (Tul.) Lindau). A young and an old leaf from each plant were inoculated with *M. fragariae* on both surfaces until runoff, using an airbrush operated at 100 kPa of air pressure. The plants were placed in a mist chamber for 96 hrs and then relocated to the greenhouse for symptom development. A completely randomized design with four replicates per genotype was used. The plants were observed 10, 11, 14 and 21 days after inoculation. The level of susceptibility was evaluated based on the maximum disease severity (MDS) and area under the disease progress curve (AUDPC) for each kind of leaf. MDS was calculated for each replicate and the average was determined for each genotype and type of leaf (young or old). A homogeneity of variance test was conducted to determine if the MDS values could be pooled. A cluster analysis was used for both types of leaves to group genotypes with similar levels of susceptibility to leaf spot. SJ9327-17, SJ9323-3 and SJ9314-46 were the most resistant genotypes. These hardy, leaf spot resistant selections are under evaluation in four regions in Quebec.. There was some variation in classification when we compared the young or older leaves. SJ937-1, SJ939-120 classified as resistant when we inoculated their young leaves but ranked as semi-susceptible when their older leaves were inoculated opposite to the response of SJ9323-4, SJ939-20, SJ9335-26 and SJ9335-21, the young leaves of which were susceptible to the leaf spot. It seems that it is important to evaluate the leaf susceptibility both on young and old leaves for a complete screening against leaf spot.

1 Ecole Nationale d'Ingénieurs des Travaux en Horticulture et en Paysage, Angers Cedex, France

COMPARISON OF THREE METHODS TO EVALUATE FRUIT FIRMNESS IN ADVANCED STRAWBERRY SELECTIONS

Shahrokh Khanizadeh, Isabelle Lagrave [1], Jennifer DeEll and Johanne Cousineau

Fruit firmness is one of the most important factors in the Quebec strawberry breeding program. This characteristic is especially important in fruit varieties that are to be machine harvested or that are destined for out of province markets. The initial firmness test on the first progeny is normally done manually by the breeder. Firmness evaluation of advanced selections is done manually and with the aid of an instrument (Durofel and Lloyd). The objectives of this study were to compare two instrumental methods of measuring firmness (Durofel and Lloyd instrument) in strawberry with the manual method which was done either by an experienced evaluator or a novice (summer student) with a few weeks of training. The two cultivars Bounty and Kent, and four advanced selections from the Quebec strawberry breeding program were used in the experiment. Results showed a significant correlation between the methods tested. However, there was an interaction between the method used and the genotype which indicated that the level of firmness of a variety depended in part on the method used to measure it. Nonetheless, the results did support the use of the manual method for evaluating strawberry seedlings in field conditions. It also suggested that a novice is capable of estimating firmness manually within a few weeks of training.

1 ENESAD, Dijon, France

THE EFFECTS OF ROOM TEMPERATURE AND COLD ROOM STORAGE ON STRAWBERRY FRUIT COLOR AND FIRMNESS

Shahrokh Khanizadeh, Isabelle Lagrave [1] and Johanne Cousineau

The effects of storage at room temperature (20EC) and at 4EC on the color, skin and flesh firmness of six advanced strawberry selections and three known cultivars were determined.

Skin firmness increased for two days and decreased for the remaining three days when fruit were stored at 20EC. Storage at 4EC for 5 or 10 days increased the skin firmness of all genotypes tested. The change in flesh firmness during storage at 20EC was genotype dependent. Kent and Bounty softened quickly while Chambly, SJ8416-1, and SJ83OR-2 became firmer during the first two days in storage and then rapidly softened the following three days. Advanced selection SJ89264-6 remained firm during storage at both 20EC and 4EC during the entire experiment. Storage of the other genotypes at 4EC had little effect on flesh firmness but further storage at 20EC reduced firmness in Chambly, SJ89700-1, and SJ8916-50. The exterior and interior color of all genotypes tested darkened during storage at both 20EC and 4EC.

1 ENESAD, Dijon, France

EVALUATION OF THE SPRING FROST SUSCEPTIBILITY OF STRAWBERRY GENOTYPES USING CHLOROPHYLL FLUORESCENCE MEASUREMENT

Shahrokh Khanizadeh, Jennifer DeEll and Nadia Hakam

Frost tolerance of the flower buds is one of the most important characteristics of strawberry cultivars which produce fruit very early or early in the season. Several attempts have been made to evaluate and predict the total damage caused by an early spring frost to the primary, secondary or tertiary flower buds. The objective of this study was to evaluate chlorophyll fluorescence (CF) as a suitable rapid method to assess spring frost injury of strawberry flowers. An attempt was made to compare a decrease in CF with the visual evaluation of necrosis (VEN) based on the amount of dark, damaged, or water soaked tissue of the pistil. The goal was to determine if there is a correlation between a decrease in CF and the appearance of visual symptoms due to frost.

Sixty-three strawberry genotypes (Addie, Annapolis, Apollo, Bemanil, Blomidon, Bogota, Bounty, Canoga, Cardinal, Chambly, Chandler, Cheam, Cornwallis, Cruz, Darrow, Darstar, Dermeland, Douglas, Dukat, Earlibelle, Elvira, Favette, Gilbert, Glooscap, Grenadier, Guardian, Hapil, Hecker, Honeoye, Idil, Jewel, Joliette, Kent, Korona, Lateglow, Lester, Micmac, Midway, Mimek, Oka, Primella, Protem, Raritan, Redchief, Redcoat, Regina,Robinson, Settler, Sparkle, Splendida, Stoplight, St-Clair, Sunrize, Tago, Tenira, Toro, Tyee, Vantage, Veegem, Veeglow, Veestar, Vibrant, Zephir) with varying levels of chilling susceptibility were used in this experiment. The plants were grown in the greenhouse under a 16 hours light period at 20-22C during the daytime and 16-18C at night. For the CF and VEN measurements, the plants were stored at –3C for 24 hours followed by 24 hours in the greenhouse. The CF measurements were made on dark-adapted tissue, using the Fv/Fm test of an OS-500 Modulated Fluorometer. For the VEN method, the flowers which had a dark, damaged, or water soaked pistils were counted.

The results showed that variable fluorescence (Fv) decreased as the temperature was lowered. The spring frost resistant cultivars maintained Fv at a stable level and had a smaller regression slope ($ß_1$) while the susceptible cultivars had a very dramatic decrease in Fv. The CF method gave results which correlated with the VEN results.

The strong relationship between chilling tolerance determined via visual and fluorescence techniques supports the use of CF in selecting resistant spring frost selections in a breeding program. The use of CF will allow the breeder not only to select for spring frost resistant selections independently of environmental changes but also to select frost resistant seedlings prior to planting in the field.

MACEXCEL: A NEW HARDY COLUMNAR SCAB AND MILDEW RESISTANT APPLE

Shahrokh Khanizadeh, Johanne Cousineau, Yvon Groleau, Raymond Granger, Gilles Rousselle, and L. P. S. Spangelo

Pedigree: O-522 (Red Melba x R6T68 (Jonathan x 26830-2 (include Rome Beauty and M. Floribunda ancestry) x McIntosh Wijicks

Tree characteristics: hardy, columnar habit with a few very upright side branches when grown on MM-106, moderately vigorous, good yield of fruit borne on spurs.

Flower characteristics: Fruit characteristics: average weight 121 g, axial diameter 56 mm, transverse diameter 69 mm, mainly oblate to round-conic, sometimes short-round-conic, with some ribbing; basin: deep, narrow to medium width, surface irregular and ridged; calyx: open, lobes persistent and erect, calyx tube U-shaped, stamens in basal position; cavity: mainly acuminate, medium depth and width, smooth; stem: mainly long, sometimes short, medium diameter, can have a bit of red on one side; core: small, closed, in median position, with clasping non-prominent core lines and prominent green core dots; skin: smooth, medium thick, blotched and striped pinkish-red to dark red over a greenish-yellow ground, heavy bloom, no russeting, average number of small to medium size lenticels which are not very conspicuous; flesh: firm, crisp, juicy, creamy-white; flavor: acceptable; end use: good as a columnar tree to be grafted on dwarfing rootstocks for home gardeners specially when there are limited space in gardens; ripens second week of September in Frelighsburg, QC.

Other characteristics: resistant to apple scab and powdery mildew, no evidence of fireblight in our orchards during the evaluation period.

QUEBEC APPLE CULTIVAR AND ROOTSTOCK BREEDING PROGRAM

Shahrokh Khanizadeh, Johanne Cousineau, Yvon Groleau, Raymond L. Granger and Gilles Rousselle

The history of apple breeding at St-Jean started in 1970 with the transfer of genetic material from Dr. Lloyd P.S. Spangelo of the Ottawa Research Station in Frelighsburg, a sub-station of the Agriculture and Agri-Food Canada station in St-Jean-sur-Richelieu, Quebec. The objectives of the program were to develop suitable cultivars for juice and cider production, to breed improved scab resistant cultivars for fresh markets, and to find size controlling rootstocks which would be adapted to Quebec conditions. Since 1970, numerous cultivars have been released from St-Jean including 'Blair' (1973), 'Richelieu' (1990), 'Rouville' (1991, 'Primevère' (1995 with Purdue University) and 'Belmac' (1995)), all of which are hardy scab resistant cultivars. All of the introductions have proven to be immune to North America's five known races of *Venturia inaequalis.* Presently advanced selections 10280, 79-09, R124A04, R125A44, R130A09, 74-50-13, 77-13-11, A14R3A108,

A16R5A15, A23R7A60, A33R5A67, A36R7A87, A38R6A74, FAR006A013, FAR026A042, FAR095A007, O-5410, O-654, and O-662 have been evaluated for fruit shape, fruit quality, sensory data, ripening season, storage, tree habit, hardiness, leaves, etc in the last several years at Frelighsburg and at our private partner's sites.

Apple rootstock breeding, selection and evaluation are also part of the St-Jean program. There are 14 advanced hardy rootstocks presently being evaluated at three different sites. They range in vigor from extreme dwarf to semi-vigorous. Improved Ottawa 3 (IO3) is a new strain of the Ottawa3 rootstock which is more productive, precocious and easier to propagate. Present apple cultivar and rootstock breeding aims have emphasized cold hardiness, disease tolerance and dessert quality. The mandate is to establish a private- and public-sector partnership for cultivar and rootstock development based on the needs of the Quebec apple growing industry and the presence of suitable genetic materials that will present high fruit quality and yield, and tolerance to pests and diseases.

The short term objectives are: 1) to evaluate the existing materials in Frelighsburg and to release, remove or transfer the genotypes to other AAFC research stations for further evaluation, 2) to reduce the number of experiments performed to accommodate our existing budget and to find a potential alternate site should the Frelighsburg sub-station be closed in the future, and 3) to concentrate on the genetic materials which are winter hardy and are tolerant to pests and diseases.

NEW HARDY ROOTSTOCKS FROM THE QUEBEC APPLE BREEDING PROGRAM

Shahrokh Khanizadeh, Yvon Groleau, Fadia Saad, Raymond Granger and Gilles Rousselle

One of the long-term objectives of the Quebec apple breeding program is to develop new hardy rootstocks adapted to our harsh winter conditions and soil types. The plan is to select hardy rootstocks that produce a good frame and branch distribution requiring a minimum of pruning and that are compatible with the cultivars used in our climate.

In 1975, seeds were collected from open pollinated Ottawa 3 trees (46 trees) and crosses were made between *Malus robusta* 5 and either M.27 (237 trees) or Budagovsky 57490 (211 trees). The seedlings were planted in a nursery in 1980; in 1982, all the trees were replanted at 5.5 x 3.0 m with "Spartan" as a scion. Standard orchard management practices were applied each year. Of the 908 trees started in 1979, 409 were eliminated naturally due to lack of winter hardiness (-40EC) during 1980-1990. Trunk circumference, measured at 25 cm above the graft union and used to calculate trunk cross-sectional area (TCSA), as well as tree height and tree spread were measured in 1990 on the remaining 499 trees. Yield and incidence of rootsuckers were recorded annually from 1988-1990. Total yield was calculated as the total number of fruits (over 3 years) multiplied by the average fruit weight of Spartan, estimated at 150g. Tree height and spread were measured respectively, as the maximum vertical extension of the tree, and the maximum horizontal extension of the canopy along the rank. The following criteria were used to select promising seedlings: production efficiencies of m 1.0 or more, trunk cross-sectional areas of 65 cm^2 or less, a maximum tree height / spread of 3.0 m, and/or the presence of 10 rootsuckers or less. Based on these criteria, 62 seedlings were selected from the 499 trees that had not been eliminated due to lack of winter hardiness. Of these seedlings, six had production efficiencies of m 1.5 with a small trunk cross-sectional area (29 cm^2). Two of the selections were very dwarf, producing trees around 1.6 m in height. Ten others produced small trees, with heights varying between 2.0 and 3.0 meters. Among the selections showing high yield efficiencies and tree heights lower than 3.0 meters, three had a final spread of less than 3.0 meters. Almost all the selections with the desired yield efficiency, height, spread, as well as TCSA criteria resulted from the cross between *M. robusta* 5 and M.27. Only one was the result of *M. robusta* x "Budagovsky 57490".

NEW HARDY SCAB RESISTANT APPLE SELECTIONS FOR CIDER PRODUCTION

Shahrokh Khanizadeh, Yvon Groleau, Fadia Saad, Robert Demoy

Apples are one of the leading deciduous fruit crops grown in Quebec. Much of the crop is consumed fresh although there is a high percentage of fruit which are used for processing. Apart from using the apples for making juice, several producers use cultivars such as 'Golden Russet' or 'McIntosh' for cider production. There are, at present, no cider specific cultivars which have been bred for Quebec growing conditions. The aim of this project was to develop hardy, disease resistant apple genotypes specifically for cider production.

Five genotypes (12166, 10625, 0-654, 13323, 14199) were chosen from a population of scab resistant apple seedlings grown originally to test for juice and cider production. They were put in replicated trials with standard cultivars (Yarlington Mill, Golden Russet, McIntosh, Summerland, Makamik) and evaluated for important characteristics in cider production. Significant differences were observed between the varieties of apples with respect to pectin, sugars, titratable acidity and pH. Juice produced from '13323' had an above average value for total sugars, possessed the second lowest value for titratable acidity, and the highest pH value. 'Yarlington Mill' juice stood out from the rest as having the lowest value for titratable acidity and a high pH of 3.96. It also possessed the lowest value for total sugars. 'Golden Russet' juice had a very high total sugar content, as well as a high total pectin content.

Cider was produced from the juice of the above genotypes using our partner's production method (Verger du Minot Inc.) without adding or correcting the sugar, acid, or tannin levels during fermentation. The cider samples were evaluated by a taste panel consisting of 6 certified Commission judges. They were tested for aroma and taste with an emphasis on apparent flavor and taste-related components (fruit intensity and appeal, acid and tannin levels). Samples were examined for the characteristics that would affect a finished cider, not as finished ciders themselves. An overall quality rank was assigned to each cider. Of all the genotypes tested, ciders made from "Yarlington Mill", "12166", and "10625" were ranked the best. Since "12166" and "10625" are also scab resistant and hardy they offer an interesting choice for Quebec growers who wish to grow apples for cider production.

Collaborator: Verger du Minot Inc., Hemmingford, Quebec

COMPARISON OF 19 FLOWERING CRAB APPLES AS POLLINIZERS FOR COMMERCIAL MCINTOSH APPLE ORCHARD

Shahrokh Khanizadeh, Raymond Granger and Yvon Groleau

McIntosh is still one of the predominant cultivar in Quebec orchards. Improvement of the pollination, controlled atmosphere storage, cultural practices, etc, is presently under further experimentation to improve the quality and quantity before and after storage. One of the issue is to obtain the maximum fruit set using the best pollinizer. McIntosh trees were hand-pollinated with pollen collected from 18 crab-apples and 'Liberty', a scab resistant cultivar. Each source of pollen was evaluated before use for viability. Three trees of McIntosh were used for each pollen source. Three hundred blossoms on a single branch were pollinated on each tree and a comparable branch on the same tree was tagged as an indicator of fruit set under natural condition. Fruit were counted at maturity on the hand pollinated and natural pollinated branches. Pollen from 'Carmine', 'Dolgo', 'Eleyi Neville Copeman', 'Hopa', 'Liberty', 'Makamik, 'Pioneer scarlet', 'Radiant' and 'Sun Dog' significantly increased the fruit set compared to the other crab apples used as pollinizer compared to naturally pollinated branch. No significant difference was observed between red or white flowering crab apples.

SEED GERMINATION AND SURVIVAL OF GINSENG UNDER TREE CANOPIES.

Shahrokh Khanizadeh, Louis Gauthier [1], Pascale Charest[2], and Martine Dorais[2]

A factorial experiment was set up to evaluate the effects of seeding depth, seeding type (stratified seeds, non-stratified seeds and seedlings), and mulch type (1-2 inches of deciduous tree leaves, 1-2 inches of grain straw, and naturally covered) on ginseng seed germination and survival. Each experiment was repeated under two different types of tree canopies (maple and hardwood/conifer). The seeds were sown 6-12 inches apart. Percent seed germination and survival were highest for stratified seeds covered with leaves during the winter. The effect was more pronounced under maple trees. Maximum seed germination was observed for ginseng seeded 15cm below soil surface regardless of the seed density used. The optimum seed density was 25kg /ha. These results show that it is possible to establish a ginseng population under tree canopies.

