

The 85th Annual Meeting of the
**Potato Association
of America**



**ABSTRACTS &
PROGRAM**

PAA 2001

Potato Plant Health into the New Millennium

April 22-26, 2001

World Golf Village Renaissance Resort • St. Augustine, FL

Hosted by: Hastings Research and Education Center



**UNIVERSITY OF
FLORIDA**

Institute of Food and Agricultural Sciences

Welcome to PAA 2001

As President and on behalf of the Executive Committee, I would like to welcome you to the 85th Annual meeting of this Great organization. What a beautiful place to hold this meeting. Thanks go to Dr. Pete Weingartner, his LAC and Ms. Shelby Tatlock, Conference Coordinator for hosting this meeting. Two other people that have devoted considerable time on this meeting are Mr. Steve James, Program Coordinator, and Ms Sherry Butler, Tour Coordinator.

The Potato Association is especially grateful to all the companies and organizations that have help financially sponsor this meeting. As you meet these sponsors, do express your personal thanks for their part in making the 85th Annual meeting a great success.

The educational program this year is exceptional. There are more than 145 papers or posters available for you to increase your knowledge about potatoes. The meeting begins with the Symposium on the impact of new and emerging diseases and technologies on potato seed certification, followed by breakout sessions, which will allow further presentations on these concerns along with open discussion.

Plan to attend your section meetings. Each section is the basis for a strong association, your input at the section level is extremely important! Do also plan to attend the Annual Business meeting Thursday afternoon. Your presence will be much appreciated.

May this be a time to renew old acquaintances. Please welcome those new to our Association and help them get better acquainted with PAA. Enjoy your stay in this historical area of St. Augustine and to take advantage of the special tours planned for the week. Thank you for your support by attending this year's Annual meeting.

Again Welcome,

Oscar Gutbrod

President, Potato Association of America

PAA 2001

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Pete Weingartner

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Event Sponsors:

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PAA 2001

Agenda-at-a-Glance

(A Convention Center diagram is at the back of this booklet)

Sunday, April 22, 2001

9:00am-6:00pm	Silver Springs Tour	Wentworth
12noon-7:00pm	Registration	Registration Desk
1:00pm-5:00pm	Executive Committee Meeting	Royal Melbourne
1:00pm-5:00pm	Slide Viewing	Winged Foot
3:00pm-5:00pm	Breeding & Genetics Workshop	Wentworth
5:30pm-7:00pm	Certification Sub-committee Meeting	Wentworth
7:00pm-9:00pm	President's Reception	Legends 1 & 2

Monday, April 23, 2001

6:30am-5:00pm	Registration	Registration Desk
6:30am-7:50am	Extension Section Breakfast	Ballroom A
7:00am-9:00am	Continental Breakfast	Ballroom B
7:00am-9:00am	Family & Friends Meeting Area	Wentworth
7:00am-5:00pm	Slide Viewing	Winged Foot
8:00am-8:30am	Welcome to St. Augustine	Ballroom C
8:30am-12:00pm	Symposium	Ballroom C
9:00am-4:00pm	St. Augustine Historical Tour	Wentworth
10:00am-10:15am	Break	Ballroom B
10:00am-5:00pm	Poster and Exhibit Set-Up	Ballroom D
12noon-1:30pm	Luncheon (<i>Delegates Only</i>)	Ballroom B
12noon-2:30pm	AJPR Editorial Committee	Royal Melbourne
1:30pm-4:30pm	Breakout Symposium I	Ballroom C
1:30pm-4:30pm	Breakout Symposium II	Ballroom E
3:10pm-3:30pm	Break	Ballroom B
4:30pm-4:50pm	Discussion and Wrap Up	Ballroom C
5:00pm-6:30pm	Dinner on You Own	
5:00pm-6:45pm	<u>Section Meetings</u>	
	Breeding & Genetics	Ballroom C
	Pathology & Entomology	Ballroom E
	Utilization & Marketing	Ballroom G
5:30pm-8to11pm	St. Augustine After Dark	Wentworth
7:00pm-9:00pm	<u>Section Meetings</u>	
	Physiology	Ballroom E
	Certification	Ballroom G

Tuesday, April 24, 2001

6:30am-5:30pm	Registration	Registration Desk
6:30am-8:00am	Production & Mgmt. Breakfast	Ballroom A
7:00am-9:00am	Continental Breakfast	Ballroom B
7:00am-9:00am	Family & Friends Meeting Area	Wentworth
7:00am-5:00pm	Poster Viewing	Ballroom D
7:00am-5:00pm	Slide Viewing	Winged Foot
8:00am-12noon	Executive Committee Meeting	Royal Melbourne

(Continued on back)

Tuesday, April 24, 2001 (continued)

8:15am-12noon	Concurrent Session I – Breeding	Ballroom C
8:15am-12noon	Concurrent Session II – Physiology	Ballroom E
8:30am-12noon	Concurrent Session III – Ent./Prod.	Ballroom G
8:45am-4:45pm	Shop The Outlets (half & full day)	Wentworth
9:30am-3:00pm	Summer Museum Tour	Wentworth
10:00am-10:30am	Break	Ballroom B
12noon-1:30pm	Luncheon (<i>Delegates only</i>)	Ballroom B
1:30pm-3:00pm	Concurrent Session I - Breeding	Ballroom C
1:30pm-3:00pm	Concurrent Session II - Pathology	Ballroom E
1:30pm-3:00pm	Concurrent Session III - Production	Ballroom G
3:00pm-3:30pm	Break	Ballroom B
3:30pm-4:30pm	Physiology Section Mini-Symposium	Ballroom E
3:30pm-5:00pm	Pathology Section Mini-Symposium	Ballroom C
4:00pm-10:00pm	Cracker Swamp Preserve Tour	Wentworth
5:30pm-11:00pm	West Side Story at Dinner Theater	Wentworth
6:00pm-7:00pm	Poster Session (authors present)	Ballroom D
6:00pm-8:00pm	Poster Reception	Ballroom D

Wednesday, April 25, 2001

6:30am-2:00pm	Sport or Party Boat Fishing	Wentworth
6:30am-10:00am	Registration	Registration Desk
6:30am-8:30am	Continental Breakfast	Ballroom B
7:00am-9:00am	Family & Friends Meeting Area	Wentworth
7:30am-6:00pm	Cumberland Island Tour	Wentworth
8:30am-3:00pm	Agricultural and Research Tour	Wentworth
12:30pm-5:30pm	Sailing	Wentworth
12:30pm-5:30pm	Party Boat Fishing	Wentworth
5:00pm-10:00pm	“Spudtacular” (barbecue)	Wentworth

