



CANADIAN JOURNAL OF

PLANT SCIENCE

REVUE CANADIENNE DE PHYTOLOGIE

VOLUME 84 NO. 1

JANUARY/JANVIER 2004

Canadian Journal of Plant Science

EDITOR

Y. A. Papadopoulos, Agriculture and Agri-Food Canada, Truro, NS B2N 5Z3

ASSOCIATE EDITORS

Canadian Society of Agronomy

S. Acharya, Agriculture and Agri-Food Canada, Lethbridge, AB

H. Beckie, Agriculture and Agri-Food Canada, Saskatoon, SK

S. Bittman, Agriculture and Agri-Food Canada, Agassiz, BC

A. Brûlé-Babel, University of Manitoba, Winnipeg, MB

R. Chibbar, University of Saskatchewan, Saskatoon, SK

E. Cober, Agriculture and Agri-Food Canada, Ottawa, ON

D. Clements, Trinity Western University, Langley, BC

R. L. Conner, Agriculture and Agri-Food Canada, Morden, MB

S. Darbyshire, Agriculture and Agri-Food Canada, Ottawa, ON

J. A. Ivany, Agriculture and Agri-Food Canada, Charlottetown, PE

A. Johnston, Potash and Phosphate Institute of Canada, Saskatoon, SK

P. Juskiw, Alberta Agriculture, Food and Rural Development, Lacombe, AB

D. McAndrew, Agriculture and Agri-Food Canada, Morden, MB

K. B. McRae, Agriculture and Agri-Food Canada, Kentville, NS

A. Moulin, Agriculture and Agri-Food Canada, Brandon, MB

V. W. Poysa, Agriculture and Agri-Food Canada, Harrow, ON

M. K. Upadhyaya, University of British Columbia, Vancouver, BC

S. Warwick, Agriculture and Agri-Food Canada, Ottawa, ON

Canadian Society for Horticultural Science

P. Bowen, Agriculture and Agri-Food Canada, Summerland, BC

D. Ehret, Agriculture and Agri-Food Canada, Agassiz, BC

K. MacKenzie, Agriculture and Agri-Food Canada, Kentville, NS

J.-P. Privé, Agriculture and Agri-Food Canada, Bouctouche, NB

D. Waterer, University of Saskatchewan, Saskatoon, SK

Canadian Weed Science Society

P. B. Cavers, University of Western Ontario, London, Ontario

POLICY SUBCOMMITTEE (responsible for the *Canadian Journal of Plant Science*, the *Canadian Journal of Animal Science*, and the *Canadian Journal of Soil Science*).

P. R. Hickleton, Agriculture and Agri-Food Canada, Kentville, NS (Chairman); Y. A. Papadopoulos, Agriculture and Agri-Food Canada, Truro, NS; P. Toivonen, Agriculture and Agri-Food Canada, Summerland, BC; T. M. Choo, Agriculture and Agri-Food Canada, Ottawa, ON; M. R. Carter, Agriculture and Agri-Food Canada, Charlottetown, PE; C. Drury, Agriculture and Agri-Food Canada, Harrow, ON; D. G. Maynard, Natural Resources Canada, Victoria, BC; M. A. Price, University of Alberta, Edmonton, AB; F. Silversides, Agriculture and Agri-Food Canada, Agassiz, BC; T. Scott, University of Sydney, Sydney, Australia.

Cover: *Spiraea* Snowmound. See the paper by C. Richer et al. on p. 265 of this issue.

Official Journal of the Canadian Society of Agronomy, the Canadian Society for Horticultural Science and the Canadian Weed Science Society

This journal, published by the Agricultural Institute of Canada, is devoted to original research results reported in English or French. Manuscripts concerned with any aspects of plant science will be considered. Cultivar descriptions will only be considered for crops intended for Canadian production. All manuscripts will be subject to peer review before acceptance for publication. *Manuscripts or enquiries concerning them should be directed to Mr. T. Fenton, Head, Journals Section, Agricultural Institute of Canada, Suite 1112, 141 Laurier Avenue West, Ottawa, Ontario, Canada K1P 5J3. Telephone (613) 232-9459 (ext. 309), fax: (613) 594-5190, e-mail: journals@aic.ca.* In preparation of manuscripts, authors should consult the Notice to Authors published in the January issue and the journal's Operation Manual available in PDF format on the journal's web site.