ASSESSING CHILLING TOLERANCE IN ROSES USING CHLOROPHYLL FLUORESCENCE

Nadia Hakam, Shahrokh Khanizadeh, Jennifer R. DeEll and Claude Richer

Chlorophyll fluorescence (CF) was evaluated as a technique to assess chilling injury of rose (Rosa sp.) leaves exposed to low temperatures. In the more susceptible genotypes, variable fluorescence (Fv) decreased dramatically as the temperature was lowered. In the less susceptible genotypes Fv was more stable and decreased more slowly as the temperature fell. Our results suggest that measurement of CF may provide a rapid method to pre-screen genotypes for chilling susceptibility, as required in plant breeding. Results with the CF method were similar to those with VEN (Conseil des Productions Végétales du Québec, 1990; Richer et al., 1997). The small differences observed between classification based on VEN vs CF could have been due to VEN being based on an observer's subjectivity. The decrease in Fv of all genotypes confirms the findings of Hetherington et al. (1983a, b), who introduced screening methods based on changes in Fv to assess the relative tolerance of crop plants to chilling and heat stresses. The decrease in Fv in roses with decreasing temperatures followed a pattern similar to that of other crops e.g., peanut (*Arachis hypogaea*), maize (*Zea mays*) and rice (*Oryza sativa*) that are susceptible to chilling injury (Smillie and Hetherington, 1990). Therefore, a relationship between the decrease of Fv at 0 EC and chilling sensitivity exists and this may be used for selection in breeding programs. In this study, the rates of decrease in Fv agreed for the most part with the expected relative chilling sensitivity of the rose genotypes tested. The strong relationship between chilling tolerance determined via visual and fluorescence techniques supports the inference that rapid reduction in fluorescence indicates actual tissue injury.

The CF method is relatively rapid, reliable, non-destructive, quantitative and diagnostic. In comparison with other methods, CF probably has the greatest potential for quality assessment in nurseries, as well as in breeding programs. Measurement of CF is a useful method for the early recognition and quantitative measurement of cellular disturbance caused by low temperature injury. It could possibly be used to detect genotypes that are not susceptible to low temperature injury during the winter, but no such relationship has been reported to date. Our results indicate that the CF method can be used on detached leaves *in vitro* without destroying the plants.

ROOTING OF ROSE MICRO-CUTTINGS DERIVED FROM *IN VITRO* CULTURE

Claude Richer and Christian Bédard [1]

Propagating plants on their own roots, either through cuttings or *in vitro* culture permits the exact reproduction of desired traits. With the cutting method, it takes several years before a new rose cultivar is ready to be placed on the market. New technologies therefore need to be developed to accelerate this process of introducing new cultivars. Direct rooting provides a link between *in vitro* culture and the conventional cutting technique. Factors such as hormones, the substrate used and mycorrhizal development were studied in four rose varieties in the Explorer Series™: 'Lambert Closse' (LC), 'Captain Samuel Holland' (CSH), 'William Booth' (WB) and 'George Vancouver' (GV).

Micro-cuttings with at least two nodes were collected from plants at least two months old derived from *in vitro* culture. A number of hormonal treatments were tested and the results are presented in Table 1.

Direct rooting of plants obtained from *in vitro* culture indicates that the four roses in the Explorer Series™ can be propagated without hormonal treatment in a well-aerated substrate.

Adventitious root formation in roses depends solely on the hormone dose that is applied and is not linked to the presence of root primordia on the plant (Salm van der *et al.,*1996). The concentrations of hormones used in *in vitro* culture range from

Table 1. Effects of different hormone concentrations on the rooting percentage, survival, number, mean length and width of roots on micro-cuttings from 'Captain Samuel Holland' (CSH), 'George Vancouver' (GV), 'Lambert Closse' (LC) and 'William Booth' (WB) roses cultivated *in vitro*.

Cultivar	Treatment (ppm)	Evaluation Parameters				
		Percentage		Roots		
		Rooting	Survival	Number	Length (cm)	Width (cm)
CSH	0	85.8±10.7	86.1±9.7	5.6±0.9	5.0±1.5	3.4±0.6
CSH	2500	74.0±12.8	69.3±20.2	8.6±3.0	4.0±0.8	3.5±0.9
CSH	5000	58.0±8.6	50.3±10.6	9.4±2.5	2.5±0.7	2.4±0.7
CSH	7500	19.9±11.9	15.8±12.9	9.0±1.9	2.6±1.3	2.5±0.6
GV	0	84.7±12.1	84.4±11.0	6.8±2.2	4.2±0.7	2.8±0.2
GV	2500	48.3±14.2	40.6±13.1	18.2±3.0	1.4±0.4	2.6±0.3
GV	5000	28.1±13.5	21.5±12.6	10.6±3.3	1.8±0.7	2.3±0.3
GV	7500	23.6±10.8	16.3±8.0	10.4±2.0	1.0±0.5	1.7±0.5
LC	0	79.9±10.9	81.2±11.6	7.6±2.1	2.4±0.9	3.0±0.7
LC	2500	78.1±9.4	70.2±9.0	15.0±3.4	2.1±0.9	3.1±0.8
LC	5000	55.2±15.3	38.2±14.9	14.4±2.7	1.2±0.8	2.2±0.9
LC	7500	61.8±19.2	38.9±19.9	19.8±3.1	1.2±0.5	2.9±0.8
WB	0	83.0±8.7	78.5±8.8	6.6±2.4	5.4±1.4	3.4±0.6
WB	2500	53.5±14.8	41.3±12.8	20.0±8.6	1.9±0.7	2.6±0.3
WB	5000	43.1±18.2	26.4±16.0	13.6±3.3	2.1±1.2	2.4±0.6
WB	7500	43.4±25.6	30.2±19.0	22.8±19.4	1.7±0.2	3.0±0.5

25 to 30 ppm (Short and Robert, 1991), in contrast with conventional cutting, where the range of concentrations used is 5000 to 7000 ppm depending on the development stage of the cutting (Richer-Leclerc *et al.*, 1989). The direct rooting technique is more closely related to *in vitro* culture than to the conventional use of cuttings, and the results of this experiment show that the concentrations employed were too high. If the experiment had been carried out at a different time of year, the results would have differed substantially. Owing to the great sensitivity of micro-cuttings to moisture stress, all the parameters that cause differences in moisture availability have to be controlled.

In ornamental horticulture, direct rooting of plantlets obtained through *in vitro* culture should be considered a complement to classical propagation techniques such as cuttings, grafting and clonal propagation in general. For many species and especially new varieties, the mass production of plants is the technical factor limiting their use or even their availability and conservation.

1 Prepared in collaboration with the nursery Jardinière du Nord, Saint-Félix-de-Valois (Quebec)

EFFECT OF HORMONAL TREATMENTS ON ROOTING OF CUTTINGS FROM TWO SPECIES OF LATE LILACS

Claude Richer, Frédéric Tronchet[1] and Chantal Gauthier

This study deals with rooting quality in cuttings of late lilacs, *Syringa* x *prestoniae* McKelv. and *Syringa villosa* Vahl, when harvested in July, outside the dates recommended for these two species. In all, 400 cuttings of *S. prestonia* and 350 cuttings of *S. villosa* were exposed to hormonal solutions at various concentrations; Table 1 describes the treatments that were evaluated (40 or 35 cuttings per treatment). The cuttings were soaked for 5 seconds in their respective hormonal solutions, except in treatments T_3, T_6 and T_9, where the cuttings were first soaked for 10 hours in 2 cm of a citric acid solution (100 ppm) around the basal injury.

The study revealed variations in the responses of the two species when they underwent similar treatments. Based on the results, it was determined that during the postflowering period, samples of *Syringa* x *prestoniae* McKelv. (Table 2) may need to be soaked in auxin when placed in the substrate, using a 10 000 ppm solution of indolebutyric acid (IBA) (T_2), in order to improve rooting quality. However, no plant hormone treatment is necessary to propagate *Syringa villosa* Vahl. by cuttings during the fruiting period (Table 3, page 40). In fact, the rate of rooting was found to be maximal in the control.

In *Syringa* x *prestoniae* McKelv, the percent rooting obtained with T_2 was significantly higher (95%) than that obtained with treatments T_1, T_6 and T_{10}. Furthermore, T_6 was significantly lower (65%) than the T_2 and T_4 treatments.

The number of primary roots observed in the cuttings subjected to T_2 was significantly higher (43.62) than that observed in the other treatments. Although the results for T_2 were not statistically different from those of the other treatments, it produced the largest percentage of secondary roots (39.97%) and T_{10} the lowest percentage (20.52%). The mean length of the primary roots obtained for T_2 was greater than that obtained for the other treatments (44.02 mm) and the corresponding value for T_1 was the lowest (26.49 mm).

With *S. villosa*, it appears that the rooting percentages vary from 83 to 100% and that the cuttings associated with T_5 and T_{10} all

rooted. The results for T_2 correspond to the largest mean for primary roots (41.06) and those for T_4 the lowest mean (20.34). The cuttings subjected to T_{10} had the highest percentage of primary roots bearing secondary roots (39.96). Those cuttings also had the largest mean root length (44.82 mm). There was a highly significant difference between this mean length value and that associated with the other treatments. The mean for T_9 (23.72 mm) differed significantly from that obtained for T_5 (33.84 mm) and T_2 (32.42 mm).

1 Intern from the Science Faculty at Université d'Angers, Angers, France.

COMPARISON OF THE EFFECT OF AUTUMN PROTECTION ON THE COLD HARDENING OF SIX ORNAMENTAL SHRUBS

Claude Richer, Raymond Pellerin, Marc Légaré[1] and Marie-Claude Limoges[2]

Some container-grown woody ornamental shrub species are damaged by the first killing autumn frosts. Cold hardening of the aerial parts of the plant occurs in several stages, and the application of fall protection increases the degree of hardening in some plants, thus improving their survival and their growth the following year. Three fall protection treatments were assessed on six woody

Table 1. Hormonal treatments applied to cuttings of *Syringa x prestoniae McKelv. and Syringa villosa Vahl.* (IBA = indolebutyric acid; NA = naphthaleneacetic acid)

Treatment	Hormones used	Concentration
T_1	IBA	5 000 ppm
T_2	IBA	10 000 ppm
T_3	Citric acid + (T_1)	100 ppm citric acid
T_4	NA	500 ppm
T_5	NA	1 000 ppm
T_6	Citric acid + (T_4)	100 ppm citric acid
T_7	IBA + NA	2 500 ppm of IBA and 250 ppm NA
T_8	IBA + NA	5 000 ppm of IBA and 500 ppm NA
T_9	Citric acid +(T_7)	100 ppm citric acid
T_{10}	No hormones	

Table 2. Rooting results for *Syringa* x *prestoniae*.

Treatment (%)	Rooting (number)	Primary Roots (%)	Secondary Roots (mm)	Mean Length
T_1	70.00^{bc}	19.45^{b}	30.93^{NS}	26.49^{NS}
T_2	95.00^{a}	43.62^{a}	39.97^{NS}	44.02^{NS}
T_3	82.50^{abc}	10.40^{c}	30.88^{NS}	34.03^{NS}
T_4	90.00^{ab}	16.90^{bc}	28.98^{NS}	36.86^{NS}
T_5	82.50^{abc}	14.32^{bc}	31.61^{NS}	34.42^{NS}
T_6	65.00^{c}	12.10^{c}	29.30^{NS}	28.81^{NS}
T_7	85.00^{abc}	14.82^{bc}	25.14^{NS}	31.95^{NS}
T_8	87.50^{abc}	19.80^{b}	28.34^{NS}	39.39^{NS}
T_9	87.50^{abc}	11.80^{c}	32.07^{NS}	35.07^{NS}
T_{10}	70.00^{bc}	13.80^{bc}	20.52^{NS}	27.08^{NS}

For a given column, the difference between the results marked with different letters is statistically significant (analysed by the Waller-Duncan K-ratio T to $P < 0.05$)

Table 3. Rooting results for *Syringa villosa* Vahl.

Treatment	Rooting (%)	Primary Roots (number)	Secondary Roots (%)	Mean Length (mm)
T_1	88.57^{NS}	30.83^{NS}	16.94^{b}	26.21^{bc}
T_2	97.14^{NS}	41.06^{NS}	22.80^{b}	32.42^{b}
T_3	91.43^{NS}	25.29^{NS}	16.62^{b}	26.92^{bc}
T_4	88.57^{NS}	20.34^{NS}	23.38^{b}	27.57^{bc}
T_5	100.00^{NS}	39.54^{NS}	25.36^{b}	33.84^{b}
T_6	85.71^{NS}	25.74^{NS}	21.20^{b}	27.27^{bc}
T_7	82.85^{NS}	24.11^{NS}	28.08^{ab}	26.44^{bc}
T_8	88.57^{NS}	34.26^{NS}	26.25^{b}	28.58^{bc}
T_9	85.71^{NS}	21.91^{NS}	23.04^{b}	23.72^{c}
T_s	100.00^{NS}	25.40^{NS}	39.96^{a}	44.82^{a}

For a given column, the difference between the results marked with different letters is statistically significant (analysed by the Waller-Duncan K-ratio T to P < 0.05)

ornamental species: the geotextile Texel 7605, the geotextile Arbo Plus and a control situation with no protection. This study, undertaken in collaboration with three nursery operators, considered the climatic effects of two winters on the behaviour of *Weigela* "Carnaval', *Spiraea* "Froebelii'', *Spiraea* "Shirobana'', *Parthenocissus* "Veitchii'', *Spiraea* "Crispa'' and *Cotoneaster* "Coral Beauty'', at four different nurseries: Pépinière Abbostford, Pépinière L'Avenir, Québec Multiplants and the L'Assomption research farm. Data on winter damage, dry matter and growth were measured in each species.

Cotoneaster "Coral Beauty''

Overly harsh winter conditions may prevent the survival of plants of this species, even if they undergo increased hardening during the fall. It is therefore necessary to modify the winter protection during particularly inclement winters. It was clear that damage noted in the fall had actually occurred during the autumn period and that applying winter protection is an effective way to reduce the level of damage observed the following spring.

Spiraea "Shirobana''

There is no point in covering the plants of this species in the fall solely to avert winter damage. Autumn cover will not help to increase their cold resistance at all. The fall protection treatments nonetheless influence the development of the vegetative mass of the plants.

Spiraea "Froebelii''

The results show that for this species, there is no need to apply fall protection, given that the control plants underwent less damage than those that received protection in autumn. The frequency distribution of winter damage shows that stem tip injuries constituted the only type of damage sustained and that this was less of a problem at the L'Assomption site than at the other sites. Plant mortality was observed in the spring on 10% of the shrubs, regardless of the treatment, including the control plants, twice as many of which died compared with those that had been protected the previous autumn. No difference was noted among the treatments at the Abbotsford site.

Spiraea "Crispa'' and *Weigela* "Carnaval'

With regard to these two species, when the winter is mild, fall protection provides no guarantee that the plants will survive, but if the winter is harsh, plants protected in the fall will sustain less damage or the damage will be less severe.

When the winter is harsh, applying fall covers reduces the intensity of winter damage; however, this does not have a significant effect on plant growth the following season or on branching.

Parthenocissus "Veitchii''

Mortality in this species occurred primarily in winter, with some plants also dying in the fall. Plants that had protection during periods of intense cold in the fall were more vulnerable than when they were exposed to very cold temperatures prior to application of the winter covers.

These results clearly show that applying fall protection is effective for certain species, but not worthwhile for others. It is therefore best to select a production approach that is consistent with the physiological adaptation response of the plants to the effects of the fall climate.

TOLERANCE OF EIGHT CULTIVARS OF *THUJA OCCIDENTALIS* L. TO THE CLIMATIC CONDITIONS IN NORTHEASTERN CANADA

Jacques-André Rioux[1], Pascale Marquis , Claude Richer-Leclerc and Marie-Pierre Lamy[1]

Determination of the hardiness zone of a plant can vary from one author to another, depending on whether this evaluation is based solely on the plant''s survival or on its growth and optimal development. Cultivars are known to differ from the wild type of the species in terms of cold-hardiness. Some specimens of *Thuja occidentalis* L. were established during six consecutive years, from 1985 to 1990 and eight cultivars were also planted: 'Fastigiata',

1 Institut Québecois de Développement de l'Horticulture Ornementale

'Lutea', 'Reidii', 'Wareana' and 'Woodwardii' in 1985 and 'Little Champion', 'Pulcherrima' and 'Smaragd' in 1986. The plants from each of these plantings were assessed during a five-year period at six to nine sites distributed in three regions (Table 1, REPLOQ 1995).

The cultivars 'Woodwardii', 'Reidii', 'Wareana' and 'Lutea' showed a cold resistance similar to that of the wild type of the species. The 'Pulcherrima' cultivar was the most affected of the eight cultivars tested. The cultivars 'Little Champion', 'Smaragd' and 'Fastigiata' showed a response that was intermediate compared with the previously mentioned cultivars. In addition, height and width growth in the plants of the species and in each of its cultivars were affected by the environmental conditions at the sites.

The results of this trial show that the acclimation potential of *Thuja occidentalis* L. may be greater than what is stated in the literature and this potential differs among the cultivars.

The eight cultivars of Thuja occidentalis L. can be classified in three categories based on their growth 1) the cultivars 'Little Champion', 'Reidii' and 'Fastigiata' exhibited similar growth from one site to the next, thus approximating the behaviour of the wild type of the species, 2) the cultivars 'Smaragd' and 'Woodwardii' did not respond nearly as well in clayey soils and on sites where the weather conditions were harsher and 3) the cultivars "Lutea", "Wareana" and "Pulcherrima" were in-between the two previous categories in terms of growth.

1 Plant Science Department, Faculty of Agricultural and Food Science, Laval University, Sainte-Foy, Quebec, Canada G1K 7P4.

Table 1. Climatic zone and soil type at the test sites.

Site	Region[z]	Zone[y]	Soil Type
1 - Sainte-Anne-de-Bellevue	1	5b	Saint-Bernard loam
2 - Sainte-Clotilde	1	5b	Norton gravelly sand with pebbles
3 - Saint-Hyacinthe	1	5a	Sainte-Rosalie clay
4 - L'Assomption on clay	1	5a	Sainte-Rosalie clay
5 - L'Assomption on sand	1	5a	Soulanges loam
6 - Deschambault	2	4b	Champlain silty loam
7 - Sainte-Foy	2	4b	St-Nicolas shaley loam
8 - La Pocatière	2	4a	St-André loam (1985), Kamouraska clay (1989)
9 - Normandin	3	2b	Normandin clayey loam
10 - Kapuskasing	3	2a	"Hearst" silty clay

Z= Region : 1= Montreal region, 2= Quebec City and Lower St Lawrence region, 3= Lac Saint-Jean and northeastern Ontario region.
Y= Cold-hardiness zones according to Sherck and Buckley (1972)

Table 2. *A priori* differences among the three regions in terms of the final height and width (cm) of plants of *Thuja occidentalis* L.