Thursday, April 26, 2001

7:00am-5:00pm	Registration	Registration Desk
7:00am-9:00am	Continental Breakfast	Ballroom A
7:00am-9:00am	Family & Friends Meeting Area	Wentworth
7:00am-10:30am	Slide Viewing	Winged Foot
7:00am-12noon	Posters & Exhibits displays removed	Ballroom D
8:00am-12noon	Executive Committee Meeting	Royal Melbourne
8:15am-12noon	Concurrent Session I – Breeding	Ballroom C
8:15am-10:00am	Concurrent Session III – Prod./General	Ballroom G
8:30am-11:45am	Concurrent Session II – Pathology	Ballroom E
10:00am-10:30am	Break	Ballroom D
11:00am-4:00pm	Anastasia State Park Beach Excursion	Wentworth
12noon-1:30pm	Luncheon (Delegates only)	Ballroom F & G
12:30pm-5:00pm	Cruise & Shop St. Augustine Tour	Wentworth
1:30pm-4:00pm	Annual PAA Business Meeting	Ballroom C
6:00pm-7:00pm	Awards Reception	Ballroom A
7:00pm- 9:30pm	Awards Dinner	Ballroom B
9:30pm	Conference Concludes	

Friday, April 27, 2001

8:00am-6:00pm	Kennedy Space Center Tour	Wentworth
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General Program

Monday Morning, April 23, 2001

8:00 am **Plenary Session** *Ballroom C*
Presiding: Oscar Gutbrod, PAA President

Welcome: Dr. Michael V. Martin, Vice President for Agricultural and Natural Resources, University of Florida, IFAS, Gainesville, FL and Dr. Pete Weingartner, Chair Florida LAC

Symposium: *Ballroom C*

Impact of New and Emerging Diseases and Technologies on Potato Seed Certification

Presiding: Dr. Pete Weingartner, UF, IFAS, Hastings REC, Hastings, FL

8:30am **Symposium Introduction (Sponsored by the Pathology and Certification Sections)** - Pete Weingartner

8:40am **(S1) The Challenge to Produce High Quality Certified Seed Potatoes.** Davidson, Robert D.*, Colorado State University, Department of Horticulture and Landscape Architecture, Fort Collins, CO 80523-1173.

9:10am **(S2) Tobacco Rattle (TRV) and Potato Mop-Top Viruses (PMTV) in Europe.** Dale, M.F.B., Barker, H. & Brown, D.J.F.*, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, U.K.

9:40am **(S31) Bacterial Wilt of Potato Caused by *Ralstonia solanacearum*: A Growing Threat to Seed and Ware Potato Production.** Pradhanang, P.M.* and M.T. Momol, University of Florida, IFAS, NFREC, Quincy, FL 32351-9500

10:00am **Break** *Ballroom B*

10:15am **(S3) The Impact of Soil (and Seed) Borne Diseases without Vectors on Seed Potato Certification.** Secor, Gary, A.* and Neil C. Gudmestad, Department of Plant Pathology, North Dakota State University, Fargo, ND 58105.

10:45am **(S4) Statistical Sampling for Soil-Borne Pathogens in Seed Potatoes.** Littell, Ramon C.*, Department of Statistics, Institute of Food and Agricultural Sciences, University of Florida, Box 110339, Gainesville, Florida 32100-0339.

11:15am **(S5) Emerging Technologies for Detection of Plant Pathogens: Advantages and Limitations.** Mills, Dallice*, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902.

11:45am **Symposium Wrap-Up**

12:00 **Adjourn**

Monday Afternoon, April 23, 2001

Breakout Symposium I:

Ballroom C

New and Emerging Soil-Borne Diseases Caused by Fungi

Presiding: Dr. William Campbell, Alaska Plant Material Center, Palmer, AK

- 1:30pm **(S6) Transmission of *Phytophthora infestans* from Potato Seed Tubers to Sprouts: Implications for Management and Certification.** Inglis, D. A.* and M. L. Powelson, Washington State Univ. REU, Mount Vernon, WA 98273 and Oregon State Univ., Corvallis, OR 97331.
- 1:50pm **(S7) Black Dot: A Recently Recognized Economically Important Disease of Potato.** Johnson, Dennis A.*, Brad Geary, and L. Tsrer (Lahkim), Washington State University, University of Idaho, and Gilat Experiment Station, respectively.
- 2:10pm **(S8) Powdery Scab: An Emerging Disease on Potato.** Christ, B. J.*, Department of Plant Pathology, Penn State University, University Park, PA 16802.
- 2:30pm **(S9) Potato Wart Disease - Reality and Myth.** Proudfoot, Kenneth G.*, Kenneth Proudfoot Consultants Ltd., Box 84, Goulds, NF A1S 1G3.
- 2:50pm **(S10) *Verticillium dahliae* in North American Certified Seed Potatoes - How Important is it?** Rowe, Randall C.*, Dept. of Plant Pathology, The Ohio State University/OARDC, Wooster OH 44691.
- 3:10pm **Break** *Ballroom B*
- 3:30pm **(S11) Silver Scurf, an Emerging Potato Disease.** Geary, Brad*, D. A. Johnson, P. B. Hamm, S. James and K. A. Rykbost. University of Idaho, 29603 U of I Ln, Parma, ID 83660, Washington State University, P.O. Box 646430, Pullman, WA 99164-6430, Hermiston Ag. Research & Extension Center P.O. Box 105, Oregon State University, Hermiston 97838, Powell Butte and Klamath Falls.
- 3:50pm **(S12) The Contribution of Population Biology and Genetics for Developing Seed Certification Programs for *Rhizoctonia*.** Cubeta, Marc A.*, Paulo C. Ceresini and H. David Shew, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.
- 4:10pm **(S13) Dynamics of Ridomil Resistance in Populations of *Phytophthora Erythroseptica*, cause of Pink Rot of Potato.** Lambert D.H.* and A.I. Currier, University of Maine, Orono, ME 04469.
- 4:30pm **Discussion & Wrap up** (both Breakout Symposiums together) *Ballroom C*
Presiding: Dr. Jeff Miller, Research and Ext.Center, University of Idaho, Aberdeen, ID and Dr. Hossein El-Nashaar, North Dakota State Seed Dept., Fargo, ND.

Monday Afternoon, April 23, 2001

Breakout Symposium II:

Ballroom E

New and Emerging Soil-Borne Diseases Caused by Nematodes and Viruses

Presiding: Dr. Johnathan L. Whitworth, Idaho Crop Improvement Assoc., Inc. Idaho Falls, ID.