La revue, publiée par l'Institut agricole du Canada, reçoit les comptes rendus de recherches originales rédigés en anglais ou en français. Les textes peuvent porter sur n'importe quel aspect de la phytotechnie. Tous les manuscrits seront soumis à une lecture par des pairs avant d'être acceptés pour publication. *Les manuscrits ou toute demande de renseignements à leur sujet doivent être adressés à M. T. Fenton, Agricultural Institute of Canada, Suite 1112, 141 Laurier Avenue West, Ottawa, Ontario, Canada K1P 5J3. Téléphone: (613) 232-9459, télécopieur: (613) 594-5190, courriel: journals@aic.ca.* Pour la présentation à adopter, les auteurs sont priés de consulter les Recommandations aux auteurs qu'ils trouveront au dos d'un numéro récent de la revue.

The use of trade names in this publication does not imply endorsement by the Agricultural Institute of Canada, the Canadian Society of Agronomy, the Canadian Society for Horticultural Science or the Canadian Weed Science Society, nor criticism of similar products not mentioned. All product names mentioned herein may be the trademark or registered trademark of their respective owners.

La mention de marques déposées dans la présente publication ne signifie pas que celles-ci ont l'appui de l'Institut agricole du Canada, de la Société Canadienne d'Agronomie, ou de la Société Canadienne de Science Horticole, ni constitue une critique à l'égard d'autres produits similaires non mentionnés.

Canadian Journal of Plant Science is covered in *Biological & Agricultural Index*, *Current Contents AB&ES*, *CABS*, *Chemical Abstracts*, *Ecological Abstracts*, *Elsevier BIOBASE/Current Awareness in Biological Sciences*, *Environmental Periodicals Bibliography*, *GEOTitles*

Canadian Journal of Plant Science is available on-line at:
<http://pubs.nrc-cnrc.gc.ca/aic-journals/cjps.html>

Subscriptions and Publication

The *Canadian Journal of Plant Science* is published four times a year, in January, April, July and October. The journal is available in print and electronic format. The electronic format is available only in combination with a print subscription (except for members of member organizations of the Agricultural Institute of Canada). Annual subscription rates for 2004, payable in advance, are: **Print only** individuals in Canada \$80.00, other countries \$85.00; institutions and libraries (multiusers) in Canada \$125.00, other countries \$155.00; for members of member organizations of the Agricultural Institute of Canada, Canada \$34.00, elsewhere \$35.00. Single copies cost \$29.00 for individuals and \$43.00 for multiusers. **Print plus electronic access** individuals in Canada \$91.00, other countries \$99.00; institutions and libraries (multiusers) in Canada \$142.00, other countries \$177.00; for members of member organizations of the Agricultural Institute of Canada, Canada \$38.00, elsewhere \$39.00. **Electronic only** (available only to members of AIC member organizations) Canada \$29.00, other countries \$29.00.

GST is not included in the above rates. Canadian subscribers are required to add 7% GST to these rates unless officially exempt. The GST registration number of the AIC is 106689094RT. This applies to Canadian subscribers only (i.e., Canadian delivery addresses). Canadian agents purchasing for foreign destinations are not required to pay GST on those clients. Agents outside Canada purchasing for Canadian destinations are required to pay GST. Enquiries about subscriptions should be directed to Subscriptions, Agricultural Institute of Canada, Suite 1112, 141 Laurier Avenue West, Ottawa, Ontario, Canada K1P 5J3. Telephone (613) 232-9459 ext. 307, e-mail: services@aic.ca. Information about Canadian Journal of Plant Science is available on the journal's web site: <http://pubs.nrc-cnrc.gc.ca/aic-journals/cjps.html>

We acknowledge the financial support of the Government of Canada, through the Publications Assistance Program (PAP) toward our mailing costs.