Region[z]	Evaluation Year				
	1	2	3	4	5
			Final Height (cm)		
Region 1 vs Region 2	27.2 vs 35.0	52.1 vs 57.6	85.3 vs 79.6	123.7 vs 107.6	150.1 vs 114.2
	*	NS	NS	NS	*
Region 2 vs Region 3	35.0 vs 24.3	57.6 vs 41.5	79.6 vs 61.2	107.6 vs 76.4	114.2 vs 92.6
	**	*	NS	*	NS
Region 1 vs Region 3	27.2 vs 24.3	52.1 vs 41.5	85.3 vs 61.2	123.7 vs 76.4	150.1 vs 92.6
	NS	NS	*	*	**
			Final Width (cm)		
Region 1 vs Region 2	24.4 vs 30.9	43.0 vs 52.2	67.7 vs 75.7	94.7 vs 97.2	106.8 vs 105.7
	**	**	NS	NS	NS
Region 2 vs Region 3	30.9 vs 24.3	52.2 vs 41.5	75.7 vs 61.2	97.2 vs 76.4	105.7 vs 92.6
	**	**	*	**	*
Region 1 vs Region 3	24.4 vs 24.3	43.0 vs 41.5	67.7 vs 75.7	94.7 vs 97.2	106.8 vs 105.7
	NS	NS	NS	*	NS

Z = Region: region 1 is represented by the L'Assomption site, region 2 by the sites in Sainte-Foy and La Pocatière and region 3 by the sites in Normandin and Kapuskasing.
NS = non-significant; * = significant at a level of 0.05; ** = significant at a level of 0.001.

BIOLOGICAL CONTROL OF THE SOD WEBWORM IN QUEBEC USING ENTOMOPATHOGENIC NEMATODES

Louis Simard, Guy Bélair and Jacques Brodeur[1]

The virulence of four entomopathogenic nematodes was tested on larvae of the sod webworm (*Chrysoteuchia topiaria,* Lepidoptera; Pyralidae), a turf pest that is native to Quebec. In the laboratory, eight concentrations of nematodes were applied to filter paper inside petri dishes stored at a temperature of 24°C for five days. The species *Heterorhabditis megidis* showed the greatest virulence with an LD_{50} of 6 nematodes/larva. The LD_{50} values for the other three nematode species (*Steinernema glaseri*, *Steinernema carpocapsae* and *Steinernema feltiae*) were 34, 68 and 126. The effect of four different contact periods on the mortality of sod webworm larvae was also assessed using the species *H. megidis* and *S. carpocapsae*. The results showed that it takes at least 24 hours for the nematodes *S.carpocapsae* and *H.megidis* to achieve mortality rates >80% at a concentration of 1000 nematodes/larva. Preliminary tests involving the application of entomopathogenic nematodes (*H. megidis*, *S. carpocapsae* and *S. feltiae*) on sod webworms were conducted on residential properties in the regions of Quebec City and Montreal. The statistical analysis indicated that, at some sites, a significant reduction occurred in the number of live sod webworm larvae present in the treatments involving entomopathogenic nematodes. As a rule, the efficacy of these nematodes was comparable to that of an insecticide (Diazinon). Finally, this research revealed a contagious distribution of the sod webworm populations at all of the test sites. With a suitable monitoring method, localized applications of entomopathogenic nematodes can be made, thereby making it possible to reduce the large quantities of pesticide typically employed in the urban environment.

1 Laval University

DEVELOPMENT OF A BIOASSY USING *AZADIRACHTA INDICA*

Marie-Josée Gauvin, André Bélanger and Guy Boivin

In collaboration with Agriculture and Agri-Food Canada, the International Development Research Centre (IRDC), Pronatex and IRSAT, an applied science and technology research institute in Burkina Faso, we are developing a bioassay that can be used to quantify the insecticidal potential of neem seed (*Azadirachta indica*) extracts and relate it to the azadirachtin concentration present in these extracts. This method will permit the manufacture of a standardized product of high quality, given that in nature, differences in temperature, relative humidity and light intensity influence the azadirachtin concentration (%) in neem seeds (Ermel *et al.*, 1986).

The insect used in developing the bioassay was the fruit fly, *Drosophila melanogaster* (Diptera: Drosophilidae). This insect was selected for three reasons: ease of rearing, broad geographic range and short life cycle.

In each of the replications (10 different concentrations of azadirachtin per replicate), 10 third-instar larvae were placed in a Solo© cup containing some diet and a certain amount of azadirachtin. Every day, we recorded the number of adult drosophila that emerged and we removed them; this was continued for up to 14 days of incubation. This allowed us to determine the percent emergence of adult fruit flies according to the azadirachtin concentration and hence the percent mortality. Once it has been perfected, the bioassay can be used to assess the insecticidal potential of the raw materials, i.e. the neem seeds harvested in the field, right through that of the final product developed for use on crops in Burkina Faso.

MODEL FOR FORECASTING STRAWBERRY BUD WEEVIL ACTIVITY IN STRAWBERRY FIELDS

Noubar J. Bostanian, Michael Binns[1], Joe Kovach[2], Gaétan Racette and Gérard Mailloux[3]

Three different methods (sweep net, vacuum collector and brushing plants over a cardboard container) were tested for sampling strawberry bud weevils (*Anthonomus signatus* Say) (Coleoptera: Curculionidae) in strawberry fields. The results suggest that the sweep net is the best sampling method for this insect. A model for forecasting adult abundance has been developed to describe and predict the development of populations of this pest. This research was conducted in strawberry fields that were in their second year of production. Overwintering adults begin to appear in fields at a point when 300 degree days (DD) had accumulated above the base temperature of 0°C, as of April 1. The adults reached maximum abundance between 500 and 670 DD. A treatment approach based on applying cypermethrin or chlorpyrifos during this period was found to be effective in controlling this strawberry pest. The population size of the summer generation peaks between 1250 and 1650 DD. Treatment with chlorpyrifos at 1679 DD reduces the number of weevils in the summer generation and hence the quantity of floral buds clipped by the weevils in fields the following year.

1 Eastern Cereal and Oilseed Research Centre, AAFC
2 New York State Agriculture Experiment Station, Cornell University, Geneva, NY
3 Institut de recherche et de développement en agroenvironnement, St-Hyacinthe.

SUPPRESSION OF THE APPLE MAGGOT BY USING TRAPS ALONG ORCHARD BORDERS

Noubar J. Bostanian, Charles Vincent, Gérald Chouinard[1] and Gaétan Racette

Trapping of adult apple maggots (*Rhagoletis pomonella* (Walsh)) [Diptera: Tephritidae] along the edges of apple orchards (*Malus pumila* Mil.) is an effective physical control method. In commercial orchards, this approach has made it possible to obtain apple crops consisting of 99.5 to 100% healthy fruit. The traps used were red spheres (diameter of 9 cm) or yellow plaques (28 cm x 21.5 cm) placed between two half-spheres. They were coated with glue and baited with butyl hexanoate. The number of traps to be installed was determined according to the length of the orchard edge that was potentially exposed to direct infestation by *R. pomonella*. In the plots, along the sides bordering a wooded area, the traps were spaced about 10 m apart along the row, or placed on

apple trees at the end of each row. On the sides adjacent to grass prairie or chemically treated orchards, a trap spacing of 20 m was used. To achieve a level of control acceptable to apple growers, the maggot populations had to be small to medium in size. Sensitivity to apple maggot attack was found to vary from one cultivar to another. This factor must be taken into consideration by producers planning to apply this method under commercial conditions.

1 Centre de Recherche en Productions Végétales, MAPAC.

TOXICITY OF PESTICIDES TO MITE PREDATORS IN QUEBEC APPLE ORCHARDS

Nancy Larocque, Noubar J. Bostanian, Gaétan Racette and Jacques Lasnier[1]

Studies were conducted under the apple orchard integrated pest control program to determine the toxicity of certain pesticides to two predators of phytophagous mites, *Agistemus fleschneri* (Summers) (Stigmaeidae) and *Amblyseius fallacis* (Garman) (Phytoseiidae). In the case of *A. fleschneri*, our results showed that the fungicides used (Flint® 50WG, Nova® 40WP, Nustar® 20DF, Sovran® 50WG) had no toxic effect on the females or the eggs. The insecticides that were tested (Warrior® (120g/l), Admire® (240 g/l)) exhibited no toxic effect on the two developmental stages of *A. fleschneri* whereas the insecticide Pyramite® is highly toxic (>70% mortality) to females at a dose as low as 1/16 of the recommended dose.

With regard to *Amblyseius fallacis*, the fungicides Captan® 80WP, Nova® 40WP, Polyram® 80WP and Sovran® 50WG did not have a toxic effect on the females, nymphs, eggs or fecundity. However, Dithane® reduces egg eclosion (26.4%) and is toxic (55% mortality) to the nymphs of *A. fallacis*. Pyramite® 75WG does not cause significant mortality (<20%) of females and does not affect fecundity or egg eclosion in *A. fallacis*.

Our results clearly show that, in general, the fungicides do not affect the different developmental stages of *A. fleschneri* or *A. fallacis*. With regard to insecticides, Pyramite® was the only one found to be toxic to adults of *A. fleschneri*, but it is not toxic to those of *A. fallacis*. The differing sensitivity to Pyramite of the two predatory species studied shows that the toxicity of pesticides may vary both between species and within a given species, from one orchard to another. This depends on the treatment program applied by the apple producer. Thus, predators that are able to develop resistance to pesticides with varying modes of action are a real asset, since different insecticides can be used throughout the summer, thereby reducing resistance among insect pests.

1 Directeur CO -Lab R&D Inc., Roxton Falls, Quebec, Canada.

MATHEMATICAL MODELS FOR APPLE PHENOLOGY AND PEST PREDICTIONS USING THE RECHERCHE TBASE SOFTWARE

Gaétan Bourgeois, Marc L'Écuyer, Gérald Chouinard[1], Geneviève Gay, Yves Malenfant, Anne-Marie Fortier, Dominique Plouffe and Hélène Laurence

Degree-days are heat units, which are widely used in agriculture to track the development of living organisms based on temperature fluctuations. During recent work in the modelling laboratory, we had the opportunity to assess various methods of computing degree-days and determining the most suitable base temperature for given organisms. In this research, which covered fewer than 10 sets of data (years, sites, sowings, etc.) it soon became clear that using electronic spreadsheets for data processing was very time-consuming. In addition, extensive data manipulation always increases the risk of error.

Following this initial work, we received several requests to develop new heat unit models for various organisms, for which 50 to 250 data sets were available. We therefore decided to structure a uniform meteorological database for a number of Quebec sites and to develop a software program, called Recherche Tbase, which would allow us to extract biological information from the observation files, determine the most suitable base temperature and method of calculating degree-days and finally quickly compare the predictions from the chosen model with observations collected in the field.

Recherche Tbase is composed of three modules, the "biological information" module the "base temperature determination" module and the "comparison of observations and predictions" module.

The "biological information" module is used to determine the date of a biological event (insect catch threshold, developmental stage of a plant, etc.) and to link the year and site where the observations were made with a weather file. The weather files are from a daily meteorological database that covers 59 sites in Quebec and extends back more than 20 years. This module can be used to predict a cumulative percentage, an observed value or a cumulative value. The starting date of the predictions can be a fixed calendar date or a biological event. The file created by this module is then tapped by the other modules.

The "base temperature determination" module computes the number of degree-days required for the biological event specified in the first module; it also calculates the mean, the standard deviation and the coefficient of variation (C.V.) for a set of data and for the base temperatures from 0.0 to 15.0°C using intervals of 0.1°C. The program also offers six different methods of calculation: simple average, double average, simple triangle, double triangle, single sine and double sine. The best base temperature is that which corresponds to the lowest coefficient of variation.

The "comparison of observations and predictions" module is an evaluation tool that can be used to compare the observations in the biological data file with a prediction based on the mean degree-days value obtained for the selected base temperature and method. There are three possible statistical outputs: sum of differences, sum of absolute differences and sum of squares between the observations and predictions.

By using insect capture data from the Apple Orchard Network (1977 to 1998) with the software Recherche Tbase, we were able to update the apple phenology model and several models for predicting the activity of apple pests. The software allowed us to develop more comprehensive models, which included a larger number of thresholds than before. The predictive models for insect pests described in Table 1 were revised or created by the software and incorporated into the CIPRA software. We used a precise procedure in revising the apple pest models. First, a literature review was carried out to find the base temperature for the individual insect species as determined experimentally. This value may differ from the best base temperature computed by the

Table 1: Comparison of previous models used in CIPRA for predictions about apple pests and the updated models devised with the Recherche Tbase software.

Pest	Number of thresholds in earlier models	Number of thresholds in updated models
Codling moth (*Cydia pomonella*	2	6
European apple sawfly (*Hoplocampa testudinea*	1	3
Spotted tentiform leafminer (*Phyllonorycter blancardella)*	1	5
Apple maggot (*Rhagoletis pomonella)*	3	3
Speckled green fruitworm *(Orthosia hibisci)*	0	3
Dogwood borer (*Synanthedon scitula*)	0	3
Obliquebanded leafroller (*Choristoneura rosaceana)*	1	4
Redbanded leafroller (*Argyrotaenia velutinana)*	1	9
Fruittree leafroller (*Archips argirospilus)*	0	3
Tufted apple budmoth (*Platynota idaeusalis*	0	3
Tarnished plantbug (*Lygus lineolaris)*	1	3
Apple phenology	6	6

program, which is based primarily on simple statistics. After making a decision about the most suitable base temperature for our climatic conditions, we undertook to analyse the available insect capture data and then did some sorting to eliminate certain samples that were not suitable for the analysis (erroneous data, negligible number of captures, etc.). Later, the data were fed into the program to determine the number of degree-days required for each of the key stages in the insect"s development. The results were then compared with those from other models described in the literature. If the model we created compared favourably with those other models, it was integrated with the CIPRA software (Table 1).

Recherche Tbase enabled us to modify or create eleven insect models and to update the apple phenology model within a very short timeframe. We can now process information from several datasets in a few hours, whereas it would take several weeks to do this if we used electronic spreadsheets. The new software program thus represents an important tool for extracting biological data, creating models based on degree-days and validating these models. Modules can be added to the software through programming in Visual Basic language. In summary, Recherche Tbase is a user-friendly software program designed to quickly validate or create models based on the use of degree-days to predict insect development, crop phenology and other biological events governed by changes in temperature.

1 Institut de recherche et de développement en agro-environnement, Saint-Hyacinthe (Qc), Canada J2S 7B8.

CIRCADIAN ACTIVITY OF LYGUS LINEOLARIS AND EFFECTIVENESS OF SAMPLING PROCEDURES IN STRAWBERRY FIELDS

Benoit Rancourt, Charles Vincent, and D. De Oliveira[1]

The activity of the adult tarnished plant bug, *Lygus lineolaris*, Palisot de Beauvois, (Hemiptera: Miridae) was studied on a day-neutral strawberry cultivar in 1991 and 1992 at L'Acadie, Quebec, Canada.

Observations of adult tarnished plant bug at different periods of the day on cage-covered plants revealed that the insects were located most of the time on reproductive parts. Study of the flight activity using sticky posts revealed that most of the captures were obtained <1 m from the ground level and that the period of the day at which the maximum counts occurr varied among seasons. Three pest sampling methods (white sticky trap, tapping of flower clusters, D-Vac) were evaluated over continuous 24-h periods. Maximum captures of adults with the white sticky trap were made at midday, whereas the two other methods proved more effective at the beginning or the end of the day or during night. For nymphs, maximum catches were obtained during the day using tapping and D-Vac; white sticky traps were ineffective. Because the D-Vac captures individuals present on all parts of the plant, these counts were used to monitor the effectiveness of the two other sampling techniques.

The results suggest that tapping flower clusters throughout the day is a very effective sampling method to estimate nymphal populations in strawberries. However, sampling of populations with a high proportion of adults should take into account the bias caused by their flight activity, and sampling should be conducted early in the morning or at the end of the day.

1 Department of Biological Sciences, University of Quebec in Montreal.

VACUUMING TARNISHED PLANT BUG ON STRAWBERRY: A BENCH STUDY OF OPERATIONAL PARAMETERS VERSUS INSECT BEHAVIOR

Charles Vincent and Roger Chagnon

A study was done with a test bench to understand the effects of two operational parameters on vaccuuming efficacy of an insect pest.

Nymphs and adults of tarnished plant bug, *Lygus lineolaris*, Palisot de Beauvois. (Hemiptera: Miridae) marked with fluorescent powder were positioned on strawberry plants according to three height class. Three speeds of inlet (i.e. 2, 4 and 6 km/h) and two

heights of inlet relative to the top canopy (passage at 2/3 and 3/3 of the canopy) were investigated. The marked insects were then found thanks to a UV light and their class height or substrate (i.e. soil, leaf, stem or fruit/flower) was noted.

The efficacy of vacuum was optimal when inlet was passed at 4 km/h with the inlet at 2/3 of the strawberry canopy. Nymphs were typically more vacuumed than adults. Most (64.5%) individuals that were not vacuumed did not changed position after inlet passage. Most (85.9%) individuals that changed position after inlet passage experienced vertical movements, mostly downward movements.

EFFECTS OF THE ENTOMOPATHOGENIC FUNGUS *BEAUVERIA BASSIANA* ON THE OBLIQUE BANDED LEAFROLLER

Silva I. Todorova[1], Daniel Coderre[1], Charles Vincent, and Jean-Charles Côté.

Twenty-three isolates of *Beauveria bassiana* (Balsamo) Vuillemin (Lepidoptera: Tortricidae) from different host and geographical origins were evaluated under laboratory conditions for pathogenicity against third instar of the oblique banded leafroller, *Choristoneura rosaceana* Harris (Lepidoptera: Tortricidae).

At 10^7 conidia/ml, all *B. bassiana* isolates caused more than 66% larval and pupal mortality 60 days following treatment. Isolates 2727, 1525, 2990, 14 and 16 caused the highest (i.e. 80 - 89%) larval and pupal mortality against *C. rosaceana*. Relative to the control, isolate 63 significantly increased and isolate 44860 significantly decreased larval developmental time. Isolates 2727, 2990 and 37 significantly decreased *C. rosaceana* pupal weights. Isolates 139, 2727 and 2990 significantly increased the percentage of male adults that emerged following the treatments.