- 1:30pm **(S14) Certification Issues Surrounding Columbia Root-knot Nematode (*Meloidogyne chitwoodi*).** Ingham, Russell E.* and Philip B. Hamm, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331 and Department of Botany and Plant Pathology, Oregon State University, Hermiston Agriculture Research and Extension Center, P.O. Box 105, Hermiston, OR 97838.
- 1:50pm **(S15) Distribution, Biology and Efficiency of the Vector of Tobacco Rattle Virus Causing Corky Ringspot Disease of Potato in the Pacific Northwest.** Mojtahedi, Hassan^{1*}, G. S. Santo¹, P. E. Thomas², J. M. Crosslin¹, and C. R. Brown². ¹Washington State University, Irrigated Agriculture Research and Extension Center, 24106 Bunn Rd. Prosser, WA, and ²USDA-ARS, Prosser, WA.
- 2:10pm **(S16) An Apparent New Strain of Tobacco Rattle Virus that causes Systemic Symptoms in Potatoes.** Thomas, P. E.*¹, K. Thompson², R. E. Ingham³, and J. M. Crosslin⁴, ¹Agricultural Research Service, U.S. Department of Agriculture, ⁴Washington State University, 24106 N. Bunn Road, Prosser, WA 99350-9687, ²Agro Engineering, 0210 Road 2 South, Alamosa, Co 81101, ³Oregon State University, 2082 Cordley Hall, Corvallis, OR 97331-2902.
- 2:30pm **(S17) Control of Corky Ringspot in Oregon.** Ingham, Russell E., Philip B. Hamm* and Kenneth A. Rykbost, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331, Department of Botany and Plant Pathology, Oregon State University, Hermiston Agriculture Research and Extension Center, P.O. Box 105, Hermiston, OR 97838 and Department of Crop Science, Oregon State University, Klamath Experiment Station, 6941 Washburn Way, Klamath Falls, OR 97603.
- 2:50pm **(S18) Defending the Profitability of Growing Potato in the Columbia Basin: Development of Corky Ringspot and Columbia Root-knot Nematode Resistant Germplasm.** Brown, C. R.^{1*}, H. Mojtahedi², G. S. Santo², P. Hamm³, R. Novy⁴, D. Corsini⁴, S. Love⁵, and S. James⁶, ¹USDA/ARS, Prosser, WA, ²Washington State University-Irrigated Agriculture Research and Extension Center, Prosser, WA, ³Oregon State University-Hermiston Agricultural Research and Extension Center, Hermiston, Oregon; ⁴USDA/ARS, Aberdeen, Idaho, ⁵University of Idaho, Aberdeen, ID, ⁶Oregon State University-Central Oregon Experiment Station, Madras, OR.
- 3:10pm **Break** *Ballroom B*

- 3:30pm **(S19) Development of Russet-Type Germplasm with Resistance to Corky Ringspot.** Love, Stephen L.*¹, Thomas A. Salaiz¹, Joseph J. Pavek¹, and Charles R. Brown². ¹University of Idaho, Aberdeen R & E Center, Aberdeen, ID 83210. ²USDA/ARS, Washington State University IAREC, Prosser, WA 99350.
- 3:50pm **(S20) Reduction and Elimination of Tobacco Rattle Virus from Soils in Alfalfa Cultures.** Thomas, P. E.^{1*}, H. Mojtahedi², J. M. Crosslin³, and G. S. Santo^{4, 1,3}. Agricultural Research Service, U.S. Department of Agriculture, ^{2,4}Washington State University, 24106 N. Bunn Road, Prosser, WA 99350-9687.
- 4:10pm **(S21) Biology and Distribution of Potato Cyst Nematodes in North America and their Economic Impact on Potato Production.** Brodie, B. B.*, USDA, ARS, Dept. of Plant Pathology, Cornell University, Ithaca, NY 14853.
- 4:30pm **Discussion & Wrap up** (both Breakout Symposiums together) *Ballroom C*
Presiding: Dr. Jeff Miller, Research and Ext.Center, University of Idaho, Aberdeen, ID and Dr. Hossein El-Nashaar, North Dakota State Seed Dept., Fargo, ND.

Tuesday Morning, April 24, 2001

Concurrent Session I: -- Breeding

Ballroom C

Presiding: J. Creighton Miller Jr. Department of Horticultural Sciences, Texas A & M University, College Station, TX.

- 8:15am **(1) Ploidy Reduction of a Fertile Tetraploid Intermonoploid Somatic Hybrid for Studying Somaclonal Variation.** Lightbourn, Gordon* and Richard E. Veilleux, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.
- 8:30am **(2) Resistance of *Solanum andigenum* Accessions Maintained at VIR and US Potato Genebanks to Golden Nematode.** Kiru, Stepan*¹, Svetlana Makovskaya² and John Bamberg³, ¹N. Vavilov Res. Institute (VIR), B. Morskaya Str. 42, St. Petersburg, 190000, RUSSIA; ²All Russian Plant Protection Institute, Podbelskoe shosse 14, VIZR, Poushkine, St. Petersburg 199606, RUSSIA; ³USDA/ARS, US Potato Genebank, 4312 Hwy 42, Sturgeon Bay, WI 54235 USA.
- 8:45am **(3) Analyses of Scab Reaction Evaluation Data from Long Term Field Plots.** Murphy, Agnes*, Xing-Yao Xiong, George C.C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, 850 Lincoln Rd., Fredericton, NB, E3B 4Z7.
- 9:00am **(4) Genetic Studies of Unilateral Incompatibility between Diploid (1EBN) Mexican Species *Solanum pinnatisectum* and *S. cardiophyllum* subsp. *cardiophyllum*.** Kuhl, J. C., M. J. Havey, and R. E. Hanneman, Jr.*, Vegetable Crops Research Unit, USDA, Agricultural Research Service, Department of Horticulture, University of Wisconsin, Madison, WI 53706.