©2004 The Agricultural Institute of Canada. Permission to photocopy for internal use or for the personal use of specific clients is granted by the Agricultural Institute of Canada for libraries and other users registered with the Copyright Clearance Centre (CCC), provided that a fee of \$5.00 per copy is paid directly to the CCC, Transactional Reporting Service, 222 Rosewood Drive, Danvers, MA 01923, USA. Special requests should be addressed to the Agricultural Institute of Canada, Suite 1112, 141 Laurier Avenue West, Ottawa, ON, Canada K1P 5J3. The agreement to publish in AIC journals implies that the author(s) agrees to release the article for copying to the CCC.

0008-4220/2004 \$5.00. Publications mail registration no. 09553.

Canadian Journal of Plant Science USPS #0009-685 is published quarterly for \$155.00 per year. Periodicals postage paid at Champlain, N.Y. and additional offices. Address changes should be sent to IMS of N.Y., 100 Walnut St. #3, P.O. Box 1518, Champlain, N.Y. 12919-1518. For details call IMS at 1 (800) 428-3003.

AGRONOMY SECTION

Grain

- Predicting agronomic performance of barley using canopy reflectance data
T. G. Fetch, Jr., B. J. Steffenson, and V. D. Pederson 1-9
- Long-term assessment of management of an annual legume green manure crop for fallow replacement in the Brown soil zone
R. P. Zentner, C. A. Campbell, V. O. Biederbeck, F. Selles, R. Lemke, P. G. Jefferson, and Y. Gan 11-22
- Amplified fragment length polymorphism analysis of 96 Canadian oat cultivars released between 1886 and 2001
Y.-B. Fu, S. Kibite, and K. W. Richards 23-30
- Planting date and suboptimal seedbed temperature effects on dry bean establishment, phenology and yield
P. Balasubramanian, A. Vandenberg, and P. Hucl 31-36
- Endophytic rhizobia in barley, wheat and canola roots
N. Z. Lupwayi, G. W. Clayton, K. G. Hanson, W. A. Rice, and V. O. Biederbeck 37-45
- The effect of foliar copper application on grain yield and quality of wheat
R. E. Karamanos, Q. Pomarenski, T. B. Goh, and N. A. Flore 47-56
- Development of a new field inoculation technique to assess partial resistance in soybean to *Scierotinia sclerotiorum*
J. Audclair, G. J. Boland, E. Cober, G. L. Graf, J. R. Steadman, J. Zilka, and I. Rajcan 57-64
- Fatty acid and elemental composition of mature seeds of beach pea [*Lathyrus maritimus* (L.) Bigel.]
G. Chinnasamy, A. K. Bal, and D. B. McKenzie 65-69
- How well do early-generation quality tests predict flour performance?
K. Kaur, O. M. Lukow, K. R. Preston, and L. J. Malcolmson 71-78
- Inoculant formulation and fertilizer nitrogen effects on field pea: Nodulation, N₂ fixation and nitrogen partitioning
G. W. Clayton, W. A. Rice, N. Z. Lupwayi, A. M. Johnston, G. P. Lafond, C. A. Grant, and F. Walley 79-88
- Inoculant formulation and fertilizer nitrogen effects on field pea: Crop yield and seed quality
G. W. Clayton, W. A. Rice, N. Z. Lupwayi, A. M. Johnston, G. P. Lafond, C. A. Grant, and F. Walley 89-96
- Optimal time for remote sensing to relate to crop grain yield on the Canadian prairies
P. Basnyat, B. McConkey, G. P. Lafond, A. Moulin, and Y. Pelcat 97-103