1 Département des Sciences Biologiques, Université du Québec à Montréal.

EFFECTS OF FIVE INSECTICIDES USED IN APPLE ORCHARDS ON *HYALIODES VITRIPENNIS* (SAY)

Noubar. J. Bostanian, Nancy Larocque, Charles Vincent , Gérald Chouinard[1] and Yvon Morin [2]

Azinphos-methyl, carbaryl, dimethoate, phosmet and phosalone are currently used in apple orchards to manage apple aphid, apple maggot, woolly apple aphid and leaf eating caterpillars.

Among the five insecticides evaluated, dimethoate, carbaryl and azinphosmethyl were the most toxic to the nymphs and adults of *Hyaliodes vitripennis* (Say) (Hemiptera: Miridae) from two regions. Phosalone was the least toxic. Nymphs were more resistant than the adults. Thus, while the LC_{50} for dimethoate was 130 ppm for nymphs, it was 3 ppm for adults from St. Jean-Baptiste-de-Rouville. There were also significant differences in the level of resistance between the two regions where the *H. vitripennis* were collected. At St. Alexandre the LC_{50} for phosalone on nymphs was 19, 250 ppm whereas, at St. Jean-Baptiste-de-Rouville it was 160, 000 ppm.

1 Institut de Recherche et de Développement en Agro-environement, St. Hyacinthe, Qc, Canada.
2 Agrilus Inc., P. O. Box 234, St. Alexandre d''Iberville, Qc, Canada.

SUSCEPTIBILITY OF APPLE CULTIVARS TO INFECTION BY *VENTURIA INAEQUALIS* IN THE GREENHOUSE

Odile Carisse, Megan Dewdney[1], Jollin Charest[1] and Tim Paulitz[1].

Apple scab, caused by the fungus *Venturia inaequalis,* is the most serious disease of apples in eastern Canada. During the last century, much effort has been invested in developing varieties resistant to this disease, although unfortunately none has been grown extensively commercially. In North America, most epidemiological studies on apple scab have been based on the McIntosh cultivar, which is highly susceptible to the disease, and the results of these studies have been the basis for recommended treatments. Knowledge on the susceptibility of other cultivars grown in Canada is limited, however, and the hypothesis that the McIntosh variety is representative of other cultivars has not been proven. Since Canadian growers are increasingly turning to varieties other than McIntosh, it is essential to compare the susceptibility of these varieties to apple scab with that of McIntosh, in order to determine treatment regimens for them.

The objective of this study, therefore, was to study the susceptibility of 21 apple cultivars to apple scab and to compare the results with those for the McIntosh cultivar.

Methodology

The cultivars evaluated are listed in Table 1. The trees, grown in 10 L containers, were inoculated with infected apple leaves containing mature pseudothecia placed on mesh above the plants.

Table 1. Classification of cultivars according to susceptibility to apple scab
Class 5 represents maximum susceptibility, although no cultivars were assigned to this class.

Cultivar	Class	Cultivar	Class	Cultivar	Class
Vista Bella	4	Lodi	3	Royal Gala	2
McIntosh	4	Jonagold	3	Early Geneva	2
Red Cortland	4	Lobo	3	Red Delicious	2
Cortland	4	Northern Spy	3	Sunrise	2
Jersey Mac	3	Spartan	3	Paulared	2
Empire	3	Jonamac	3	Idared	2
Mutsu	3	Golden Delicious	2	Golden Russet	1

The ascospores were discharged by watering the leaves (thus simulating rain) and ascospore concentrations were measured using volumetric samplers placed below the leaves. Cultivar susceptibility was assessed based on the following factors: severity (number of lesions per cm^2 of leaf area), incidence (number of leaves infected), incubation period, latency period, size of lesions and conidia production. Leaf area was measured at inoculation and when severity was being assessed. The incubation and latency periods were defined as the time between inoculation and the appearance of the first lesions and between inoculation and the appearance of the first conidia, respectively. The size of the lesions and conidia production were measured about 28 days after inoculation or just before the lesions coalesced.

Results

Significant differences were noted among cultivars for all factors studied. An example of cultivar classification by severity, expressed as the number of lesions per cm^2, is shown in Figure 1. The average number of lesions per cm^2 of leaf area ranged from 0.03 for the cultivar Paulared to 0.75 for McIntosh. Cultivars were grouped into five categories representing different levels of susceptibility according to all the factors studies

McGill University, Montreal, Quebec, Canada, H9X 3V9.

SPATIAL DISTRIBUTION OF ASCOSPORES OF *VENTURIA INAEQUALIS* IN A COMMERCIAL ORCHARD

Odile Carisse, Jollin Charest[1], Pierre Dutilleul[1], Megan Dewdney[1], Tim Paulitz[1] and Vincent Philion[2]

Currently, the control of apple scab, caused by the fungus *Venturia inaequalis,* is achieved mainly through the application of fungicides to control the primary infections brought about by the ascospores. Despite all the information available on this disease, very few control programs take account of the quantity of ascospores present in infected orchards. When available ascospores are taken into account, some fungicide applications can be eliminated, particularly early in the season when there are few leaves and the infection risk is low. At present, there is no direct way to measure the quantity of inoculum present. Furthermore, methods based on autumn sampling of the disease do not adequately predict the absolute quantity of inoculum that will be present the following year. To do so, volumetric samplers must be used to measure real-time airborne concentrations of ascospores in the orchard. Measuring this parameter, however, presents a number of problems. In addition, it is difficult to determine if measurements or readings are representative of the orchard in question.

The objective of this study was to examine the spatial dispersion (uniformity of ascospore concentrations) in a commercial orchard plot.

Methodology

An orchard plot of one hectare in the Dunham region was divided into 40 quadrats, each 13.5 m X 10 m (Figure 1). In each quadrat, a volumetric sampler was installed before the onset of primary infection.

The quantity of ascospores present in the air was measured during all periods of diurnal rainfall of at least six hours' duration.

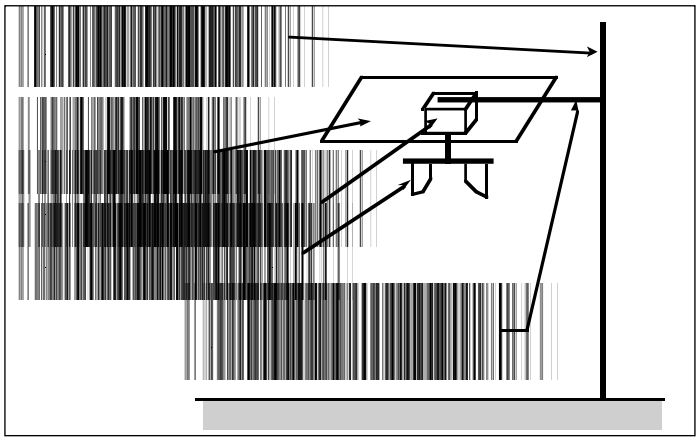

Figure 1. Échantillonneur volumétrique

In each quadrat, the level of scab present during the preceding autumn and the density of leaf litter in spring were also measured to calculate the ascospore potential.

Results

The ascospore potential varied from quadrat to quadrat, ranging from 49 to 17,893 ascospores /m^2 (Figure 3). Airborne ascospore concentrations were also variable, although the extent of the variation differed depending on the date (compare Figures 3 and 4). Geostatistical analyses showed that airborne ascospores were not distributed uniformly throughout the plot. We observed, however, a strong correlation between ascospore potential and the actual quantity of ascospores measured in the air (r= .73). This makes it possible to optimize the position of the sampler in the area at the greatest risk based on a summary evaluation of scab the previous autumn.

1 Macdonald College, McGill University
2 IRDA

RÉCUPAIR ORCHARD SPRAYER

Bernard Panneton

In this project to develop an orchard sprayer that reduces drift and permits recovery of the spray liquid, a second-generation prototype has been designed and manufactured. Subsequent modifications to the sprayer have improved vertical clearance and ease of operating the machine in the field. The pneumatic support system and the spray liquid recovery unit have also been improved, and nozzle placement has been adjusted. These changes were made following field testing in a commercial orchard in the fall of 1998. The foliage cover rates obtained with the prototype in these tests were comparable on average to those obtained with a conventional sprayer. However, within-tree spray distribution was not completely uniform: some parts of the tree received greater spray coverage than others with this prototype.

During the summer of 1999, the new prototype was used to treat some commercial orchard plots throughout the season in an effort to compare the phytosanitary efficacy of this treatment with that obtained in plots using a conventional sprayer. The spray recovery rate was also determined at different foliage development stages. A patent application has been filed in Canada and the United States.

With the present sprayer design, the spray liquid recovery rate in dwarf apple orchards ranges from 10 to 20% depending on foliage development. Ongoing tests have shown that the recovery rate can be increased to as much as 30% by modifying the spray recovery screens. From a plant protection standpoint, the year of testing in a commercial orchard showed that the performance of *RÉCUPAIR* is comparable to that of a conventional sprayer in terms of controlling apple scab and insects.

At present, the design concept is being tested in some Florida orange groves in collaboration with the Citrus Research and Education Center. We are hoping to find a manufacturer interested in joining our team to continue the development of *RÉCUPAIR*.

Prepared in collaboration with: Roger Thériault, Soil and Agricultural Engineering Department, FSAA, Laval University and Ferme Au Pic Enr.

BACILLUS THURINGIENSIS VARIETIES CLASSIFIED ACCORDING TO THE 16S RRNA GENETIC FOOTPRINTS

Kwang-Bo Joung[1] and Jean-Charles Côté

Bacillus thuringiensis (Bt) is a bacterium whose normal habitat is the soil. During the course of its development Bt produces two inclusion bodies consisting of a spore and a crystal The latter is toxic for various insect larvae. Many strains of Bt have been developped and made commercially available for use as alternative to chemical insecticides in the control of insect pests. Many products are now commercially available for use in forestry and agriculture. Unfortunately these products are aimed at a limited number of insects. Research programs have been implemented in order to enrich the existing collections of Bt, and thereby discover strains that harbor new insecticidal properties. These screening programs have brought forth so much success that we know now of as many as tens of thousands of Bt strains. Classifying this plethora of Bt strains according to their various insecticidal properties remains a daunting task. Some classification systems have been proposed that rely on biochemical tests or on serotyping. Here we propose a classification system based on DNA restriction fragments lenght polymorphism (RFLP). Eighty-five strains of *Bacillus thuringiensis* (eighty serovars) were studied for classification by 16S rRNA gene RFLP.

Chromosomal DNA was cleaved with restriction enzyme *Hin*dIII and *EcoR*I, electrophoretically separated and hybridized with a radio-labeled 16S rRNA gene probe from *Bacillus subtilis*. A total of thirty-four possible different *Hin*dIII bands and thirty-eight possible different *EcoR*I bands could be distinguished. When the set of data from two restriction enzymes were combined, all eighty-five strains tested showed distinct restriction patterns. Some strains from same serovar (*kurstaki* HD-1 and *kurstaki* HD-73; *morrisoni*, *sandiego* and *tenebrionis*) and from same serovar but represented as a biotype strain (*entomocidus* and *subtoxicus*) also showed distinct restriction patterns (Figure 1).

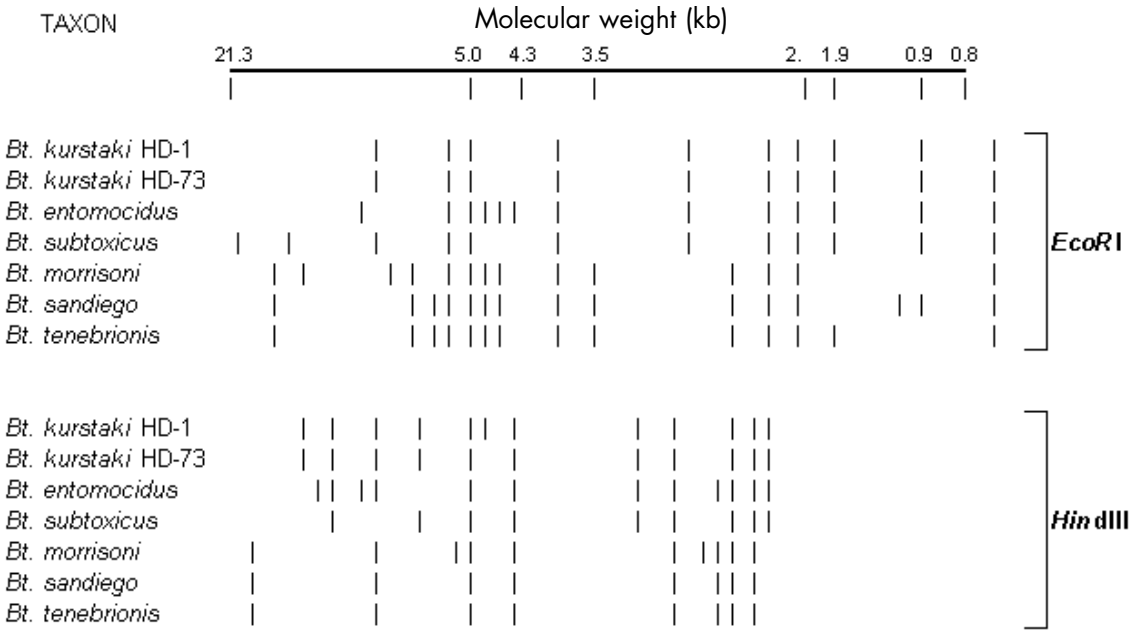

Figure 1. Schematic representation of 16S rRNA gene restriction patterns for *Hin*dIII and *EcoR*I

Comparative analysis of the 16S rRNA gene restriction patterns revealed a phylogenetic tree that comprised four distinct clusters and one ungrouped serovar, *Bacillus thuringiensis* serovar *finitimus*, at the 93% DNA relatedness (Figure 2).

1 Programme de doctorat en Sciences de l'environnement, Université du Québec à Montréal.

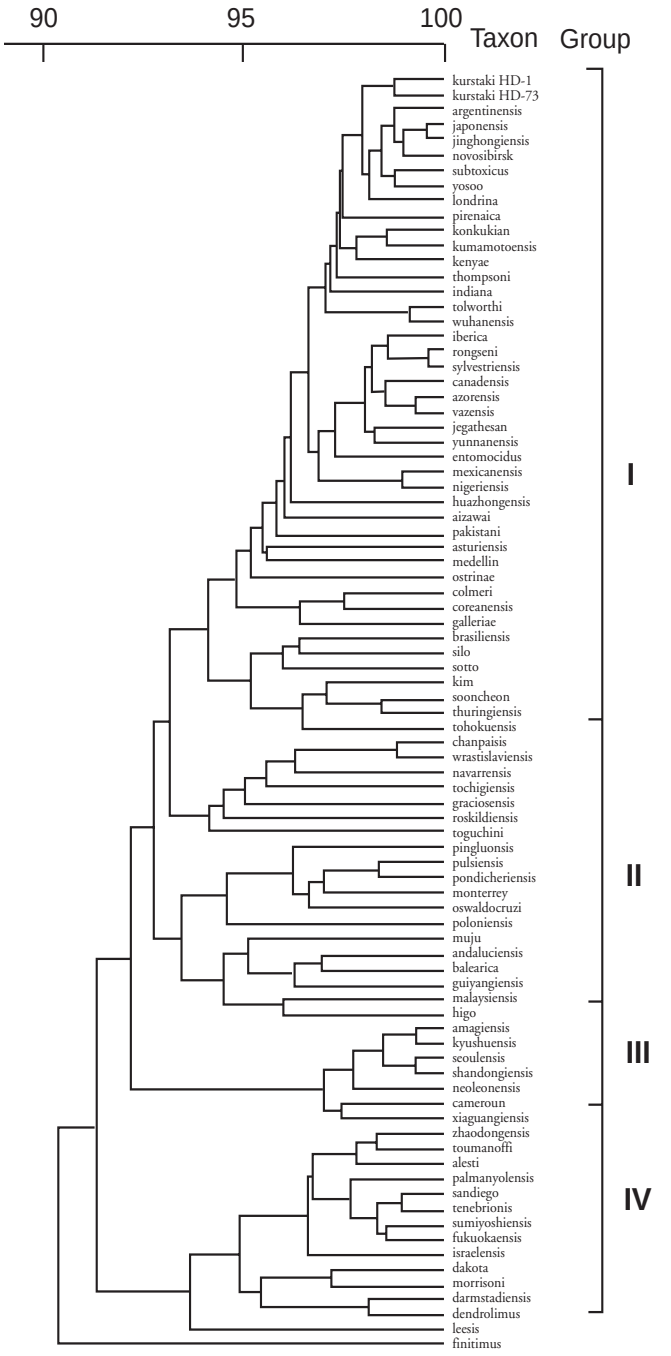

Figure 2. Phylogenetic relationships of *Bacillus thuringiensis* serovars. The dendrogram was generated by unweighted average linkage clustering from a matrix of Upholt's coefficient.

A NEW INSERTION SEQUENCE, IS231M IN A NEW STRAIN OF *BACILLUS THURINGIENSIS*.

***Yong Chul Jung*[1]*, Jean - Charles Côté , and Young Sup Chung*[1]**

During sporulation *Bacillus thuringiensis* (Bt) produces parasporal crystalline inclusions that possess insecticidal activity upon ingestion. The toxic proteins are encoded by the *cry* genes. These genes are classified according to the insecticidal properties of the encoded protein against different classes of insects. The multiple locations and genetic mobility of *cry* genes encoding insecticidal crystal proteins or delta- endotoxins have been attributed to their close association with both class I insertion sequence (IS) elements and class II transposons.

A new insertion sequence IS *231* element, named IS *231*M, has been isolated from a novel *Bacillus thuringiensis* strain named M15 and characterized by the analysis of complete nucleotide sequence. The cloned 1.9 - and 2.5 - kb *Hin*dIII fragments from the plasmid DNA of the isolate M15 were shown to have two open reading frames that code for 334 (ORF 1) and 143 (ORF 2) amino acids, respectively (Fgure 1, page 49).