- 9:15am **(5) Wild Potato Germplasm Collecting Expedition to Honduras and Panama.** Spooner, David M.^{1*}, Alberto Salas², and Robert Hijmans², ¹USDA, ARS; Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI, 53706-1590, and ²International Potato Center(CIP), Apartado 1558, La Molina, Lima 12, Peru.
- 9:30am **(6) Identification of Named Varieties, Advanced Selections, and Accessions with High Antioxidant Activity for use in Breeding Potatoes for Enhanced Human Health Benefits.** Hale, Anna L.^{*1}, Luis Cisneros-Zevallos¹, John B. Bamberg², and J. Creighton Miller, Jr.¹, ¹Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133, ²USDA/Agriculture Research Service, Inter-Regional Potato Introduction Station, 4312 Hwy. 42, Sturgeon Bay, WI 54235.
(GRADUATE STUDENT COMPETITION)
- 9:45am **(7) Aflp Mapping of Genes Controlling Leptine Synthesis in Tetraploid Potatoes.** Sagredo, Boris*, Abbas Lafta, Howard Casper, and Jim Lorenzen, Dept. of Plant Sciences, North Dakota State University, Fargo, N.D. 58105.
(GRADUATE STUDENT COMPETITION)
- 10:00am **Break** *Ballroom B*
- 10:30am **(8) Mapping of Genes Associated to Late Blight, *Verticillium* Wilt and Cold Sweetening Resistance in Potatoes.** Saha, M. C.* and J. H. Lorenzen, North Dakota State University, Dept. of Plant Sciences, Loftsgard Hall, Fargo, ND 58105.
(GRADUATE STUDENT COMPETITION)
- 10:45am **(9) Identifying Resistance to *Phytophthora infestans* Earlier in Breeding.** Posch, Danielle M.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.
(GRADUATE STUDENT COMPETITION)
- 11:00am **(10) Marker Analysis of Monoploid Potato.** Varrieur, John M.* and Richard E. Veilleux, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.
(GRADUATE STUDENT COMPETITION)
- 11:15am **(11) Obtaining Sexual Hybrids Between *Solanum pinnatisectum* (IEBN) and Cultivated Potato Germplasm.** Zlesak, David C.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.
(GRADUATE STUDENT COMPETITION)
- 11:30am **(12) Taxonomy of Mexican Diploid Wild Potato (*Solanum sect. Petota*) Species: Morphological and Microsatellite Data.** Lara-Cabrera, Sabina I.* and David M. Spooner, USDA, ARS; University of Wisconsin-Madison, 1575 Linden Drive, Madison, WI 53706.
(GRADUATE STUDENT COMPETITION)

11:45am **(13) Transgenic Resistance to Colorado Potato Beetle (*Leptinotarsa decemlineata*) Transmitted to Tetraploid Potato through 4x-2x Hybridization.** Johnson, A. A. T.*; B. A. Nault and R. E. Veilleux.
Department of Horticulture, Virginia Polytechnic Inst. & State U.,
Blacksburg, VA 24061 and Eastern Shore Ag. Res. Ext. Ctr., Painter, VA
23420.
(GRADUATE STUDENT COMPETITION)

12:00 **Adjourn**

Tuesday Afternoon, April 24, 2001

Concurrent Session I: -- Breeding

Ballroom C

Presiding: Dr. G. Craig Yencho, Department of Horticultural Sciences, NCSU,
Vernon James Research & Ext. Center. Plymouth, NC

- 1:30pm **(14) Modified Conventional Breeding Methods to Efficiently Transfer Unique Late Blight Resistance from 2x(1EBN) Mexican Species to 2x(2EBN) and 4x(4EBN) Breeding Lines.** Hamernik, A. J.*, M. Ramon, and R. E. Hanneman, Jr., Vegetable Crops Research Unit, USDA, Agricultural Research Service, Department of Horticulture, University of Wisconsin, Madison, WI 53706.
- 1:45pm **(15) Identification of 4°C Chipping in 12 Late Blight Resistant *Solanum* Species.** Hayes, Ryan J.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.
- 2:00pm **(16) Sucrose Esters Derived from *Solanum berthaultii* and Resistance to Potato Late Blight.** Yencho, G. Craig*¹, Mark Clough¹, and Robert Goth², ¹Department of Horticultural Science, North Carolina State University, Vernon G. James Research and Extension Center, 207 Research Station Road, Plymouth, NC 27962, and ²USDA/ARS/Plant Science Institute, Vegetable Laboratory, Beltsville, MD 20705.
- 2:15pm **(17) Accelerating the Chromosome Walk Towards Late Blight Resistance with the Help of FISH.** Naess, S. K. *, J. M. Bradeen, J. Song, G. T. Haberlach, S. M. Wielgus, J. A. Davis J. Jiang and J. P. Helgeson, USDA/ARS Plant Disease Resistance Research Unit, Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706 USA.
- 2:30pm **(18) Analysis of Segregation for Late Blight Resistance in Potato Families Screened at Toluca Valley, Mexico.** Novy, Richard*¹, Dennis Corsini¹, Joe Pavek¹, Hector Lozoya-Saldana², and Alejandro Hernandez-Vilchis², ¹USDA-ARS, Aberdeen, ID 83210 and ²PICTIPAPA, Metepec, Mexico.

2:45pm **(19) Variety Selection for Resistance to Abiotic Stresses, A Summary of Ohio's Involvement in the North-Central and Northeast Regional Genetics and Breeding Projects.** Kleinhenz, Matthew D.*, E.C. Wittmeyer, Mark A. Bennett, and Richard L. Hassell, The Ohio State University, Ohio Agricultural Research and Development Center and Department of Horticulture and Crop Science, 1680 Madison Avenue, Wooster, OH 44691-4096, 2001 Fyffe Court, Columbus, OH 43210-1086, 2021 Coffey Road, Columbus, OH 43210-1086, Clemson University, Coastal Research Station, 2865 Savannah Highway, Charleston, S.C. 29414-5332.

3:00pm **Adjourn**

Tuesday Morning, April 24, 2001

Concurrent Session II: --Physiology

Ballroom E

Presiding: Dr Chad Hutchinson, University of Florida, IFAS, Hastings REC, Hastings, FL.