- Use of N-(n-butyl)thiophosphoric triamide (NBPT) to increase safety of seed-placed urea
R. E. Karamanos, J. T. Harapiak, N. A. Flore, and T. B. Stonehouse 105-116
- Zinc response of dry beans in Manitoba
T. B. Goh and R. E. Karamanos 213-216
- Farmer-directed on-farm experimentation examining the impact of companion planting barley and oats on timothy-alfalfa forage establishment in central Newfoundland
D. Spaner and A. G. Todd 217-221
- Forage**
- Seed yield and yield components of creeping bentgrass cultivars
D. J. Cattani, S. R. Smith, Jr., P. R. Miller, D. E. Feindel, and R. Gjurić 117-124
- Parent-offspring regression in meadow brome grass (*Bromus riparius* Rehm.): Evaluation of two methodologies on heritability estimates
M. R. A. de Araujo and B. E. Coulman 125-127
- Season of year effect on response of orchardgrass to N fertilizer in a maritime climate
S. Bittman, B. J. Zebbarth, C. G. Kowsienko, and D. E. Hunt 129-142
- Yield potential and forage quality of annual forage legumes in southern Alberta and northeast Saskatchewan
J. Fraser, D. McCartney, H. Najda, and Z. Mir 143-155
- Carbon isotope discrimination of tall fescue cultivars across an irrigation gradient
K. B. Jensen, K. H. Asay, D. A. Johnson, and B. L. Waldron 157-162
- Herbage productivity and nutritive value of nine grasses in the Peace River region of northwestern Canada
N. A. Fairey 163-171
- Establishing winterfat in prairie restorations in Saskatchewan
J. T. Romo 173-179
- Morphology, forage and seed yield of soybean cultivars of different maturity grown as a forage crop in Turkey
S. Altinok, I. Erdogdu, and I. Rajcan 181-186
- Cropping systems for annual forage production in northeast Saskatchewan
D. McCartney, L. Townley-Smith, A. Vaage, and J. Pearen 187-194

Direct assessment of competitive ability and defoliation tolerance in perennial grasses

C. Saint Pierre, C. A. Busso, O. A. Montenegro, G. D. Rodriguez, H. D. Giorgetti, T. Montani, and O. A. Bravo 195-204

The influence of harvest management and fertilizer application on seasonal yield, crude protein concentration and N offtake of grasses in northeast Saskatchewan

D. H. McCartney, S. Bittman, and W. F. Nuttall 205-212

Cultivar Descriptions

Black Violet common bean

H.-H. Mündel, F. A. Kiehn, H. C. Huang, R. L. Conner, and G. Saindon 223-225

Early Rose pink bean

H.-H. Mündel, F. A. Kiehn, H. C. Huang, R. L. Conner, and G. Saindon 227-229

Morden003 navy bean

H.-H. Mündel, F. A. Kiehn, H. C. Huang, R. L. Conner, G. Saindon, and G. Kemp 231-233

Miser field pea

D.-J. Bing, T. Warkentin, A. Xue, R. Conner, A. Sloan, Y. Gan, D. Gehl, C. Vera, K. Turkington, G. Clayton, and D. Orr 235-236

CDC Golden field pea

T. Warkentin, A. Vandenberg, S. Banniza, and A. Slinkard 237-238

CDC Striker field pea

T. Warkentin, A. Vandenberg, S. Banniza, and A. Slinkard 239-240

Boudrias oat

S. Kibite, J. G. Menzies, J. Chong, B. McCallum, J. Noll, and S. Haber 241-243

ARC Mountain View June grass

J. Woosaree, S.N. Acharya, and B. A. Darroch 245-247

Abstracts of Technical Papers

249-257

P256, P297, L

HORTICULTURE SECTION

Fruit

Leaf absorption, withdrawal and remobilization of autumn-applied urea-N in apple

S. Guak, D. Neilsen, P. Milard, and N. E. Looney 259-264

Ornamental

Évaluation de la croissance et des dommages hivernaux de six cultivars de spirées japonaise en réponse aux diverses conditions climatiques du nord-est canadien

C. Richer, J. A. Rioux, et M. P. Lamy 265-277

Multiplication in vitro de *Syringa vulgaris*

'Katherine Havemayer' et 'Charles Joly'
D. Charlebois et C. Richer 279-289

Vegetable

Comparative performance of the L* a* b* colour space and North American colour charts for determining chipping quality in tubers of potato (*Solanum tuberosum* L.)

W.K. Coleman 291-298

Influence de la concentration de la solution nutritive sur la croissance et la nutrition minérale de la tomate

P. Morard, E. Caumes, et J. Silvestre 299-304

PEST MANAGEMENT SECTION

Entomology

Eastward expansion and discovery of the soybean biotype of western corn rootworm (*Diabrotica virgifera virgifera* LeConte) in Canada

F. Meloche and P. Hermans 305-309

Resistance of canola-quality cultivars of yellow mustard, *Sinapis alba* L. to the cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Marsham)

J. P. McCaffrey, B. L. Harmon, J. Brown, and J. B. Davis 397-399

Pathology

Assessing resistance to spring black stem and leaf spot of alfalfa caused by *Phoma* spp.