The nucleotide sequence alignment between IS *231* M and the other iso IS - *231* elements encoding the open reading frame shows that IS *231* M is more closely related to IS *231* F (87 %) followed by IS *231* G (79 %) (Table 1, page 49). IS *231* M is 1652 - bp long and is delimited by two imperfect 20 - bp inverted repeat sequences with three mismatches, which are flanked by two perfect 11 - bp direct repeats (DRs).

1 Département de Sciences Biologiques, Université de Montréal, Québec, Canada, H3C 3J7

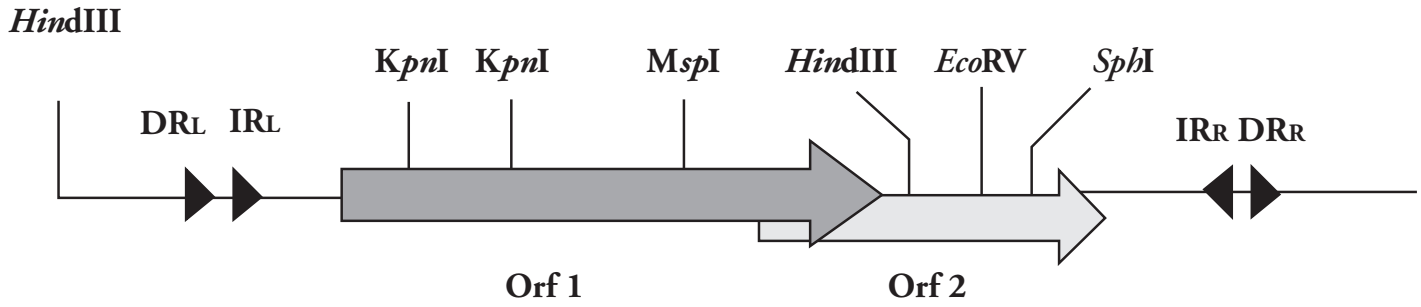

Figure 1. Physical map of IS231M. Open arrows indicate the two open reading frames ORF1 and ORF2. Closed arrowheads indicate the short repeated DNA sequences, inversed (IR) and direct (DR). The 1.9 kb *Hin*dIII fragment contains an open reading frame (ORF 1) and part of a second open reading frame (ORF 2). The 2.5 kb *Hin*dIII fragment holds the 3N section of ORF 2. Also indicated are the restriction sites used.

Table 1. Percentage of maximal identities found in the aligned nucleotidic sequences of IS 231 M and the other IS 231 iso-elements.

	IS *231*A	IS *231*B	IS *231*C	IS *231*D	IS *231*E	IS *231*F	IS *231*G	IS *231*V	IS*231*W
IS*231*M	75	75	74	74	75	87	79	65	65

OTHER

TRIAL PRODUCTION OF PEPPERMINT ESSENTIAL OILS ON A COMMERCIAL SCALE

André Bélanger and Nathalie Grondin

The main goal of this three-year project was to develop and optimize peppermint essential oil production in the area of Bedford, Quebec. Various laboratory and field tests were conducted to improve the yield and quality of the essential oil. A variety of extractions were performed using several stills, achieving essential oil yields of 2%. We were able to show that the provenance of the peppermint had a marked effect on yield.

Tests were conducted using samples of dried plants with different moisture contents. Under our experimental conditions, peppermint gave the best essential oil yield when it had been dried to about 40% moisture. Other tests were carried out with peppermint harvested at different stages of growth. The best yield in terms of plant material was obtained on July 27, 1999, whereas the best essential oil yield was obtained a week earlier. Overall, the plant material yield per square foot reached a peak level around mid-July.

In mid-June, the menthone and menthol concentrations were both 33%. The menthone level dropped as low as 28% in early July, but rose back to 37% at harvest. Conversely, the menthol level peaked at 37% in early July and measured 28% at harvest.

ESSENTIAL OIL FROM LABRADOR TEA

André Bélanger, France Boudreau and Nathalie Grondin

Research on essential oil from the leaves of Labrador Tea (*Ledum groenlandicum* Retzius) was conducted over a two-year period in 1997 and 1998. The plants used came from the Grondines region in Quebec. The goal of the project was to identify the harvest periods and plant drying or processing methods that would allow us to obtain the best yields and the highest quality essential oils from laboratory-based distillation using a pilot still or a commercial one.

Two harvests were made in 1997, one on July 13 and another on August 1; and three harvests were made in 1998, on June 16, July 26 and October 15. Since we had noticed a difference in the colour and texture of Labrador Tea leaves during the extractions done in 1997 and since this had not been taken into consideration, the leaves were divided by age in 1998 prior to all extractions. The leaves were considered old when their underside was an orangey brown, but young when the underside was white or beige. The quantity of young leaves declined as the season progressed : the June harvest contained 38% of these, the July harvest 24% and the October harvest only 18%.

The essential oil yield declined with progressively later harvest dates: plants collected in July gave a better yield than those harvested at the end of August. Furthermore, old leaves produced a small yield compared with young leaves. β-phellandrene was the primary constituent in young leaves, and acorone in old leaves, followed by a compound which has not yet been identified. The yield from microwave extraction was higher and the chemical composition differed from that obtained through steam distillation. However, β-phellandrene was not the main compound in young leaves and they contained other compounds in larger proportions. In order to carry out commercial-scale trials, extractions were performed on the premises of Aliksir Inc. at Grondines, using a vat that can hold a tonne of plant material. The best yields were obtained when the moisture content of the plants was reduced to between 40 and 48%.

The plant yields and moisture contents decreased over the season. In the case of young leaves, the best yield was obtained in June and the chemical composition was found to vary also. In June, β-phellandrene made up about 70% of the essential oil composition, whereas in July, although still a major constituent, its

proportion had dropped to 35%, and selina-3,11-dien-1-ol accounted for 10%. With regard to plants harvested in October, the primary compound was α-selinene, followed by p-cymen-8-ol. At that time, β-phellandrene made up only 9% of the essential oil. The percentage of β-phellandrene in young leaves decreased with each harvest, whereas t-p-mentha-2,8-dien-1-ol and p-cymen-8-ol increased. The old leaves generally contained α-selinene and β-phellandrene.

ESSENTIAL OIL FROM *ACORUS CALAMUS* IN QUEBEC

André Bélanger, France Boudreau and Nathalie Grondin

Sweet flag (*Acorus calamus* L.) is a perennial plant that grows around swamps and along rivers and ponds, in North America, Europe and Asia. The rhizomes of this plant have long been used as an ingredient in traditional medicines and as a flavouring for beverages. They contain a volatile oil that has a pleasant smell and taste and that can be obtained by steam distillation.

A. calamus plants were harvested several times during 1997 and 1998, and several methods of extraction were tested on the rhizomes, roots and leaves, which were dried separately to various moisture levels. The processes used to extract oil from the rhizomes were steam distillation, extraction with a homogenizer, a Soxhlet and a mortar, along with microwave-assisted extraction. Essential oil was obtained from the roots by steam distillation, mortar extraction and microwave extraction, whereas steam distillation and hydrodiffusion were used on the leaves. Gas chromatography analysis was done on the different extracts of *A. calamus* using two capillary columns with opposite polarities.

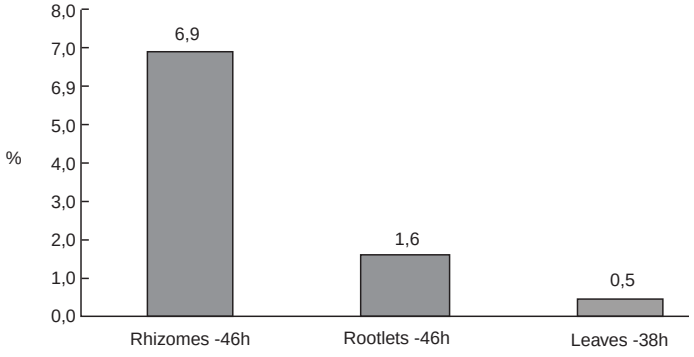

Figure 1. Essential oils yields according to the various parts of *Acorus Calamus*

Essential oil extraction from the rhizomes of *A. calamus* produced the highest yields (Figure 1). However, preparing the rhizomes prior to extraction required a great deal of effort (Figure 2). Chopping the rhizomes into pieces about 3 mm long gave a lot more essential oil compared with pieces 3-4 cm long. The highest yields were obtained through Soxhlet extraction. Extraction from the roots gave yields of between 0.3 and 4% depending on the method employed; this is a much lower percentage than that obtained for the rhizomes. Extraction of oil from the leaves did not give good results, with yields of only about 0.3%. No correlations were found between harvest periods and the essential oil yields from the rhizomes, roots and leaves. The essential oils from the different parts of the sweet flag differed in their composition: oil extracted from rhizomes was composed largely of isoshyobunone, preisocalamendiol, calamendiol, acorenone and acorone, whereas that extracted from roots was composed of α-selinene and isoacorone. With regard to the leaves, the main compound was geranyl acetate. What is quite unusual about the *A. calamus* in Quebec is the fact that it does not contain β-asarone, considered a toxic substance on account of its carcinogenic properties.

INTEGRATION OF A LASER LEVELLING SYSTEM WITH THE RDS SENSOR FOR ROOT VEGETABLES TO PERMIT TOPOGRAPHIC MAPPING

Bernard Panneton

This project involved adapting the RDS RCYM in order to record the signals from a laser levelling system via the interface developed at the Horticultural Research and Development Centre (HRDC), with the ultimate aim of producing topographic maps. The laser, laser sensor and hydraulic control unit of a laser levelling system were used to keep the laser sensor positioned at all times in the laser light beam. The movements of the hydraulic cylinder holding the sensor in place were recorded by using an ultrasound sensor that measures the distance between a point on the ground and an aluminium disk attached to the laser detector support. The resulting measurements were recorded by the RDS RCYM via the interface developed at the HRDC. The system has been tested on an onion seeder. A computer program has been designed for pre-processing the data, and topographic maps can be generated by using the RDS Plot and Plan software as if the data were yield data. The system worked well and can generate maps with a vertical resolution of about 5 cm; the horizontal resolution is limited solely by the precision of the DGPS system being used, which is typically 1 m.

In collaboration with: Innotag Inc. - C.A.M.S. and Terres Noires Ltée

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COLLABORATIVE RESEARCH

Bélair, G., M.Sc., Nematology

Evaluation of the toxicity of *Bacillus thuringiensis* to the nematode *Caenorhabditis elegans*. Collaboration : University of Montreal. HRDC researcher: J.C. Côté, Ph.D.

Biological control of white grub and sod webworm with entomopathogenic nematodes in turfgrass. Collaboration : Laval University.

Biological control of the June beetle and sod webworms in turf. Collaboration : Laval University Collaborating researcher: Jacques Brodeur.

Bélanger, A., Ph.D., Organic Analytical Chemistry

Aromatic plants in Morocco. Centre de recherche pour le développement international, Institut agronomique et vétérinaire Hassan II.** Projects finished before March 31, 2000

Effect of tansy oil combined with dillapiol on obliquebanded leafrollers. Collaboration : UQTR. HRDC researcher: C. Vincent, Ph.D., Agr.*

Development of biopesticides based on extracts from plants grown in Quebec. HRDC researcher: C. Vincent, Ph.D., Agr.*

Natural insecticides extracted from indigenous plants in Quebec. Collaboration : Urgel Delisle Inc. HRDC researchers: C. Vincent, Ph.D., Agr. and N.J. Bostanian, Ph.D.

Bioinsecticide (Africa). Development of an extraction method for plants with a biocidal potential to obtain maximum insecticidal activity. Collaboration: IRSAT, Ouagadougou. Collaborating researcher: Rigobert Yaméogo, Ph.D.

Benoit, D.L., Ph.D., Weed Science

Evaluation of three types of cultivators in market garden crops grown in organic soils and mineral soils. Collaboration : Macdonald College of McGill University, MAPAQ and the Fondation québécoise pour la recherche en agro-foresterie. HRDC researcher: G. Bourgeois, Ph.D., Agr.*

Modelling of weed development in organic soil. CollaborationU : Agriculture and Agri-Food Canada, Ste Foy. HRDC researcher: G. Bourgeois, Ph.D., Agr.*

Dynamics of weed seedbanks in a barley-red clover rotation. Associated researcher: Anne Légère, Ph.D., Agriculture and Agri-Food Canada, Ste Foy.*

Dynamics of weed seedbanks in organic soil for a carrot-onion rotation. Collaboration : Laval University.

Géophyte - Analysis of yield maps dervied from mapping of agronomic parameters. Collaboration : Coopérative fédérée du Québec, PRISME, Hauts-Monts Inc. and Société coopérative du sud de Montréal. HRDC researchers: B. Panneton, Ph.D., Eng., T. Piekutowski, Eng., N. Tremblay, Ph.D., Agr. and G. Bourgeois, Ph.D., Agr.*

Study of yellow nutsedge agro-ecology to develop an integrated management program for onions grown in muck soil. Associated researcher: François Tardif, Ph.D., University of Guelph.

Evaluation of the risk of weed infestation from a weed seedbank. Collaboration : INRA Dijon and EWRS working group.*

Development of decision support tools for weed management in annual production systems. Collaboration : INRA Dijon, AAFC Ste-Foy, Institut de malherbologie and MAPAQ.*

Comparison of different methods of seeding indicator plants for use in evaluating mechanical cultivators.*

Boivin, G., Ph.D., Biological Control of Insects

Biological control of cabbage maggot. Collaboration : Macdonald Coll. of McGill Univ.

Behaviour of parasitoids. Collaboration : INRA-Antibes.

Parasitoids of cabbage maggot. : Univ. de Rennes I.

Evaluation of host selection in *Trichogramma* spp. Collaboration : Services Bio-contrôle Inc.

Physiology of egg laying in *Aleochara bilineata*. Collaboration : McGill Univ.

Increase in the volume of eggs of *Aleochara bilineata* (Gyll.) over time. Collaboration : McGill Univ. and Univ. de Rennes I (France).

Impact of plant complexity on search success and parasitism of host insects in *Trichogramma* sp. Collaboration : Macdonald Coll., McGill Univ.

Impact of parasitism of cabbage maggot pupae by *Aleochara bilineata* depending on soil type. Collaboration : McGill Univ.

RAPD identification of two staphylinids that are predators and parasites of cabbage maggot. Collaboration : INRA (France), Univ. de Rennes I (France), UQAM, DNA Landmarks Inc.

Bostanian, N.J., Ph.D., Fruit Entomology Lab

Biodiversity of arthropods in orchards. Collaboration : Agriculture and Agri-Food Canada, Ottawa.

Establishment of thresholds for cruciferous pests. Collaboration : Agriculture Québec.*

Testing of a miticide. Collaboration : BASF.

Biological control of mites. Collaboration : Pomitech.

Thresholds for Colorado potato beetles in potato crops. Collaboration : Réseau de dépistage agricole du Centre du Québec.*

Simulated defoliation of potato plants. Collaboration : MAPAQ.*

Efficacy of the indigenous predator *Hyaliodes vitripennis* for biological control of insects and mites in orchards. Collaboration : Agrilus Inc., MAPAQ and Laval University. HRDC researcher: C. Vincent, Agr., Ph.D.

Effects of certain insecticides on the predator *Hyaliodes vitripennis*. Collaboration : UQTR, Agrilus inc., MAPAQ and Laval University. HRDC researcher: C. Vincent, Agr., Ph.D.*

Natural insecticides extracted from indigenous plants in Quebec. Collaboration : Urgel Delisle Inc. HRDC researchers: A. Bélanger, Ph.D. and C. Vincent, Agr., Ph.D.

Natural insecticides extracted from plants native to Quebec. Collaboration: Urgel Delisle Inc. HRDC researchers: A. Bélanger, Ph.D. and C. Vincent, Ph.D., Agr.

Bourgeois, G., Ph.D., Agricultural Systems Modeling

Development of CIPRA. Collaboration : Quebec Department of Agriculture, Fisheries and Food (MAPAQ) and Environment Canada.

Optimization of fungicide applications by using a forecasting model for cercospora blight of carrot, leaf blight of onion and downy mildew of lettuce. Collaboration : Environment Canada.

Integration of climate normals into the CIPRA software. Collaboration : Institut de recherche et développement en agroenvironnement (IRDA), Saint-Hyacinthe.

Spatiotemporal optimization of plant protection measures and hourly definition of risk periods for certain pests of tree fruits. : Agrilus inc. and MAPAQ.

Determination of specific parameters for lettuce, onion and carrot crops for use in predicting leaf wetness duration from standard meteorological data. Collaboration : University of Guelph, Ontario and INRA Thiverval-Grignon, France.

Evaluation of different methods for computing degree-days. HRDC researcher: G. Boivin, Ph.D.

Assessment and updating of forecasting methods for phenological stages of apple, McIntosh variety. Collaboration : IRDA, Saint-Hyacinthe.*

Evaluation and updating of predicted development stages of the oblique-banded leafroller, an apple pest. Collaboration : IRDA, Saint-Hyacinthe.*

Use of weather radars to characterize the spatial distribution of precipitation and the soil moisture balance across the agricultural landscape. Collaboration : Fondation québécoise pour la recherche en agro-foresterie, McGill University and Environment Canada.

Initialization of models for forecasting insect development in market garden and fruit crops based on meteorogical observations. Collaboration : IRDA, Saint-Hyacinthe. HRDC researcher: G. Boivin, Ph.D.

Development and implementation of mathematical models for predicting weed species emergence and development. Collaboration : IRDA, Saint-Hyacinthe and Environment Canada. HRDC researcher: D.L. Benoit, Ph.D.

Automation of meteorological data acquisition and archiving operations. Collaboration: Cégep de St-Jean-sur-Richelieu.*

Development of a computer software program for analysing the biological data needed to develop degree-day accumulation models. Collaboration: Cégep de St-Jean-sur-Richelieu.*

Implementation of potato mildew forecasting models for real-time use within the Quebec meteorological network. Collaboration: Pros de la pomme de terre, Agréco inc., IRDA St-Hyacinthe and IRDA Ste-Foy.