- 8:15am **(20) A Potentially Important Role for Anaerobic Carbohydrate Metabolism in Determining Chip Quality of Cold-Stored Potato Tubers.** Blenkinsop, Robert W.*, Leslie J. Copp, Alejandro G. Marangoni and Rickey Y. Yada, Department of Food Science, University of Guelph, Guelph, Ontario, N1G 2W1.
(GRADUATE STUDENT COMPETITION)
- 8:30am **(21) Impact of Calcium and Nitrogen Applications on 'Burbank' Potato Tuber Size and Tuber Number.** Ozgen, Senay*, and Jiwan P. Palta, Department of Horticulture, University of Wisconsin, Madison, WI 53706.
(GRADUATE STUDENT COMPETITION)
- 8:45am **(22) Influence of Supplemental Calcium and Nitrogen Improves Potato Tuber Calcium Concentrations and Internal Quality of 'Russet Burbank' Potatoes.** Ozgen, Senay*, Christopher Gunter, Björn Karlsson and Jiwan Palta, Department of Horticulture, University of Wisconsin, Madison, WI 53706.
- 9:00am **(23) Reduction of Potato Tuber Bruising and Internal Defects by Supplemental Calcium Field Applications.** Karlsson, Björn*, Jiwan Palta and Senay Özgen, The University of Wisconsin-Madison, Department of Horticulture, 1575 Linden Dr., Madison, WI 53706.
- 9:15am **(24) Supplemental Calcium Application During Seed Tuber Production: Impact on Plant Quality and Yield the Following Year.** Gunter, Christopher C.* and Jiwan P. Palta, Purdue University - Southwest Purdue Agricultural Program, 4369 North Purdue Road, Vincennes, IN 47591 and University of Wisconsin-Madison, Madison, WI 53706.
- 9:30am **(25) Some Secondary Plant Hormones Isolated from 'Katahdin' Potato Plant Tissues Whose Levels were Influenced by Induction.** Malkawi, AA., B.L. Jensen and Alan R. Langille*, Department of Chemistry,

Department of Biosystems Science and Engineering, University of Maine,
Orono, ME 04469.

- 9:45am **(26) Potato EST Sequencing and Analysis: Which Genes Involved in Carbohydrate Metabolism are most Active in Immature Potatoes?** Li, Xiu-Qing*, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, 850 Lincoln Road, Fredericton, N.B., E3B 4Z7, CANADA.
- 10:00am **Break** *Ballroom B*
- 10:30am **(27) Aminocyclopropane Carboxylate Oxidase Genes are Cis-Regulated by Abiotic and Biotic Stresses in Potato.** Nie, Xianzhou*, Rudra P. Singh, and George C. C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.
- 10:45am **(28) Segregation for Somatic Embryogenesis in Potato.** Seabrook, Janet E. A.*, L. Katheryn Douglass and George C.C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, CANADA, E3B 4Z7.
- 11:00am **(29) A New Post-harvest Chemical, 1-Methylcyclopropene, Delays Fry Colour Darkening.** Prange, Robert K.*¹, Jin-Cheol Jeong², and Barbara J. Daniels-Lake¹, ¹Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, NS B4N 1J5, Canada, ²National Alpine Agricultural Experiment Station, RDA, Pyoungchang, Kangwon 232-950, Korea.
- 11:15am **(30) Long-term Exposure to Ethylene Affects Polyamine Levels and Sprout Development in ‘Russet Burbank’ and ‘Shepody’ Potatoes.** Jin-Cheol, Jeong¹, Robert K. Prange*² and Barbara J. Daniels-Lake², ¹National Alpine Agricultural Experiment Station, RDA, Pyoungchang, Kangwon 232-950, Korea, ²Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, NS B4N 1J5, Canada.
- 11:30am **(31) Effect of Chlorpropham (CIPC) upon Carbohydrate Metabolism During Storage of Chipping Potatoes.** Copp, Leslie J.*, Robert W. Blenkinsop, Rickey Y. Yada and Alejandro G. Marangoni, Department of Food Science, University of Guelph, Guelph, ON N1G 2W1.
- 11:45am **(32) Biological Agents for Dual Control of Dry Rot Disease and Sprouting of Potatoes in Storage.** Slininger, P.J.*, D.A. Schisler, L.P. Meagher, K. D. Burkhead, and R.J. Bothast, NCAUR, USDA-ARS, Peoria, IL.
- 12:00 **Adjourn**

Tuesday Afternoon, April 24, 2001

Concurrent Session II: -- Pathology

Ballroom E

Presiding: Dr. Steve B. Johnson, UMaine Cooperative Extension, Presque Isle, ME.

- 1:30pm **(33) Potato Seed Treatment for Controlling *Rhizoctonia solani* Infection.** Naranjo, Patrick*¹, Greta Schuster¹, David Bender², Ron Thomason¹, Jeff Koym², ¹West Texas A&M University, Canyon, TX, ²Texas Agricultural Experiment Station, Lubbock, TX.
(GRADUATE STUDENT COMPETITION)
- 1:45pm **(34) Relative Sensitivity of ELISA and RT-PCR Methods for Early Detection of Potato Leaf Roll Virus (PLRV) in Russet Burbank Potatoes under PEI Conditions.** Singh, R.¹, X. Nie¹, Robert Coffin*², D. Huestis³, M. Burns², W. Burns², J. Zeng¹, A. Dilworth¹, D. Munn³, ¹AAFC, Fredericton, NB, E3B 4Z7, ²Cavendish Farms, New Annan, PE, C1N 5J5, ³PEI Produce, Summerside, PE.
- 2:00pm **(35) Determination of a Threshold Absorbance Value of PVY Detection in Sprouts and Leaves by ELISA and Comparison with Visual Field Readings.** Singh, Mathuresh*¹, George Tai², Lynn Moore³ and Sandy Perley³, ¹International Certification Services, 385 Wilsey Rd, Fredericton, N.B., Canada E3B 5N6, ²Agriculture and Agri-Food Canada, Potato Research Centre, PO Box 20280, Fredericton, N.B., Canada E3B 4Z7, ³NB Agriculture, Fisheries & Aquaculture, PO Box 6000, Fredericton, N.B. Canada E3B 5H1.
- 2:15pm **(36) Viral Mixed Infections in International Potato Clones in the Toluca Valley, Mexico.** Roman-Vázquez, Reynaldo¹, Héctor Lozoya-Saldaña*^{1,2}, and Alejandro Hernández-Vilchis², ¹Depts. of Parasitology and Plant Sciences, Autonomous University of Chapingo, Chapingo, México 56230, and ²International Cooperative Program for Potato Late Blight, Metepec, México 52176.
- 2:30pm **(37) Is the Resistance of the Potato Cultivar Shepody to Potato Virus A a Hypersensitive Response?** Nie, Xianzhou* and Rudra P. Singh, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, NB, Canada E3B 4Z7.
- 2:45pm **(38) Sodium Sulphite Mediated Attenuation of Polyphenolics in Nucleic Acid Extraction for RT-PCR.** Singh, Rudra P.*¹, Xianzhou Nie¹, Mathuresh Singh², Robert Coffin³ and Patricia Duplessis⁴, ¹Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, NB, Canada E3B 4Z7, ²Agricultural Certification Services, NB Potato Agency, 245 Hilton Road, Unit 25, Fredericton, NB, Canada E3B 5N6; ³Cavendish Farms, P.O. Box 3500, Summerside, PEI, Canada C1N 5J5, ⁴Crop Diversification Centre North, RR6, 17507 Fort Road, Edmonton, Alberta, Canada T5B 4K3.
- 3:00pm **Break** *Ballroom B*

Pathology Section Mini-Symposium:

Ballroom C

Late Blight is a Global Problem

Presiding: Dr. Wanda Collins, International Potato Center, Lima, Peru.