H. Wang, S. F. Hwang, K. F. Chang, B. D. Gossen, G. D. Turnbull, and R. J. Howard 311-317

A novel source of resistance to verticillium wilt in alfalfa

B. D. Gossen and P. G. Jefferson 401-404

Weed Science

Tillage index predicts weed seedling recruitment depth

R. C. Van Acker, W. J. Bullied, and M. J. du Croix Sissons 319-326

The biology of Canadian weeds. 127. *Panicum capillare* L.

D. R. Clements, A. DiTommaso, S. J. Darbyshire, P. B. Cavers, and A. D. Sartonov 327-341

The biology of Canadian weeds. 128. *Leucanthemum vulgare* Lam.

D. R. Clements, D. E. Cole, S. Darbyshire, J. King, and A. McClay 343-363

The biology of Canadian weeds. 129.
Phragmites australis (Cav.) Trin. ex Steud
T. K. Mai and L. Narine

365-395

Sensitivity of kidney beans (*Phaseolus vulgaris*) to
soil applications of S-metolachlor and imazethapyr
P. Sökemir, N. Sötker, C. Şropşahin,
and T. Cowan

405-407

Acknowledgement of Reviewers

408

Notice to authors

Recommendations aux auteurs

Coming in future issues of AIC journals

CANADIAN JOURNAL OF PLANT SCIENCE

Sulphur fertilizer and tillage management of cereals and
wheat in western Canada
C. A. Grant, A. M. Johnston, and G. W. Clayton

Impacts of using polyethylene sleeves and wavelength-
selective mulch in vineyards. II. Effects on growth, leaf gas
exchange, yield components and fruit quality of Vitis
vitifera cv. Merlot
P. A. Bawa, C. P. Rogiersoff, and B. Eitzinger

The reactions of Canadian spring wheat genotypes to
inoculation with *Claviceps purpurea*, the causal agent of ergot
I. O. Mousa

Response of processing cereal to fertilizers on mineral
soils in Nova Scotia
K. I. N. Jones, D. J. Dodson, and E. G. Specht

CANADIAN JOURNAL OF SOIL SCIENCE

Soil dissolved organic carbon: influence of water filled
pore space and red clover addition and relationships with
microbial biomass carbon
Y. Q. Zhang, C. P. Drury, and B. D. Kay

Soil properties influencing compactability of forest soils in
British Columbia
M. Kozic, C. E. Beiler, F. Tsai, L. Dampier, and S. Rakusa

Response of forage grass to sulphur applications on
coastal British Columbia soils
C. G. Karalaka

Calibration and modification of impedance probe for near
surface soil moisture measurements
T. D. Ferguson, W. Tisdale, T. L. Colman, T. J. Jackson, and
H. Towels

CANADIAN JOURNAL OF ANIMAL SCIENCE

Effect of partially replacing silage with straw-barley-
soybean meal mixtures on cow-calf performance
E. Charney and J. L. Dwyerfield

Changes in delayed type hypersensitivity, egg antibody
content and immune cell fatty acid composition of layer
birds fed conjugated linoleic acid, n-6 or n-3 fatty acids
R. K. Schwarz and G. Oberin

Performance of growing-finishing pigs fed barley-based
diets supplemented with normal or high-fat oat
P. A. Thakur, H. W. Soto, and B. G. Rossing

Ultrasonic imaging of marbling at feedlot entry as a
predictor of carcass quality grade
G. P. Keefe, I. R. Dohoo, J. E. Vekros, and R. L. Miller

MACDONALD CAMPUS
LIBRARY

APR - 2 2004

MCGILL UNIVERSITY

Effect of medium nitrogen level on potato microtuber protein concentrations. Estela Ortiz-Medina and Danielle J. Donnelly. McGill University, Ste-Anne-de-Bellevue, Québec (eortiz2@po-box.mcgill.ca).