Impact of climate change on crop growth and associated pests: a modelling approach. Collaboration: Soils and Crops Research and Development Centre, Environment Canada Ste-Foy and Environment Canada Ville St-Laurent.

Tools for managing broccoli quality: A pilot project to determine the feasibility of modelling and remote sensing technology to provide pre-harvest and post-harvest quality prediction. Collaboration: USDA/ARS. HRDC researchers: J. DeEll, Ph.D. and S. Jenni, Ph.D.

Evaluation and updating of predictions on the development stages of apple pests (coddling moth, European apple sawfly, dogwood borer, green fruitworm, redbanded leafroller, apple maggot, fruittree leafroller, tufted apple budmoth, tarnished plantbug). Collaboration: IRDA St-Hyacinthe.*

Modelling of nematode survival in organic soil. HRDC researcher: G. Bélair, M.Sc.

Design and implementation of a software program that can convert hourly meteorological data sets into user-selected formats. Collaboration: Cégep de St-Jean-sur-Richelieu

Carisse, O., Ph.D., Phytopathology

Biological control of bacterial wilt (dry leaf spot) of lettuce. Collaboration : INRA Avignon (France), Association des jardiniers maraîchers and Univ. Sherbrooke.

Evaluation of the efficacy of various phytosanitary products against bacterial wilt (dry leaf spot) in greenhouse-grown lettuce. Collaboration : Association des Jardiniers Maraîchers du Québec.*

Epidemiological studies on a new lettuce disease in Quebec: bacterial wilt (dry leaf spot). Susceptibility of lettuce cultivars to dry leaf spot. Collaboration : Association des Jardiniers Maraîchers du Québec and CORPAQ.

Evaluation of a forecasting model for use in controlling downy mildew of lettuce (*Bremia lactucea*). Collaboration : Ontario FS2002 and Rohm and Haas Inc.*

Development of a control program for black rot of cabbage caused by the bacterium *Xanthomonas campestris* pv. *campestris.* Susceptibility of cabbage and cauliflower cultivars to black rot. Collaboration : Ass. des Jardiniers Maraîchers du Québec.*

Study on contamination sources of the bacteria that cause for black rot of cabbage and leaf spot of lettuce. Collaboration : Université de Sherbrooke, Association des Jardiniers Maraîchers du Québec and CORPAQ .*

Determination of the active principle of Lonlife in the Salox powder formulation. Collaboration : Produits Naturels Jefo Inc.and Toxen, UQAM.*

Evaluation of a forecasting model for cercospora blight of carrot in mineral soil. Collaboration : Agro-Production Lanaudière Inc. HRDC researcher: G. Bourgeois, Ph.D., Agr.

Evaluation of the effectiveness of fungal antagonists in inhibiting ascospore production by *Venturia inaequalis* on naturally and artificially infected leaves. Collaboration : McGill University.*

Isolation and purification of antibiotics from a coelomycete that is a potential biocontrol agent for apple scab. Collaboration : Philom Bios. and Univ. Sherbrooke.*

Microscopic observations of the interaction of isolate P130A with *Venturia inaequalis* and other phytopathogenic fungi. Collaboration : Philom Bios and Univ. Sherbrooke.

Comparison of Coelomycete isolates using morphological aspect and scanning electron microscopy for purpose identification. Collaboration : Philom Bios and Laval Univ.

Elaboration of a DNA probe for recovering a coelomycete isolate using specific digestions and ITS DNA patterns. Collaboration : Philom Bios and AAFC, Summerland.

Updating of tools routinely used in controlling apple scab. Cultivar susceptibility and ascospore dose. Collaboration : McGill University.

Updating of tools routinely used in controlling apple scab. Evaluation of a new control method for apple scab. Collaboration: McGill University.

Biological control of *Fusarium graminearum*, the main causal agent of fusarium head blight of wheat and maize. Collaboration : McGill University.

New hardy leaf spot resistant strawberry selections. Collaboration : ENITHP, Angers (France). HRDC researcher: S. Khanizadeh, Ph.D.

Strawberry leaf spot. Collaboration : Laval University. HRDC researcher: G. Bourgeois, Ph.D., Agr.*

Development of a forecasting model for downy mildew sporulation in lettuce. Collaboration : Macdonald College of McGill University. HRDC researcher: G. Bourgeois, Ph.D., Agr.*

Breeding of strawberry cultivars for resistance to red stele (*Phytophthora fragariae*) and foliar diseases (leaf spot and leaf scorch). Collaboration : Conseil des Recherches en Pêche et en Agro-Alimentaire du Québec (CORPAQ), Macdonald College of McGill University and MAPAQ. 1993-1996. HRDC researcher: S. Khanizadeh, Ph.D.*

Development of a real-time detection kit for airborne inoculum that can be used to time fungicide applications more effectively to control economically important diseases. Collaboration: FCAR-IRDA

Development of alternative control methods for late blight and silver scurf in potato. Collaboration: FCAR-IRDA.

Mechanisms involved in suppression of soilborne plant diseases by compost: synergy between resistance and plant-induced resistance. Collaboration: NSERC.

Côté, J.C.,Ph.D., Microbiology

Genetic fingerprinting of *Bacillus thuringiensis*. Collaboration : University of Mtl and UQAM.

Evaluation of the toxicity of *Bacillus thuringiensis* to the nematode *Caenorhabditis elegans*. Collaboration : University of Mtl. HRDC researcher: G. Bélair, M.Sc.

Evaluation of the toxicity of *Beauveria bassiana* to the tarnished plant bug. Collaboration : UQAM.

Evaluation of the toxicity of *Beauveria bassiana* to the twelve-spotted lady beetle. Collaboration : UQAM.

Evaluation of the toxicity of *Beauveria bassiana* to the obliquebanded leafroller. Collaboration : UQAM. HRDC researcher: C. Vincent, Ph.D., Agr.

Characterization of the new M15 strain of Bacillus thuringiensis. Collaboration: University of Montreal.

Screening of new Bacillus strains presenting new pesticide properties. Collaboration: UQAM, University of Montreal, Pasteur Institute, Korea Research Institute in Biosciences and Biotechnology

Development of Beauveria bassiana as a biological pesticide for greenhouse use. Collaboration: UQAM.

DeEll, J.R. Ph.D., Postharvest Physiology

Use of chlorophyll fluorescence to assess lettuce quality. Collaboration : University of Guelph, Ontario.*

Methods to evaluate iceberg lettuce firmness. Collaboration : University of Guelph, Ontario.

Improving fruit firmness of McIntosh apples during long-term storage (controlled atmosphere). Collaboration : Fédération des Producteurs de Pommes du Québec.*

Storage of new apples selections. HRDC researcher: S. Khanizadeh, Ph.D.

Research on storage of fresh broccoli. Collaboration : Les Jardins Paul Cousineau et fils inc. HRDC researcher: C. Vigneault, Ph.D., Eng.

Chlorophyll fluorescence as a nondestructive indicator of broccoli quality. Collaboration : AAFC Summerland, BC.

Characterization and control of black speck development in broccoli. AAFC Summerland, BC.*

Efficient use of late-season fungicide spraying according to the incubation period for apple scab in storage. Collaborating researcher: V. Philion (IRDA).

Management of fruit and vegetable storerooms during major power failures. HRDC researcher: C. Vigneault,

Jenni, S., Ph.D., Vegetable Crop Physiology and Production Management

A systemic approach for producing celery: consolidation of the early produce market. Collaboration : Conseil des Recherches en Pêche et en Agro-alimentaire du Québec (CORPAQ). McGill University. Collaborating researcher: K. Stewart, Ph.D.

Molecular markers as innovative tools for supporting the creation of lettuce adapted to Quebec. Collaboration: Conseil des Recherches en Pêche et en Agro-alimentaire du Québec (CORPAQ). McGill University. Collaborating researcher: M. Fortin, Ph.D.

Tools for optimizing broccoli quality. Collaboration: USDA-AAFC Agreement. Collaborating researchers: G. Bourgeois, Ph.D. (HRDC) and E.Barnes, Ph.D.

Khanizadeh, S., Ph.D., Plant Breeding physiology of Fruits and Small Fruits

Strawberry diseases. Collaboration : Agriculture Québec.*

Breeding of raspberry plants. Collaboration : Agriculture Québec and Macdonald College of McGill University.

Breeding of strawberry plants. Collaboration : Macdonald College of McGill University.

Breeding of strawberry cultivars for resistance to red stele (*Phytophthora fragariae*) and foliar diseases (leaf spot and leaf scorch). Collaboration : Conseil des Recherches en Pêche et en Agro-Alimentaire du Québec (CORPAQ), Macdonald College of McGill University and MAPAQ. 1993-1996. HRDC researcher: O. Carisse, Ph.D.*

Quebec apple cultivars and rootstocks testing network. Collaboration : A. Lassonde Inc., Fédération des Producteurs de Pommes du Québec, Pépinière Dominique Savio, Pépinière Luc Rodrigue, Bayer Co., Rohm & Haas, Hoerchst Noram, Laval University, McGill University, MAPAQ and CPVQ Inc.

Hardy apple cultivars with resistance to apple scab. Collaboration : Laval University, Macdonald College of McGill University and the Fédération des Producteurs de Pommes du Québec.*

Molecular marking of resistance genes for raspberry breeding in Quebec. Collaboration : MAPAQ and Macdonald College of McGill University.*

New hardy and dwarfing apple rootstocks. Collaboration : AAFC (Ottawa, Ont.).*

Susceptibility of strawberry plants to leaf spot: comparative study of new selections and known cultivars. Collaboration : ENITHP (Angers, France) and Macdonald College of McGill University. HRDC researcher: O. Carisse, Ph.D.*

Comparaison of three methodes to evaluate fruit firmness in advanced strawberry selections. Collaboration : ENESAD Dijon, France. HRDC researcher: J. DeEll, Ph.D.

New apple selections. HRDC researcher: J. DeEll, Ph.D.

Comparison of chlorophyll fluorescence as an evaluation method for apple storage quality. Collaboration: ENESAD Dijon, France, HRDC researcher: J. DeEll, Ph.D.

Panneton, B., Ph.D., Vegetable Crop Engineering Unit

Pesticide drift in orchards. Collaboration : Laval University.*

Boom sprayer. Collaboration : Laval University and Grégoire et fils Inc.*

Physical pest control methods in plant protection: book project. Collaboration : INRA (Bordeaux, France). HRDC researcher: C. Vincent, Ph.D., Agr.

Emission cycle of a sex pheromone in female *Anaphes listronoti*, egg parasitoids of carrot weevils. Collaboration : McGill University. HRDC researchers: G. Boivin, Ph.D., C. Vigneault, Ph.D., Eng

Field trials to asses the effectiveness of air-assist delivery. Collaboration : Laval University.

GéoPhyte - Analysis of yield maps derived from mapping of agronomic parameters. Collaboration : Coopérative Fédérée du Québec, PRISME, Hauts-Monts Inc. and Société coopérative agricole du sud de Montréal. HRDC researchers: T. Piekutowski, Eng., G. Bourgeois, Ph.D. Agr., N. Tremblay, Ph.D. Agr., D.L. Benoit, Ph.D.*

Piekutowski, T.,[Ph.D.], Precision Agriculture/Agricultural Geomatics

Analysis of correlations between multidate infra-red airborne photographs and yield data. Research associate: B. Panneton, Ph.D., Eng.

Remote sensing of potato late blight. Collaboration : V. Philion (IRDA) and PRISME.

Analysis of airborne LIDAR topographic data. Collaboration : Coopérative Hauts-Monts.

GeoPhyte - Analysis of spatial yield variations through mapping of agronomic parameters. Collaboration : Coopérative Fédérée du Québec, PRISME, Hauts-Monts Inc. and Société coopérative agricole du sud de Montréal. HRDC researchers: B. Panneton, Ph.D., Eng., G. Bourgeois, Ph.D. Agr., N. Tremblay, Ph.D. Agr., and D.L. Benoit, Ph.D.

Richer, C., M.Sc., Ornamental Plant Management

Ornamental woody plant testing network. Collaboration : Agriculture Québec, Laval University, I.T.A. St-Hyacinthe, Centre de Recherches de Normandie, Kapuskasing, CIEL and CDBQ.

Study on the effects of ice damage and tapping on maple tree vigour. Collaboration :Centre Acer (Centre de Recherche de transfert technologique en Acériculture).

Vegetative propagation of sugar maple. Collaboration : Quebec Department of Natural Resources, Forestry Quebec and Laval University.

Propagation of native orchids using mycorrhizal substrates. Collaboration : IRAP and the firm Biosynergie*

Determination of the cold hardening potential of ornamental plants produced by various propagation techniques and exposed to natural winter conditions or ice storm conditions. Collaboration : ITA in St. Hyacinthe, Laval University, AAFC/Normandin.

Tremblay, N., Ph.D., Vegetable Nutrition and Crop Management

GéoPhyte - Analysis of yield maps derived from mapping of agronomic parameters. Collaboration : Coopérative Fédérée du Québec, PRISME, Hauts-Monts Inc. and Société coopérative agricole du sud de Montréal. HRDC researchers: B. Panneton, Ph.D., Eng., T. Piekutowski, Eng., D.L. Benoit, Ph.D. and G. Bourgeois, Ph.D., Agr.*

N and P fertilization in organic soils. Collaboration: PRISME and Laval University. HRDC researcher: G. Bourgeois, Ph.D., Agr.*

Development of guidelines for sustainable management of nitrogen fertilization in vegetable crops. Collaboration: CRH of Laval University

Vigneault, C., Ph.D., Postharvest Engineering

Preserving postharvest quality. Collaboration : Unicamp, Brazil.

Use of chlorine against pathogenic agents in tomato handling operations. Collaboration : University of Florida.

Emission cycle of a sex pheromone in female Anaphes listronoti, egg parasitoids of carrot weevils. Collaboration : McGill University. HRDC researchers: G. Boivin, Ph.D. and B. Panneton, Ph.D., Eng.*

Calibration system for tenderometers used in assessing pea quality. Collaboration : Fédération Québécoise des Producteurs de fruits et de légumes de transformation.*

Improving firmness retention in apples in controlled atmosphere storage. Collaboration : La Maison de la Pomme. HRDC researcher: J. DeEll, Ph.D.

Research on storage of fresh broccoli. Collaboration : Les Jardins Paul Cousineau et fils inc. HRDC researcher: J. DeEll, Ph.D.

Development of a six-pack packaging system for sweet corn. Collaboration: Jardins Vinet and Provigo Distribution Inc.

Optimization of forced-air precooling of corn. Collaboration: Jardins Vinet and Réfrigération Amesse inc.

Vincent, C., Ph.D., Entomology

Efficacy of the indigenous predator *Hyaliodes vitripennis* for biological control of insects and mites in orchards. Collaboration : CORPAQ, Agrilus Inc., IRDA/St-Hyacinthe and Laval University. HRDC researcher: N.J. Bostanian, Ph.D.*

Evaluation of the pathogenicity of *Beauveria bassiana* to obliquebanded leafrollers. Collaboration : UQAM. HRDC researcher: J.C. Côté, Ph.D.

Monitoring of apple orchard pests in Quebec. Collaboration : IRDA, St-Hyacinthe

Determination of the enzymatic mechanisms of insecticide resistance in the obliquebanded leafroller. Collaboration : AAFC: Summerland.

Apple maggot monitoring and spotted tentiform leafminer parasites. Collaboration : AAFC: Kentville.

Histological studies of baculovirus infections in the oblique banded leafroller. Collaboration : Université Picardie Jules Verne: Amiens (France).

Natural insecticides extracted from indigenous plants of Guinea. Collaboration : CIDA-UQAM, UQAM. HRDC researcher: A. Bélanger, Ph.D.*

Potential of *Anagyrus kamali* Moursi (hymenoptera: Encyrtidae) as a biological control agent against *Maconellicocus hirsutus* Green (Homoptera: Pseudococidae). Collaboration : McGill University.*

Integrated management of withefly populations. Collaboration : McGill University.

Physical pest control methods in plant protection: book project in English (Springer Verlag) and project on review article for Annual Review of Entomology vol.46 (2001). Collaboration : F. Fleurat-Lessard: INRA-Bordeaux (France). HRDC researcher: B. Panneton, Ph.D., Eng.*

Natural insecticides extracted from indigenous plants in Quebec. Collaboration : Urgel Delisle Inc. HRDC researchers: A. Bélanger, Ph.D. and N.J. Bostanian, Ph.D.*

Importation and release of *Lathrolestes ensator* (Braconidae) against the apple sawfly, *Hoplocampa testudinea* (Tenthredinidae). Collaboration : AAFC-ECORC: Ottawa, CABI: Delémont (Switzerland).*

Ecology and control of whitefly populations. Collaboration: Government of Burkina Faso. Collaborating researchers: R.K. Stewart and Lenli Claude Otoidobiga.

Preparation of a guide for identifying apple pests and their natural enemies for the benefit of fruitproducers, agricultural advisors and extension officials in Quebec. Collaboration: Canada-Quebec agreement, St Lawrence Vision 2000 Action Plan-Phase 3. Collaborating researchers: G. Chouinard, M. Fréchette, Y Morin and C. Brodeur.*

R & D MATCHING INVESTMENT INITIATIVE

Bélair, Guy, M. Sc., Nematology

Effect of three nematode species and of neem in the integrated management of cabbage maggot on cauliflower. Collaborators: Agro-Production Lanaudière, Ferme Bionical. From 1998/05/12 to 1999/03/31. Associated researcher: C. Vincent, Ph. D., Agr.

Effect of forage millet green manure on the development of *P. penetrans* and a soilborn fungus disease on potato. Collaborators: AERC Inc., S. Éthier, J. L Deschambault, G. St-Germain. From 1998/05/20 to 2001/03/31.

Bélanger, André, Ph. D., Organic Analytical Chemistry

Evaluation of the phytotoxicity and the insecticidal and fungicidal properties of the neem-based formulations 500 and 600 against four arthropod pests and the main diseases affecting outdoor ornamental plants. Collaborators: Pronatex. From 04/01/1998 to 11/03/1998. Associated researchers: O. Carisse, Ph. D. and C. Vincent, Ph. D., Agr.