- 3:30pm (S22) **The Global Initiative on Late Blight (GILB).** Collins, Wanda*, Deputy Director General for Research and GILB Coordinator, International Potato Center, Apartado 1558, Lima 12, Peru.
- 3:45pm (S23) **Global Initiative on Late Blight (GILB) Linkage Groups.** Lizárraga, Charlotte*, Assistant GILB Coordinator, International Potato Center, Apartado 1558, Lima 12, Peru.
- 4:00pm (S24) **Significance of Sexual Reproduction in *Phytophthora infestans* Epidemiology.** Miller J. S.*, University of Idaho, PO Box 870, Aberdeen, ID 83210.
- 4:15pm (S25) **Late Blight in the United States and Canada.** Deahl, Kenneth L.* and Richard W. Jones, USDA, ARS, PSI, Vegetable Laboratory, Beltsville, MD 20705.
- 4:30pm (S26) **Late Blight in Latin America, Africa and Asia.** Forbes, Greg*, International Potato Center, P.O. 17-21-1977, Quito, Ecuador.
- 4:45pm (S27) **Potato Late Blight in Ireland and Europe.** Cooke, Louise R.*, Applied Plant Science Dept., Queen's University Belfast, Newforge Lane, Belfast, BT9 5PX, UK.
- 5:00pm **Adjourn**

Tuesday Morning, April 24, 2001

Concurrent Session III: -- Entomology/Production

Ballroom G

Presiding: Dr. Stephen K. Ohair, University of Florida, IFAS, Tropical REC, Homestead, FL.

- 8:30am (39) **Comparative Efficacy of Fosthiozate Formulations for the Management of *Meloidogyne chitwoodi* in Idaho Potatoes.** Hafez, S.L.* and Sundararaj P., University of Idaho, Parma Research and Extension Center, 29603 U of I Lane, Parma, Idaho 83660.
- 8:45am (40) **Area-Wide Colorado Potato Beetle Management.** Sexson, Deana L.* and Jeff Wyman, University of Wisconsin, Madison, 1575 Linden Dr., Madison, WI 53706.
- 9:00am (41) **The Influence of Seed Growing and Storage Temperatures on the Performance of Five Seed Potato Cultivars.** Hornbacher, Andy*, Nora Olsen, Phil Nolte, and Lynn Woodell, University of Idaho, 3793 N. 3600 E., Kimberly, ID 83341 and University of Idaho, 1776 Science Center, Idaho Falls, ID 83402.
(GRADUATE STUDENT COMPETITION)

- 9:15am **(42) Relationship Between Calcium and Disease.** Sanchez, Elsa S.* and Larry K. Hiller, Washington State University, Department of Horticulture and Landscape Architecture, Pullman, WA 99163.
(GRADUATE STUDENT COMPETITION)
- 9:30am **(43) High Quality Minituber Production by Planting Sprouts Detached from Imported Basic Seed Tubers under Aphid-Proof Screenhouse in a Brazilian Citrus Region.** de Souza-Dias, J.A.C.*¹; C.M. de Meo²; A. Greve³; L.J. Paes⁴, ¹Plant Health Center, Agronomic Institute (IAC), 13001-970 Campinas, S.P., Brazil; ²SAI-Limeira, SP; ³CATI, Campinas, SP. ⁴Limeira Agriculture Secretary. ¹ CNPq fellow.
- 9:45am **(44) The Effects of the Addition of Slow Release Fertilizer on the Yield and Size Distribution of Greenhouse-Grown Minitubers.** Hughes, Becky R.* and Candy N. F. Keith, New Liskeard Agricultural Research Station, University of Guelph, Box 6007, New Liskeard ON P0J 1P0 Canada.
- 10:00am **Break** *Ballroom B*
- 10:30am **(45) Metribuzin Sensitivity and Model Evaluation.** Thompson, Asunta* and Scott Nissen, San Luis Valley Research Center, Colorado State University, 0249 East Road 9 North, Center CO 81125, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.
- 10:45am **(46) Pacific Northwest Potato Tolerance and Varietal Response to Sulfentrazone.** Hutchinson, Pamela J. S.*, Dennis J. Tonks, Corey V. Ransom, Rick A. Boydston, and Claude G. Ross, University of Idaho, Aberdeen, ID 83210, Washington State University, Davenport, WA 99122, Oregon State University, Ontario, OR 97914, USDA-ARS, Prosser, WA 99350; and FMC Corp., Loveland, CO 80537.
- 11:00am **(47) Norkotah Response to Foliar Applications of Apogee® (prohexadione-calcium).** Nissen, Scott J.*, Pamela Hutchinson, and Susie Thompson; Colorado State University, Ft. Collins, CO, University of Idaho, Aberdeen, ID and Colorado State University, San Luis Valley Research Center, Center, CO.
- 11:15am **(48) Pre-Planting Management to Maximize Short Season Yield Potential.** Mikitel, Loretta J.¹* and David Wattie², New Brunswick Department of Agriculture, Fisheries and Aquaculture, ¹Potato Development Centre, Wicklow, NB, Canada E7L 3S4, and ²Bon Accord Elite Seed Potato Centre, Bon Accord, NB, Canada E7H 2K8.
- 11:30am **(49) Efficacy of Chlorine Dioxide as a Disinfectant in Potato Storages.** Woodell, Lynn K. , Gale E. Kleinkopf *, and Nora Olsen, University of Idaho, 3793 N 3600 E, Kimberly, ID 83341-5076 and University of Idaho, PO Box 1827, Twin Falls, ID 83303-1827.

11:45am (50) **Response of Russet Burbank Potatoes to Irrigation Frequency with Set-Move Sprinkler Systems.** Stark, Jeff* and Brad King, University of Idaho, Research & Extension Center, P.O. Box 870 Aberdeen, Idaho, 83210.

12:00 **Adjourn**

Tuesday Afternoon, April 24, 2001

Concurrent Session III: -- Production

Ballroom G

Presiding: Dr. Donald Halseth, Cornell University, Ithaca, NY.