Nitrogen is an essential nutrient for plant growth. In potato crops grown in the field, optimum nitrogen fertilization is important to maximizing yield. However, it is not known to what extent nitrogen availability affects protein concentration of tuber tissues. This is more readily evaluated in a tissue culture system than in the field. Nitrogen level was varied in Murashige and Skoog medium to determine its effect on the total protein content of microtubers of four potato cultivars with a range of seasonalities. These included Norland, Shepody, Green Mountain, and Russet Burbank. Microtubers were generated from layered micropropagated plantlets using a two-step method. For all cultivars, both the mean number and size of microtubers per container were greater when medium nitrogen levels were increased. However, there were no clear trends relating medium nitrogen level to microtuber tissue protein concentration. Low medium nitrogen level tended to reduce the protein concentration in cultivars Shepody and Norland while high medium nitrogen level tended to increase the protein concentration only in Russet Burbank. These results confirm that nitrogen fertilization can promote tuber yield but suggest that tissue protein concentrations are genetically determined.

Crops and agricultural practices for biomass/bio-fuel production and greenhouse gas mitigation in eastern Canada. Juan Almaraz, Xiaomin Zhou, and Donald Smith. McGill University, Ste-Anne-de-Bellevue, Québec (jalmar1@po-box.mcgill.ca).

Crops can help to reduce the greenhouse effect because they have the capability to remove CO_2 from the atmosphere through photosynthesis to produce biomass that can be used for biofuels. Lipochitooligosaccharides (LCOs), compounds produced by rhizobia in their interactions with legume roots, can increase photosynthesis. The use of these compounds in combination with tillage practices such as no-till could be useful for both biomass production and soil carbon sequestration. The objective of the research was to determine the optimum balance between biomass production, carbon sequestration, and N_2O emission for a range of crops (corn, sorghum, soybean, and switchgrass). The treatments were tillage system (no-till in comparison with conventional tillage), nitrogen fertilization rates (0, 1/2 and full rates), and LCOs. Soil and plant variables were evaluated during the season. In 2001, crops were strongly affected by drought and the effect of treatments was small; the highest N rate was sometimes excessive. In 2002, corn responded more to nitrogen fertilization than the other crops. Sorghum grew well in all three nitrogen fertility levels. No-till plots had dry weight values lower than conventional tillage plots; those differences diminished and were not significant by the season's end. LCO application caused increased soybean biomass at mid-season, but dry conditions resulted in no difference by the end of the season. Sorghum produced the most biomass, at around 1.5 kg m^{-2} . The optimum management for greenhouse gas reduction (biomass produced vs. greenhouse gases produced during crop production) is discussed.

Modifying the dietary cation-anion difference of timothy using fertilization. Sophie Pelletier¹, Gilles Bélanger², Gaëtan F. Tremblay², Réal Michaud², Annie Brégar¹, and Guy Allard¹. ¹Université Laval, Sainte-Foy, Québec; ²Agriculture and Agri-Food Canada, Sainte-Foy, Québec (pelletiers@agr.gc.ca).

Decreasing the dietary cation-anion difference (DCAD) in forages may help to prevent milk fever of postpartum cows. A split-split-plot greenhouse experiment was conducted to establish fertilization treatments that may decrease the DCAD of timothy. We evaluated soil type (loam and clay), N fertilization (65 and 130 kg N ha^{-1}), and Cl and S fertilization (NH_4Cl at 50 and $100 \text{ kg Cl ha}^{-1}$; $(\text{NH}_4)_2\text{SO}_4$ at 35 and 70 kg S ha^{-1}). Timothy concentrations of K, Ca, Mg, Na, P, Cl, and S were determined. Concentrations of Ca, P and Mg were respectively 45, 40, and 15% higher in plants grown on loam than on clay soil, while the K concentration was 19% higher in timothy grown on clay soil. Soil type did not affect Cl and S concentrations but DM yield was higher on loam than on clay soil. Nitrogen fertilization did not affect DM yield and any of the elements used in the calculation of DCAD. Concentrations of Cl and Ca were respectively 90 and 13% higher in timothy fertilized with NH_4Cl than with $(\text{NH}_4)_2\text{SO}_4$. The Cl concentration was 55% higher in plants fertilized with 50 kg Cl ha^{-1} of NH_4Cl than with $100 \text{ kg Cl ha}^{-1}$. Timothy fertilized with $(\text{NH}_4)_2\text{SO}_4$ had a 12% greater DM yield than when fertilized with NH_4Cl . Our results indicate that soil type and Cl fertilization affect some of the elements used to calculate the DCAD.