Study on the potential for harvesting indigenous plants to produce essential oils. Collaborators: Les Produits Aliksir inc. From 1996/08/01 to 1999/03/31.

Optimization of organic fertilization in thyme grown on plastic mulch, installed for three years; Extraction and characterization of aromatic substances contained in basil. Collaborators: R&D Phytologie International inc. From 1998/05/01 to 1999/03/31. Associated researcher: L. LaFlamme, M. Sc.

Effect of three nematode species and of neem in the integrated management of cabbage maggot on cauliflower. Collaborators: Agro-Production Lanaudière, Ferme Bionical. From 1998/05/12 to 1999/03/31. HRDC researchers: G. Bélair, M. Sc. and C. Vincent, Ph. D., Agr.

Evaluation of the phytotoxicity of neem-based formulations to two market garden plants and of their insecticidal properties against three arthropod pests and two predators. Collaborators: Pronatex Inc. From 1998/11/09 to 1999/07/31. Associated researcher: C. Vincent, Ph. D., Agr.

Potential for producing galenical remedies from therapeutic plants grown in Eastern Quebec. Collaborators: Natura Signa Herboristerie du Québec. From 1997/06/01 to 2000/03/31.

Growing peppermint for commercial-scale extraction of essential oil. Collaborators: Groupe Exploration Menthe. From 1997/06/01 to 2000/03/31.

Commercial cultivation of yarrow in Quebec. Collaborators: Centre de Recherche et de Développement Technologique Agro-forestier de l'Outaouais (CREDETAO) et Coopérative agro-biologique de Papineauville (CAP). From 1999/06/01 to 2002/03/31.

Production of essential oils from indigenous Quebec plants. Collaborators: Aliksir Inc. From 1999/06/01 to 2002/07/31.

Evaluation of the biocidal properties of neem-based formulations (Phase III). Collaborators: Pronatex Inc. From 1999/10/01 to 2002/09/01.

Benoit Diane L., Ph. D., Weed Science

Weed control in pepper crops. Collaborators: Ass. Des Jardiniers Maraîchers du Québec. From 1998/09/01 to 1999/03/31.

Study of yellow nutsedge agro-ecology to develop an integrated management program for onions grown in muck soil. Collaborators: Bradford & District Vegetable Growers Association. From 1997/09/01 to 2000/03/31.

Integrated weed management in cucumbers. Collaboration: Agro Production Lanaudière inc. From 2000/04/01 to 2001/03/31.

Control of yellow nutsedge and ragweed in organic soil. Collaboration: Fédération des Producteurs Maraîchers du Québec and Phytodata. From 2000/04/01 to 2003/03/31.

Boivin Guy, Ph. D., Biological Control of Insects

Evaluation of the effectiveness of a control card for light traps used in scouting for the Eastern corn borer, *Ostrinia nubilalis* (Hüber), both univoltine and bivoltine strains. Collaborators: Fabcon Enr. and Phytodata Inc. From 05/01/1997 to 10/31/1998. HRDC researcher: Gaétan Bourgeois, Agr., Ph. D.

Evaluation of *Microctonus hyperodea* as a parasitoid of adult carrot weevils. Collaborators: Féd. des Producteurs Maraîchers du Québec. From 1998/04/01 to 1999/03/31.

Monitoring and ecology of pest aphids and their parasitoids in market garden crops. Phytodata Inc. From 1997/04/01 to 2000/03/31.

Evaluation and selection of *Trichogramma* for use in controlling cranberry pests. Collaborators: Service Bio-contrôle Inc. From 1997/04/01 to 2000/03/31.

Assessment of *Aleochara bilineata* as a predator of onion maggot eggs. Collaborators: Féd. des prod. maraîchers du Québec. From 1998/10/01 to 2000/10/31.

Development of a mathematical model for predicting the different stages of the European corn borer (bivoltine race) and adaptation of a mathematical model for the univoltine race in several regions of Quebec. Collaborators: Phytodata Inc. From 1998/10/01 to 2001/03/31. Associated researcher: G. Bourgeois, Ph. D., Agr.

Evaluation of the potential of the exotic species *Microctonus hyperodae* and its introduction as a natural enemy of the carrot weevil. Collaborators: Fédération des producteurs maraîchers du Québec, Phytodata Inc. From 1999/05/01 to 2002/03/31.

Bostanian Noubar J., Ph. D., Fruit Entomology

Validation of an integrated biological control program for phytophagous mites using indigenous predatory mites. Collaborators: Le Verger Petit et Fils, Le Verger Similibois enr., Le Verger La Pommeraie Dunham inc., Le Verger Claude Tougas 90222662 Québec inc. and Ag-Cord Inc. From 1996/06/15 to 1999/03/31.

Inventory of the predatory mites present in seven commercial orchards in southern Quebec and review of pest control treatments. Collaborators: Ag-Cord Inc., Verger Michel Jodoin, Verger Antoine Tanguay, Verger du Minot Inc., Verger Langis Lussier, Verger D. Rodrigue & Fils, Verger Landelle et Théberge Inc., Verger Pierre Jodoin Inc. From 1998/08/17 to 1999/03/31.

Inventory of predatory mite populations present in eight commercial orchards in southwestern Quebec in relation to the pesticide treatment program in use. Collaborators: Verger Michel Jodoin inc., Verger Antoine Tanguay, Verger du Minot, Verger Langis Lussier, Verger D. Rodrigue Côteaux St-Jacques, Verger de la Montagne, Verger de Tilly et Ag-Cord inc. From 1999/04/01 to 2001/03/31.

Susceptibility of the European red mite, *Panonychus ulmi* (Tetrenychidae: Acari), from apple and peach orchards to clofentezine. Collaborators: AgrEvo Canada. From 1999/04/01 to 2000/01/31.

Management of oblique-banded leafroller resistance and secondary effects of DPX on a predatory insect. Collaborators: Dupont Canada Inc., Verger Thomson, Ferme Rochon, Entreprises Marc Leduc Inc. From 1999/06/15 to 2000/06/30. HRDC researcher: C. Vincent, Ph. D., Agr.

Validation of an integrated pest management program using indigenous predatory mites for the biological control of phytophagous mites. Collaborators: Verger Similibois 90222662 Québec Inc., Verger Tougas. From 1999/04/01 to 2002/03/31.

Proposed integrated pest management program using indigenous predatory mites for the biological control of phytophagous mites in eggplant. Collaborators: Ferme Jardinier Maraîcher. From 1999/05/01 to 2002/03/31.

Inventory of pests and their dynamics in grape cultivation in southwestern Quebec. Collaborators: Vignoble L'Orpailleur, Vignoble Dietrich-Joos and Ag-Cord Inc. From 1997/06/01 to 2000/03/31. Collaborating researcher: C. Vincent, Ph.D., Agr.

Bourgeois Gaétan, Ph. D., Agricultural Systems Modeling

Evaluation of the effectiveness of a control card for light traps used in scouting for the European corn borer, *Ostrinia nubilalis* (Hüber), both univoltine and bivoltine strains. Collaborators: Fabcon Enr. and Phytodata Inc. From 05/01/1997 to 10/31/1998. HRDC researcher: Guy Boivin, Ph. D.

Model forcasting eggs hatching of potato Colorado beetle in potato and egg plant fiels. Collaborators: Agreco Inc. and Phytodata. From 1997/05/01 to 1999/03/31.

Evaluation of a forecasting model for cercospora blight of carrot in mineral soils in the region north of Montreal. Collaborators: Agro-Production Lanaudière. From 1997/06/01 to 1999/03/31. HRDC researcher: Odile Carisse, Ph. D.

Adaptation of a forecasting model for leaf blight of onion. Collaborators: Phytodata Inc. From 1998/05/20 to 2000/03/31.

Evaluation of cultivars and maturity and yield forecasting for processing vegetables. Collaborators: AMPAQ, Centre de technologies en agro-environnement, Féd. québécoise des prod. de fruits et de légumes de transformation. From 1998/04/01 to 2001/03/31. Associated researchers: S. Jenni, Ph. D., Agr. and N. Tremblay, Ph. D., Agr.

Development of a mathematical model for predicting the different stages of the European corn borer (bivoltine race) and adaptation of a mathematical model for the univoltine race in several regions of Quebec. Collaborators: Phytodata Inc. From 1998/10/01 to 2001/03/31. Associated researcher: G. Boivin, Ph. D., Agr.

Implementation and evaluation of a forecasting model for alternaria blight of carrot in mineral soil. Collaborators: Agro-Production Lanaudière Inc. From 1999/05/01 to 2002/03/31. Associated researcher: O. Carisse, Ph. D.

Prediction and control of superficial scald on apple. Collaborators: Fédération des Producteurs de Pommes du Québec, Gestion-Qualité: Fruits et Légumes et Guelph University. From 1999/08/01 to 2002/09/01. Associated researcher: J. DeEll, Ph. D.

Development and implementation of forecasting models for downy mildew and thrips of onion and application to shallot crops. Collaborators: La Ferme Spingola & Fils Ltée. From 1999/11/01 to 2003/03/31.

Development of growth models for crisphead and romaine lettuce. Collaboration: Multiveg. Inc. and Prisme enr. From 1996/04/31 to 1998/31/03.

Development of a model to predict the risk of vascular breakdown in apples in controlled atmosphere storage. Collaboration: Quality management: Fruits et Légumes inc. and Fédération des producteurs de pommes du Québec. From 1996/04/31 to 1999/03/31.

Evaluation of pest forecasting models for vegetables in Prince Edward Island. Collaboration: AAFC/CLRC and PEI Horticultural Association. From 2000/31/04 to 2003/31/03

Carisse Odile, Ph. D., Phytopathology

Control methods for white rot and grey rot in processing beans. Collaborators: Fédération québécoise des producteurs de fruits et légumes de transformation. From 06/09/1996 to 05/31/1998.

Evaluation of the phytotoxicity and the insecticidal and fungicidal properties of the neem-based formulations 500 and 600 against four arthropod pests and the main diseases affecting outdoor ornamental plants. Collaborators: Pronatex. From 04/01/1998 to 11/03/1998. Associated researchers: André Bélanger, Ph. D. and C. Vincent, Ph. D., Agr.

Evaluation of a forecasting model for cercospora blight of carrot in mineral soils. Collaborators: Agro-Production Lanaudière. From 1997/06/01 to 1999/03/31. HRDC researcher: G. Bourgeois, Ph. D., Agr.

Post-harvest control of white mould in celery. Collaborators: Multiveg. From 1998/05/01 to 1999/03/31. Associated researchers: J. DeEll, Ph. D. and C. Vigneault, Ph. D., Eng.

Implementation and evaluation of a forecasting model for alternaria blight of carrot in mineral soil. Collaborators: Agro-Production Lanaudière inc. From 1999/05/01 to 2002/03/31. Associated researcher: : G. Bourgeois, Ph. D., Agr.

Evaluation of the potential efficacy of various fungicides for checking the development of *Fusarium* bulb rot in onion. Collaborators: Les Distributeurs de Légumes du Québec. From 1999/04/01 to 2000/03/31.

Apple Scab Biofungicide Development Project. Collaborators: Philom Bios Inc. From 1996/04/29 to 2001/04/30.

Chagnon Roger, B.Sc.A., Eng., Mechanization

Development of a cauliflower leaves tying machine - Phase II. Collaborators: Les maraîchers Bec sucré and Maraîchers Dubuc et Frère. From 1998/06/01 to 1999/03/31. Associated researcher: B. Panneton, Ph. D., Eng.

Development of a machine for tying cauliflower leaves, Phase III. Collaborators: Les maraîchers Bec sucré inc. and Maraîchers Dubuc et Frère. From 1999/03/31 to 1999/10/29.

Design of a cabbage harvester. Collaborators: Univerco Hydraulique. From 1999/08/16 to 2002/03/31.

Côté Jean-Charles, Ph. D., Microbiology

Development of bioinsecticide products based on *Bacillus thuringiensis*. Collaborators: AEF Global Inc. From 1997/06/16 to 2000/03/31.

Development of bio-insecticide products based on *Bacillus thuringiensis*. Collaborators: AEF Global Inc. From 1997/06/16 to 2000/03/31.

DeEll Jennifer, Ph.D., Postharvest Physiology

Optimization of CO_2 and O_2 concentrations for controlled-atmosphere storage of broccoli, and the tolerance of different cultivars. Collaborators: Jardins Cousineau. From 1998/04/01 to 1999/03/31.

Post-harvest control of white mould in celery. Collaborators: Multiveg. From 1998/05/01 to 1999/03/31. Associated researchers: O.Carisse, Ph. D. and C. Vigneault, Ph. D., Eng.

Handling and storage of garlic cloves. Collaborators: Ultime Saveur Inc. From 1998/07/27 to 1999/09/01. Associated researcher: C. Vigneault, Ph. D., Eng.

Coatings and colouring agents to enhance the preservation and appearance of tablestock potatoes. Collaborators: C. Isabelle & Fils Inc. Du 1999/02/01 au 1999/10/31.

Controlled atmosphere storage of cauliflower. Collaborators: Les Jardins Paul Cousineau & Fils Inc. From 1999/06/01 to 1999/12/31.

Controlled atmosphere storage of imported broccoli. Collaborators: Les Jardins Paul Cousineau & Fils Inc. From 1999/04/01 to 2000/01/31. Associated researcher: C. Vigneault, Ph. D., Eng.

Effects of delaying controlled atmosphere storage on broccoli quality. Collaborators: Les Jardins Paul Cousineau & Fils Inc. From 1999/09/01 to 2000/05/01.

Development and optimization of technologies used in vacuum cooling of horticultural products. Collaborators: Réfrigération Amesse Inc. From 1998/04/01 to 2001/10/01. Associated researcher: C. Vigneault, Ph. D., Eng.

Improving the firmness of Quebec apples. Fed. of Que. Apple Producers. From 1998/08/11 to 2002/06/30. Associated researchers: S. Khanizadeh, Ph. D. and C. Vigneault, Ph. D., Eng.

Prediction and control of superficial scald on apple. Collaborators: Fédération des Producteurs de Pommes du Québec, Gestion-Qualité: Fruits et Légumes et Guelph University. From 1999/08/01 to 2002/09/01. Associated researcher: G. Bourgeois, Ph. D. agr.

Design of a cabbage harvester (assessment of damage to cabbage during harvesting and of performance in storage). Collaboration: Univerco Hydraulique inc. From 1999-2002.

Treatment of post-harvest diseases in carrot. From 2000-2001.

Evaluation of odour absorbents for broccoli during storage. Collaboration: Les Jardins Paul Cousineau et Fils inc. Collaborating researcher: Peter Toivonen, PARC-AAFC. From 2000-2001.

Jenni Sylvie, Ph. D., agr., Vegetable Crop Physiology and Production Management

Effect of a paper mulch on the growth and development of iceberg lettuce and weed control in organic soil. Collaborators: Cascades Multi-Pro inc., Innotag Inc., Léo van Winden and Macdonald College of McGill University. From 1997/04/01 to 1999/03/31.

Crop management trials for cucumber pickles. Collaborators : Fédération québécoise des prod. de fruits et légumes de transformation. From 1998/05/20 to 1999/03/31.

Production management trials in cucumber pickles. Collaborators: Fédération québécoise des producteurs de fruits et légumes de transformation. From 1999/05/01 to 2000/03/01.

Study of factors related to the appearance of brown spots in broccoli. Collaborators: Les Jardins Cousineau and Macdonald College of McGill University. From 1997/05/15 to 2000/03/31. Associated researcher: N. Tremblay, Ph. D., Agr.

Improving lettuce quality for optimum genetic resources. Collaborators: Fédération des Producteurs Maraîchers du Québec, Multiveg, Quali-T-Plus, Société coopérative agricole du Sud-Ouest du Québec. From 1997/06/01 to 2001/03/31.

Evaluation of cultivars and maturity and yield forecasting for processing vegetables. Collaborators: AMPAQ, Centre de technologies en agro-environnement, Féd. québécoise des prod. de fruits et de légumes de transformation. From 1998/04/01 to 2001/03/31. Associated researchers: G. Bourgeois, Ph. D., Agr. and N. Tremblay, Ph. D., Agr.

Effect on the agronomic performance of head lettuce of the colour and cover provided by a paper mulch. Collaborators: Cascades Multi-Pro, Innotag, Les Fermes Hotte et Van Winden. From 1999/05/01 to 2001/03/31.

Establishment of a head lettuce crop in mineral soil. Collaborators: Féd. des Prod. Maraîchers du Québec, Agro-Production Lanaudière. From 1999/06/01 to 2001/03/31.

Khanizadeh Shahrokh, Ph. D., Eng., Plant Breeding and Physiology of Fruits and Small Fruits

Improving blackberry culture. Collaborators: Pépinière A. Massé inc. From 10/11/1994 to 12/31/1998.

Developing and increasing the profitability of deciduous forests on Ile d'Orléans by re-introducing wild gingseng (Panax quinquefolium L.) to natural settings. Collaborators: Les Fraises de l'Île d'Orléans. From 1996/10/01 to 1999/03/31. Preliminary results.

Evaluation of hardy apple trees destined for processing. Collaborators: Verger du Minot inc. From 1996/05/15 to 2000/03/31.

Effects of Sevin XLR and Accell applications on fruit quality and yield in McIntosh apple trees. Collaborators: Federation of Quebec Apple Producers, Abbott Lab Ltd., Silverburn Farms Inc., Pierre Phillion and N. M. Bartlett Inc. From 1997/06/01 to 2000/03/31.

Field evaluation of advanced selections under the Quebec strawberry breeding program. Collaborators: Fédération des producteurs maraîchers du Québec and the strawberry testing network. From 1996/06/30 to 2000/03/31.

Breeding of strawberry plants for the fresh market. Collaborators: Les Fraises de l'Île d'Orléans inc. Macdonald College of McGill University. From 1996/05/15 to 2001/03/31.

Field evaluation of advanced and semi-advanced strawberry selections destined for processing, including the production of strawberry wine. Collaborators: Jardins Vieille grange and Léon Dutil. From 1997/05/15 to 2001/03/31.

Evaluation of advanced and semi-advanced selections of disease-resistant and non-disease-resistant hardy apple trees and rootstocks. Collaborators: Verger Dupuis (1983) Inc. and Verger Yvan Duchesne Inc. From 1997/05/01 to 2002/03/31.