1:30pm (51) **Survey of Environmental Conditions and Cultural Practices Associated with Embedded Stone Problems in Chip Potatoes.** Halseth, D. E.*, Department of Horticulture, Cornell University, Ithaca, NY 14853.

1:45pm (52) **Seed Physiology and Growing Temperature Influences on Early Tuber Set.** Olsen, Nora*¹ and Robert E. Thornton², ¹Dept. of PSES, University of Idaho, Twin Falls, ID, 83303 and ²Dept. of Hort. and L.A. Washington State University, Pullman, WA 99164.

2:00pm (53) **Influence Iron and Manganese Concentration in Nutrient Solution on Growth and Mineral Content of the Potato Plants.** Chang, Dong Chil*, Sung Y. Kim, Young I. Hahm, *Division of Crop Research, National Alpine Agricultural Experiment Station, RDA, Pyongchang 232-955, Korea.

2:15pm (54) **Improving Nitrogen Efficiency in Michigan Potato Systems.** Snapp, Sieglinde* and Don Smucker, Michigan State University, Dept. Horticulture, East Lansing, MI 48824 and Michigan State Extension, P.O. Box 308, Stanton, MI, 48888.

2:30pm (55) **Evaluation of Pre-Sidedress Soil Nitrogen Test (PSNT) for Use in Potatoes Following Red Clover.** Siczka, J. B.* , D. E. Halseth, C. W. Albers, and S. L. Childs.

2:45pm (56) **Effect of Planting Depth and Hilling Practices on Yield and Quality of Russet Burbank and Gem Russet Potatoes.** Bohl, William H.* and Stephen L. Love, University of Idaho, 132 S. Shilling, Blackfoot, ID 83221, University of Idaho Research & Extension Center, P.O. Box 870, Aberdeen ID 83210.

3:00pm **Break**

Physiology Section Mini Symposium:

Ballroom E

Periderm Maturation: Skin-Set Development, Measurement and Physiology

Presiding: Dr. Ed Lulai, USDA-ARS, Northern Crop Science Lab., Fargo, ND.

3:30pm (S28) **Skin-Set: Measurement and Physiology of Resistance to Tuber Skinning Wounds.** Lulai, Edward C.*, USDA-ARS, Northern Crop Science Laboratory, Fargo, ND 58105-5677.

- 3:50pm **(S29) Biochemical Changes in Cell Wall Structure Associated with Periderm Maturation.** Sabba, Robert P.* and Edward C. Lulai, USDA-ARS, Northern Crop Science Lab, Fargo, ND 58105-5677.
- 4:10pm **(S30) Relating Potato Skinning to Field Measurements of Skin-Set.** Pavlista, Alexander, D.*, University of Nebraska-Lincoln, Panhandle Research & Extension Center, 4502 Ave. I, Scottsbluff, NE 69361.
- 4:30pm **Adjourn**

Tuesday Evening, April 24, 2001

Poster Session: 6:00pm to 7:00pm (Authors present)

Ballroom D

- P1 Evaluation of Clonal Susceptibility to Variation in Tuber Shape, French Fry Yield, and After-Storage Processing Quality Across Production Regions.** Knowles, N.R.* , R.E. Thornton, N. Fuller and L. Knowles, Dept. of Horticulture & Landscape Architecture, P.O. Box 646414, Washington State University, Pullman, WA 99164-6414.
- P2 The Corrosive Effects of Purogene and Oxidate.** Norikane, Joey H.^{1*}, William W. Kirk², and Roger Brook³, ¹USDA/ARS, Department of Agricultural Engineering, Michigan State University, 220 Farrall Hall, East Lansing, MI 48824, ²Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824, ³Department of Agricultural Engineering, Michigan State University, East Lansing, MI 48824.
- P3 Efficacy of Purogene and Oxidate Disinfectants Added to Potato Storage Humidity Water for Pathogen Control.** Norikane, Joey, H.^{1*}, Roger C. Brook², and William W. Kirk³, ¹USDA/ARS, Department of Agricultural Engineering, Michigan State University, 220 Farrall Hall, East Lansing, MI 48824, ²Department of Agricultural Engineering, Michigan State University, East Lansing, MI 48824, ³Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824.
- P4 Vydate ® C-LV "over and under" Control of Nematodes and Insects in Potatoes.** Drake, G. E.* , N. D. McKinley, DuPont Crop Protection Products, Stine-Haskell Research Center, Newark DE.
- P5 Ethylene Generation from Potato Tissue is Free Radical-Mediated, Dependent on Tuber Age, and Correlated with Loss in Wound-Healing Ability.** Kumar, G.N.M., L. Knowles and N.R. Knowles*, Dept. of Horticulture & Landscape Architecture, P.O. Box 646414, Washington State University, Pullman, WA 99164-6414.
- P6 Physiological and Biochemical Markers of Seed-Tuber Productivity.** Knowles, N.R., Lisa Knowles* and G.N.M. Kumar, Dept of Horticulture & Landscape Architecture, P.O. Box 646414, Pullman, WA 99164-6414.
- P7 Optimum Soil Water Potential and Drip Tape Position for Potato (*Solanum tuberosum* L.) Drip Irrigation.** Shock, Clinton C.* , Eric P. Eldredge, Lamont D. Saunders, and Erik G. B. Feibert, Oregon State University, Malheur Experiment Station, 595 Onion Ave., Ontario, OR.