Adaptation of eastern Canadian crops and cropping systems to climate change. Juan Almaraz, Xiaomin Zhou, and Donald Smith. McGill University, Ste-Anne-de-Bellevue, Québec (jalmar1@po-box.mcgill.ca).

In the Province of Quebec, the last 2 yr were both unusually dry and hot, and probably represent the sort of climate change conditions that will be much more common in the future. Our objective was to examine the yields of several full season crops, and key elements of crop production systems for suitability to climate change conditions. Four crops were grown in the field: soybean, corn, sorghum, and switchgrass. All crops, except soybean, were fertilized with nitrogen at 0, 1/2 and the full rate, and under till and no-till conditions. Yield and/or biomass data were collected in 2001 and 2002. Additionally, data of yield for the same crops grown in Montreal and data of precipitation, evaporation and temperature were collected from the statistical records over the last 20 yr. Yield in the experiments was low, and this was associated with low precipitation during the second half of the season in both years. Yield for corn and soybean were reduced in both years. Sorghum and switchgrass are warm season crops and grew well in dry and hot conditions obtained in those years. It seems that some of the crops used were more affected by low precipitation than others. Analysis of yield data records indicated that the yield of major crops declined in the last 2 yr because of drought. Climate change conditions may make no-till systems more appropriate and lead to reductions in N fertilizer applications.

Lipo-chitooligosaccharide: handling and storage. Supanjani Supanjani, Alfred Souleimanov, and Donald L. Smith. McGill University, Ste-Anne-de-Bellevue, Québec (ssupan@po-box.mcgill.ca).

Lipo-chitooligosaccharides (LCOs or Nod factors) produced by rhizobia are not only important for the establishment of legume-rhizobia symbiosis, but also have a potential to improve somatic embryogenesis, seed germination, and plant growth and development of some important crops. We evaluated different methods of handling and storage of Nod Bj-V($\text{C}_{18:1}$ MeFuc), the major Nod factor produced by *Bradyrhizobium japonicum*, on its recovery and biological activity. During freeze drying to purify LCO solution obtained through HPLC isolation, approximately 10% of the LCO

was lost, regardless of whether polypropylene or glass material was used as the container. For sterilization, filter materials affected the amount of LCO loss, being in order: polyestersulfone (32.3%), cellulose acetate (55.1%), nylon (51.9%), polytetrafluoroethylene (62.0%) and mixed cellulose ester (68.2%). Autoclaving LCO can be used as an alternative to filtering to sterilize LCO solution; around 70% of the LCO was recovered after autoclaving for durations of 15 to 30 minutes. Storage temperature affected LCO degradation. LCO degraded faster when stored at $23 \pm 2^\circ\text{C}$ (room temperature) than at $4 \pm 1^\circ\text{C}$ (refrigerator); after a duration of 16 mo, 74% of the LCO was recovered following room temperature storage and 84% following fridge storage. When tested at the same concentration (10^{-7} M), the biological activity (root hair deformation and seed germination in soybean) of LCO obtained from autoclaved and stored samples were similar to that of freshly prepared LCO.

Enhancement of calcium uptake into soybean by nod factor.

Supanjani Supanjani, Ahsan Habib, Danielle Donnelly, and Donald L. Smith. McGill University, Ste-Anne-de-Bellevue, Québec (ssupan@po-box.mcgill.ca).