Commercialization of new strawberry genotypes through in vitro propagation and rapid production of certified plants. Collaborators: Pép. Luc Lareault, Phytoclone. From 1998/04/01 to 2002/03/31.

Effects of different cultural practices and environmental factors on the performance of vine cultivars and on wine quality. Collaborators: Vignoble de l'Orpailleur, Vignoble Dietrich-Jooss, Alain Breault. From 1998/04/01 to 2002/03/31. Associated researcher: C. Richer, M. Sc., Agr.

Use of floating row covers and mini-tunnels on everbearing strawberries. Collaborators: Fraises de l'Île d'Orléans. From 1999/04/01 to 2002/03/31. Associated researcher:: S. Jenni, Ph. D., agr.

Strawberry conservation and quality in therapeutic use : importance of antioxydants. Collaborators : Fraises de l'Île d'Orléans. From 1999/04/01 to 2002/03/31.

Strawberry breeding focused on finding an early-maturing, large-fruit genotype adapted to Quebec's climate. Collaborators: Pép. Luc Lareault, Phytoclone. From 1999/04/01 to 2002/03/31.

Wild ginseng in hardwood stands on Île d'Orléans: study of diseases and insects, yield assessment and profitability of crop planted in 1996. Collaborators: Fraises de l'Île d'Orléans. From 1999/06/01 to 2002/03/31.

Breeding everbearing strawberries. Fraises de l'Île d'Orléans. From 1999/04/01 to 2004/03/31

LaFlamme Lucette, M. Sc., Vegetable Nutrition and Crop Management

Rational fertilization of processing vegetables. Collaborators: Quebec Food Processors Association (A.M.P.A.Q.) and Les Services NPK+ inc. From 05/08/1995 to 10/31/1998. HRDC researcher: Nicolas Tremblay, Agr., Ph. D.

Optimization of organic fertilization in thyme grown on plastic mulch, installed for three years; Extraction and characterization of aromatic substances contained in basil. Collaborators: R&D Phytologie International Inc. From 1998/05/01 to 1999/03/31. Associated researcher: A. Bélanger, Ph. D.

Commercial cultivation of wild plants in the Montérégie and Outaouais regions. Collaborators: Centre de recherche et de développement technologique agro-forestier de l'Outaouais, Coopérative agro-biologique de Papineauville. From 1998/05/01 to 1999/03/31.

Panneton Bernard, Ph. D., Eng., Vegetable Crop Engineering Unit.

Measurement of drift in the orchard and development of a drift shield. Collaborators: Ferme Au Pic. From 05/01/1997 to 05/01/1998.

Analysis of yield maps derived from mapping of agronomic parameters. Collaborators: Coopérative fédérée de Québec, Hauts-Monts inc., Phytodata Inc. and Société Coopérative Agricole du sud de Montréal. From 1996/06/21 to 1999/03/31.

Air-assist delivery. Collaborators: Grégoire et Fils inc. and Laval University. From 1997/04/01 to 1999/03/31.

Yield monitoring device for carrots and onions and integration of a laser based levelling system for topography measures. Collaborators: Innotag inc. and C.A.M.S. Inc. From 1997/12/01 to 1999/03/31.

Development of a cauliflower leaves tying machine - Phase II. Collaborators: Les maraîchers Bec sucré and Maraîchers Dubuc et Frère. From 1998/06/01 to1999/ 03/31. Associated researcher: R. Chagnon, B.Sc.A., Eng.

Yield monitoring device for broccoli. Jardins Cousineau. From 1998/04/01 to 2000/03/31.

Use of a GPS guidance system to bring about a 10% reduction in the amount of pesticide used. Collaborators: Groupe Dynaco, Coopérative agroalimentaire. From 1999/04/01 to 2000/03/31.

Development of a sprayer designed for nursery use. Collaborators: Centre de Production de Plants Forestiers de Québec Inc. From 1999/04/01 to 2001/03/31.

Piekutowski Thomas, Eng., Precision Agriculture/Agricultural Geomatics

Yield monitoring device for carrots and onions and integration of a laser based levelling system for topographic data acquisition. Collaborators: Innotag inc. and C.A.M.S. Inc. From 1997/12/01 to 1999/03/31. Associated researcher: B. Panneton, Ph. D., ing.

Radiometric calibration of airborne hyperspectral imaging sensors and validation of radiometric correction algorithms for imagery. Collaborators: Agrimage Inc. From 1999/04/01 to 2000/03/31.

Richer Claude, M. Sc., Ornamental Plant Management

Comparison of autumn protection methods for the hardening of 6 species of ornamental woody shrubs to increase their winter survival and subsequent growth. Collaborators: Pépinière Abbotsford, Pépinière l'Avenir and Québec Multiplants. From 1996/08/01 to 1999/03/31.

Micropropagation of indigenous orchids and peonies. Collaborators: Phytolab. From 1997/05/01 to 2000/03/31.

Evaluation of the hardiness of ornamental woody plants. (REPLOQ)- Plantations 1993-94 Collaborators : CPVQ, Plant Products. From 1998/04/01 to 2001/09/15.

New varietal creation program for hardy roses. Collaborators: Les Floricoles, Can. Nursery Trade Ass., Pép. Charlevoix Inc., Novoplants Nurseries, Pép. Abbotsford Inc., J.C. Bakker & Sons Ltd, Phytoclone, Coop. Forestières des Hautes-Laurentides, Chloris Inc., COPF. From 1998/03/30 to 2001/03/31. Associated researcher: S. Khanizadeh, Ph. D. Eng.

Synchronization of grafting done under different climatic conditions on two Norway maple cultivars. Collaborators: Centre de production des plants forestiers de Québec inc. From 1998/12/01 to 2001/03/31.

Micropropagation of French hybrid lilacs. Collaborators: Pépinière Mont-Yamaska Inc.et Horti-Pomme Inc. From 1999/09/01 to 2001/03/01.

Evaluation of rootstocks in the production of hardy roses grafted on stems. Collaborators: Pépinière Soleil et Pépinière Dominique Savio. From 1998/04/01 to 2002/03/31.

Effects of different cultural practices and environmental factors on the performance of vine cultivars and on wine quality. Collaborators: Vignoble de l'Orpailleur, Vignoble Dietrich-Jooss, Alain Breault. From 1998/04/01 to 2002/03/31. Associated researcher: S. Khanizadeh, Ph. D. Eng.

Tremblay Nicolas, Ph. D., Agr., Vegetable Nutrition and Crop Management

Study of factors related to the appearance of brown spots in broccoli. Collaborators: Les Jardins Cousineau and Macdonald College of McGill University. From 1997/05/15 to 2000/03/31. Principal researcher: S. Jenni, Ph. D., Agr.

Evaluation of cultivars and maturity and yield forecasting for processing vegetables. Collaborators: AMPAQ, Centre de technologies en agro-environnement, Féd. québécoise des prod. de fruits et de légumes de transformation. From 1998/04/01 to 2001/03/31. Associated researchers: G. Bourgeois, Ph. D., Agr. and S. Jenni, Ph. D., Agr.

Development of guidelines for sustainable management of vegetable nitrogen nutrition. Collaborators: JPL Maraîchers Inc., Ferme J. Coulombe, Fermes Armant Chabot, Patates Dolbec, Hydro Agri North America, Nutrite Inc., Univ. Laval. From 1998/04/01 to 2001/03/31.

Evaluation of yields, size proportions and moisture content of peas relative to the tenderometer index for processing peas. Collaborators: Fédération québécoise des producteurs de fruits et de légumes de transformation. From 1999/04/01 to 2001/03/31.

A sensor based variable nitrogen application rate technology developed in Europe. Collaborateurs : Nutrite inc. Du 1999/05/01 au 2000/03/31. Chercheur associé : M. Baoluo.

Vigneault Clément, Ph. D., Eng., Postharvest Engineering

Design and testing of direct and indirect ice-to-air force-air coolers for horticultural crops. Alberta Market Gardeners Ass., Alberta Prof. Hort Growers Congress Foundations. Du 01/05/1998 au 06/30/1998.

Post-harvest control of white mould in celery. Collaborators: Multiveg. From 1998/05/01 to 1999/03/31. Associated researchers: O.Carisse, Ph. D. and J. DeEll, Ph. D.

Handling and storage of garlic cloves. Collaborators: Ultime Saveur Inc. From 1998/07/27 to 1999/09/01. Associated researcher: J. DeEll, Ph. D.

Evaluation of temperature fluctuations in refrigerated semi-trailers used to transport fresh fruits and vegetables. Collaborators: Provigo Distribution Inc. Du 1999/02/01 au 1999/12/31.

Controlled atmosphere storage of imported broccoli. Collaborators: Les Jardins Paul Cousineau & Fils Inc. From 1999/04/01 to 2000/01/31. Associated researcher: J. DeEll, Ph. D.

Development and optimization of technologies used in vacuum cooling of horticultural products. Collaborators: Réfrigération Amesse Inc. From 1998/04/01 to 2001/10/01. Associated researcher: J. DeEll, Ph. D.

Improving the firmness of Quebec apples. Collaborators: Fed. of Que. Apple Producers. From 1998/08/11 to 2002/06/30. Associated researchers: J. DeEll, Ph. D. and S. Khanizadeh, Ph. D.

Management of fruit and vegetable warehouses during major power failures. Special ice storm program. 1998-2001.

Preparation of specifications for the marketing of 200 fresh fruits and vegetables. Collaboration: Provigo Distribution Inc. 1998-2000.

Vincent Charles, Ph. D., Agr., Entomology

Evaluation of the phytotoxicity and the insecticidal and fungicidal properties of the neem-based formulations 500 and 600 against four arthropod pests and the main diseases affecting outdoor ornamental plants. Collaborators: Pronatex. From 04/01/1998 to 11/03/1998. Associated researchers: André Bélanger, Ph. D. and , O. Carisse, Ph. D.

Effect of three nematode species and of neem in the integrated management of cabbage maggot on cauliflower. Collaborators: Agro-Production Lanaudière, Ferme Bionical. From 1998/05/12 to 1999/03/31. HRDC researchers: G. Bélair, M. Sc. and A. Bélanger, Ph. D.

Evaluation of the phytotoxicity of neem-based formulations to two market garden plants and of their insecticidal properties against three arthropod pests and two predators. Collaborators: Pronatex Inc. From 1998/11/09 to 1999/07/31. HRDC researchers: A. Bélanger, Ph. D. and O.Carisse, Ph. D.

Inventory of pests and their dynamics in vineyards in southwestern Quebec. Collaborators: Vignoble L'Orpailleur, Vignoble Dietrich-Joos and Ag-Cord Inc. From 1997/06/01 to 2000/03/31. HRDC researcher: N. Bostanian, Ph.D

Evaluation of an aphicide and the insecticide resistance of aphids found in market garden crops. Collaborators: Fédération des procucteurs maraîchers du Québec, Phytodata Inc., Potagers Montréalais, Ferme Hotte et van Winden, Ferme Denis Perrier et Fils Inc., Les Jardins M et R Enrg., Jardins Boulé Inc. From 1999/06/01 to 2000/06/01.

Management of oblique-banded leafroller resistance and secondary effects of DPX on a predatory insect. Collaborators: Dupont Canada Inc., Verger Thomson, Ferme Rochon, Entreprises Marc Leduc Inc. From 1999/06/15 to 2000/06/30. HRDC researcher: N. Bostanian, Ph. D.

Field and laboratory evaluation of the insecticide resistance of the aphids found in market garden crops. Collaboration: Fédération des producteurs maraîchers du Québec/Compagnie de recherche Phytodata inc./Potagers Montréalais/Ferme Hotte and van Winden/Ferme Denis Perrier et Fils inc./Les Jardins M et R enrg/Jardins Boulé inc./as a matching investment initiative with HRDC/Agriculture and Agri-Food Canada. From 1999-2000.

WEATHER MONTHLY REPORTS

L'Acadie Substation

Month	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Standard Degree-day base=5°C	Corn thermic unit	Precipitations (mm)
1999						
March	14.7	-15.3	-1.3	5.3	2.7	0.0
April	20.5	-3.2	6.5	66.0	83.7	21.8
May	32.5	1.1	16.3	407.6	630.0	50.2
June	33.1	4.4	20.9	873.9	1366.8	61.6
July	32.7	10.5	21.7	1385.4	2176.6	141.4
August	30.9	5.3	19.0	1820.2	2884.7	57.2
September	33.9	3.2	17.5	2200.6	3494.9	182.8
October	18.5	-3.3	7.8	2292.1	3630.8	112.0
1998						
March	16.6	-19.8	-1.7	14.1	15.7	115.8
April	23.5	-3.4	7.8	103.9	155.1	40.1
May	30.7	3.1	17.4	477.9	767.8	33.8
June	31.4	6.3	18.7	896.9	1452.7	148.8
July	30.4	9.8	20.1	1365.0	2221.5	94.4
August	29.9	7.3	19.8	1824.0	2972.8	87.4
September	28.9	0.9	15.6	2143.2	3514.9	47.4
October	21.2	-2.2	9.4	2275.5	3706.0	71.0

Frelighsburg Substation

Month	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Standard Degree-day base=5°C	Corn thermic units	Precipitations (mm)
1999						
March	16.3	-19.6	-1.3	8.7	9.1	30.0
April	19.6	-5.4	6.2	64.1	79.5	24.8
May	31.4	-1.1	15.5	374.3	579.7	71.8
June	34.1	3.6	20.5	832.4	1306.4	80.8
July	32.7	10.0	21.8	1345.4	2120.3	166.4
August	29.4	5.4	18.7	1770.2	2822.0	84.6
September	33.0	0.0	17.0	2106.7	3365.9	176.9
October	21.1	-5.3	7.5	2199.3	3503.8	98.1
1998						
March	25.3	-21.9	0.6	50.7	79.0	144.0
April	22.5	-4.8	7.8	142.6	215.2	43.4
May	29.6	2.1	16.8	492.4	797.9	62.0
June	31.4	5.0	18.0	891.7	1451.3	117.6
July	31.6	8.6	19.9	1353.5	2207.9	128.2
August	30.3	6.4	19.7	1807.9	2953.2	91.4

September, october: data not available

Sainte-Clotilde Substation

Month	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Standard degree-day base=5°C	Corn thermic units	Precipitations (mm)
1999						
March	14.1	-18.9	-1.4	5.4	3.7	0.0
April	20.2	-6.0	6.5	61.6	76.7	4.0
May	32.2	-1.3	15.4	360.6	554.5	32.4
June	32.7	1.4	20.4	805.7	1249.1	49.4
July	33.3	8.2	21.7	1312.9	2036.8	107.2
August	30.5	3.3	18.4	1724.0	2707.0	58.4
September	33.1	1.2	16.7	2071.4	3263.3	183.8
October	19.3	-5.6	7.4	2153.4	3386.4	111.8
1998						
March	23.5	-20.5	0.8	37.0	57.8	110.0
April	23.3	-4.7	8.9	156.6	246.5	46.0
May	30.4	1.1	16.7	500.5	808.5	52.6
June	30.9	5.5	18.2	901.4	1459.0	153.2
July	32.4	10.4	20.1	1370.5	2213.1	99.2
August	32.1	6.7	19.6	1822.0	2945.0	103.0
September	29.2	-1.3	15.2	2126.8	3459.6	71.2
October	25.7	-4.2	9.1	2249.8	3631.1	84.2

AGRICULTURE CANADA STAFF ASSOCIATION

The Agriculture and Agri-food Canada Staff Association (APAC : L'Association du Personnel d'Agriculture Canada) was established in 1984. The objectives were to help create and maintain a pleasant social environment at CRDH. APAC organizes social meetings and sporting outings, and celebrates happy events happening in the life of its members.

APAC welcomes the new CRDH employees.
In order to ease the arrival, a short tutorial at a local bar is mandatory.

The annual BBQ is held in June by APAC. A throng gathers for this event.

Meeting of the APAC executive board in 1998. On the menu: social activities, sports, family outings.

In 1999, APAC organized the election of the Québec emblematic insect. Each insect-candidate had numerous supporters.

BBQ 96: essentials are ketchup, mustard and sunshine.

At the annual BBQ APAC members gorge on shortcakes prepared with home grown strawberries provided by breeder Khanizadeh.

An election assembly was held that elicited heated debates.

BBQ 98: the tradition of shortcakes is maintained. Some bakers come back from year to year and they show a lot of enthusiasm.

APAC organizes sporting events : hockey, curling, volley-ball, snowboard and in addition, an annual golf tournament.

Golf 98: some participants show quite a lot of energy.

Corn-husking party 99: the little ones.

APAC members are offered tours of the most beautiful parts of the Québec province.

Summer 1996: canoe-camping in Jacques Cartier Valley north of Québec City.

Halloween really gets the wild and wacky going.

Halloween 96 at CRDH : entomology is well represented. Are these insects useful or are they pests?

At harvest time APAC organizes a corn-husking party that is a must.

Each and every year, this family event brings numerous fans.

As CRDH expands new employees are hired and it becomes necessary to provide an appropriate room for meals and informal gatherings.

December 1998 – Employees room inaugural ceremony : cutting the ribbon are those who worked hard to make it happen : Roger Chagnon, Sylvie Joncas, Denis Demars, directeur, Julie Bernier and Gaétan Bourgeois, APAC's representatives.

APAC members show a rich display of cultural diversity. Each year APAC organizes a potlatch meal. The various dishes brought over offer palatable discoveries to the guests.

Potlatch 99: an occasion for fine dining.

Back to basics: a spaguetti meal

In the friendly apron competition the slug lab made a strong impression, colorwise.

Remaining in the food category : APAC organizes a breakfast each year at the end of november. Proceeds go to Société Saint-Vincent-de-Paul, a charitable institution. Year in, year out, the benefits add up to about 300$.

November 1999. Solidarity tastes good.

Needless to say, the Christmas party is the grand finale of the APAC year.

In 1999 the Christmas Party had the Medieval Times for theme. The organizing comity, dressed appropriately : second from left : Julie Bernier; fourth, Pierre Lemoyne, and next to him: Guy Boulet and Annie Ouimet.