Nod factors or lipo-chitooligosaccharides (LCOs) produced by rhizobia during legume-rhizobia symbiosis are known to cause transient increases in cytosolic calcium concentration in the root hairs of legumes. Soybean seedlings at the V1 stage were placed in treatment solutions containing LCO, rhizobial inoculum, or various other compounds. Seedlings were then transferred into test solution containing Murashige and Skoog basal salt medium and the radiotracer $^{45}\text{CaCl}_2$ to examine Ca uptake. Twenty-four hours following the addition of the radiotracer, trifoliolate leaf samples were harvested and $^{45}\text{Ca}^{2+}$ measured by liquid scintillation counting. Incubation with NodBj-V($\text{C}_{18:1}$ MeFuc) prior to testing increased the $^{45}\text{Ca}^{2+}$ uptake into seedling leaves in a concentration-dependent manner. Similarly, incubation with *Bradyrhizobium japonicum* strains 532C and USDA3 also increased $^{45}\text{Ca}^{2+}$ uptake into trifoliolate leaves. No increased $^{45}\text{Ca}^{2+}$ uptake occurred into seedling leaves following incubation with strain Bj-168, a nodC-mutant incompetent to produce LCO or either *Rhizobium leguminosarum* and *Sinorhizobium meliloti*, two Rhizobia that do not normally nodulate soybean. The tetramer or pentamer of chitosan and lumichrome also did not affect $^{45}\text{Ca}^{2+}$ uptake. This work suggests that rhizobial symbiosis, in addition to its known role in provision of nitrogen, also improves calcium uptake into soybean plants.

Farmer-directed on-farm experimentation examining the impact of companion planting barley and oats on timothy-alfalfa forage establishment in central Newfoundland. Dean Spaner¹ and Alexander Todd². ¹University of Alberta, Edmonton, Alberta; ²Agriculture and Agri-Food Canada, St. John's, Newfoundland (dean.spaner@ualberta.ca).

Growing barley or oats in the year of forage establishment is a common agronomic practice in marginal growing regions, but is

not often recommended to growers. We worked with a dairy farmer in central Newfoundland in a 4-yr study to address his question of what the best cereal species and seeding rate were for use in companion cropping during forage establishment. Our treatments consisted of barley planted at three seeding rates together with a forage companion crop of timothy (*Phleum pratense* L.) and alfalfa (*Medicago sativa* L.), and oats planted similarly. The alfalfa-timothy mixture companion planted with barley yielded 11% more forage dry matter than with oats in the year of planting, but the two species did not differ for any other forage quality trait, or yield. Increasing seeding rate from 22.5 to 67.5 kg ha⁻¹ resulted in a linear increase in forage dry matter yield in the year of planting of 32%, and linear decreases in percentage crude protein of 20%, P of 12% and Ca of 35% in the harvested forage. Companion planting oats or barley at rates increasing from 45 to 67.5 kg ha⁻¹ in the planting year resulted in a 9% increase in timothy-alfalfa in the second-year forage harvest, but did not alter any other forage quality trait. The decision process for the choice of cereal species, and the seeding rate of the companion planted cereal, will involve a producer-inferred balance between higher yields at higher seeding rates, with an inevitable forage quality decline as yields increase in the year of seeding.

Surface-banding with assisted infiltration—New low disturbance technique for applying slurry on land.

Shabtai Bittman¹, Laurens Van Vliet¹, Grant Kowalenko¹, and Sean McGinn². ¹Agriculture and Agri-Food Canada, Agassiz, British Columbia; ²Agriculture and Agri-Food Canada, Lethbridge, Alberta (bittmans@agr.gc.ca).

Manure nutrients are required for crops but applying manure onto land can lead to environmental concerns. Some of these risks can be reduced by injecting manure into soil or quickly incorporating the manure after application. However, injection and incorporation may cause excessive soil disturbance, so less disruptive systems are required. This study compared effects of applying dairy slurry on a perennial grass sward by broadcasting or banding on the soil surface, with a new technique designed for rapid infiltration with low soil disturbance. The new applicator, called AERWAY SSD (Holland Equipment, Norwich, ON), creates vertical aeration slots then bands manure over the slots. Results from 2 yr of testing in south coastal BC show that the new applicator delivers manure uniformly and does not damage existing crops. The method slightly improves crop response (yield and N offtake) to manure and reduces ammonia volatilization by over 40% and odour emission by 35% compared to surface broadcasting. There is also indication that the system will reduce surface runoff, although it does not reduce emission of nitrous oxide compared to surface broadcasting. The applicators, which are available in 2.5- to 10-m widths, have proven through extensive farm use all over North America to be robust, rapid and relatively low cost.