- P8 Utilization of Controlled Release Fertilizers in Chip Potato Production.** Hutchinson, Chad M.* and D.P. Weingartner, University of Florida/IFAS, Hastings Research and Education Center, P.O. Box 728, Hastings, FL 32145.
- P9 Crop Tolerance and Weed Control with Flumioxazin and Sulfentrazone in Pacific Northwest Potato Production.** Boydston, Rick A.*, Corey V. Ransom, and Pamela J. S. Hutchinson, USDA-ARS, Irrigated Agriculture Research and Extension Center, 24106 N. Bunn Road, Prosser, WA 99350; Malheur Experiment Station, Oregon State University, 595 Onion Ave., Ontario, OR 97914; and University of Idaho, Box AA, Aberdeen, ID 83210.
- P10 Foliar Resistance to Late Blight in Potato Clones Evaluated in National Trials in 2000.** Haynes, K.G.* , C.A. Thill, G. Secor, W.E. Fry, D.S. Douches, W.R. Stevenson, and D.P. Weingartner, USDA/ARS, Beltsville, MD 20705, University of Minnesota, St. Paul, MN 55108, North Dakota State University, Fargo, ND 58105, Cornell University, Ithaca, NY 14853, Michigan State University, East Lansing, MI 48824, University of Wisconsin, Madison, WI 53706; and University of Florida, Hastings, FL 32145.
- P11 Potato Variety Trials in Ontario 2000.** Currie, Vanessa* and Dr. J. A. Sullivan, Department of Plant Agriculture, University of Guelph, Guelph, Ontario, Canada N1G 2W1.
- P12 Comparative Growth Analysis of Russet Norkotah and Russet Norkotah Strains.** Miller, J. Creighton, Jr.^{1*}, Jeff W. Koym¹, Douglas C. Scheuring¹, Gretta Schuster², and George J.C. Fernandez³, ¹Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133, ² Division of Agriculture, West Texas A&M University, Canyon, TX 79016-0001, ³Department of Applied Economics and Statistics, University of Nevada Reno, Reno, NV 89557-0105.
- P13 *S. phurejs-s. stenotomum* Contributes High Specific Gravity and Internal Tuber Quality under High Temperature Growing Environments to 4X-2X Hybrids.** Sterrett, S.B.* , M.R. Henninger, G.C. Yenko, and K.G. Haynes, Virginia Polytechnic and State University, Painter, VA 23420; Rutgers University, New Brunswick, NJ 08903; North Carolina State University, Plymouth, NC; and USDA/ARS, Beltsville, MD 20705.
- P14 Human Serum Albumin Production in Transgenic Potato Tubers.** Farran, Inma* and Angel M. Mingo-Castel, Instituto de Agrobiotecnología y Recursos Naturales (UPNA/ CSIC), Campus Arrosadía s/n, 31006-Pamplona, Spain.
- P15 Acquisition, Retention, and Transmission of Tobravirus Particles by Trichodorid Nematodes.** Karanastasi, E., S.A., MacFarlane, U. Wyss, & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, Scotland, UK.

- P16** **Magnetic Capture of Nematodes Using Antiserum and Lectin Coated Dynabeads.** Chen, Q., L. Robertson, J.T. Jones, V.C. Blok, M.S. Philips & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, U.K.
- P17** **Lectin Attachment to *Paratrichodorus anemones* (Nematoda).** Holeva, R. C., Q., Chen, R., Neilson, J. T. Jones, & D. J. F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, U.K.
- P18** **OPEN**
- P19** **Molecular Diagnostics of Virus-Vector Trichodorid Nematodes and their Associated Tobacco Rattle Virus (TRV).** Boutsika, K., V.C. Blok, M.S. Phillips & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK.
- P20** **Subtractive Hybridization for the Isolation of Common Scab Resistance Genes from the Potato.** Goyer, Claudia*, Patrice Audy, Henry De Jong, Russ King, Agnes Murphy, George Tai, Richard Tarn, Agriculture and Agri-Food Canada, Potato Research Centre, P.O. Box 20280, 850 Lincoln, Fredericton, NB E3B 4Z7, Canada.
- P21** **Control of Black and Silver Scurf on Potato Seed Tubers.** Tsrer (Lahkim), L.^{1*}, O. Erlich¹, M. Aharon¹, M. Lavy² and I. Peretz-Alon², ¹Department of Plant Pathology, Gilat Experiment Station, Agricultural Research Organization, Ministry of Agriculture, M.P. Negev, ISRAEL, 85280; ²Maon Enterprises, M.P. Negev, ISRAEL.
- P22** **Characterization of Isolates of *Phytophthora erythroseptica* from Prince Edward Island According to Metalaxyl Sensitivity and Allozyme Genotype.** Peters, R.D.^{1*}, A.V. Sturz², B.G. Matheson², W.J. Arsenault¹, and A. Malone¹, ¹Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, P.O. Box 1210, Charlottetown, PE C1A 7M8; ²PEI Department of Agriculture and Forestry, Plant Health Research and Diagnostics, P.O. Box 1600, Charlottetown, PE C1A 7N3.
- P23** **Characterization of Late Blight in Uruguay.** Deahl, Kenneth L.*, M.C. Pagnani, F.M. Perez, B. Moravec, and L.R. Cooke, USDA, ARS, PSI, Vegetable Laboratory, Beltsville, MD 20705, INIA, Plant Pathology, Canelones 90200, Uruguay, and The Queen's University of Belfast, Belfast, Northern Ireland.
- P24** **Partial Characterization of *Phytophthora infestans* Isolates from Chile.** Secor, Gary A. *, Viviana V. Rivera and Fernando Riveros, Department of Plant Pathology, North Dakota State University, Fargo, ND 58105 and INIA Intihuasi, Apartado Posta; 36-B, LaSerena, Chile.
- P25** **Potato Late Blight: Pathogen Population Dynamics across Canada in 2000.** Platt, H.W. (Bud)* and F. Daayf, Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, Box 1210 (440 University Ave.), Charlottetown, P.E.I., Canada C1A 7M8.

- P26** **Sensitivity to Metalaxyl, Sexual Compatibility, and Aggressiveness of *Phytophthora infestans* in Venezuela.** Rodriguez, G. Dorian*, Universidad Centroccidental "Lisandro Alvarado", P.O. Box. 400 Barquisimeto, State of Lara, Venezuela.
- P27** **Effects of Temperature and Fungicide Applications on Stem Lesions of *Phytophthora infestans* on Potato.** Shepherd, C. P.*, R. M. Geddens, M. D. Stidham, DuPont Crop Protection Products, Stine-Haskell Research Center, Newark DE.
- P28** **Bioproduction of Stable Protein/Antimicrobial Peptides for Disease Control.** Jones, Richard W.*, USDA, ARS, Vegetable Laboratory, Rm. 311, Bldg. 010A, BARC-West, Beltsville, MD 20705.
- P29** **Combining Host Plant Resistance with Managed Fungicide Applications to Control Potato Late Blight (*Phytophthora infestans*).** Kirk, William¹, Kimberly Felcher^{2*}, David Douches², J. Stein¹ and R. Hammerschmidt¹, Michigan State University, East Lansing, ¹Dept. of Botany and Plant Pathology, ²Dept. of Crop and Soil Sciences.
- P30** **Gavel 75 DF Fungicide for Control of Potato Late Blight.** Harrison, W. Edd*, Douglas C. Lisk and Harvey A. Yoshida, Rohm and Haas Company.

Thursday Morning, April 26, 2001

Concurrent Session I: -- Breeding

Ballroom C

Presiding: Dr. Sal Locascio, Department Horticultural Sciences, University of Florida, IFAS, Gainesville, FL.

- 8:15am **(57) Cultural Practice, A Tool in Promoting New Advanced Selections.** Groza, Horia^{1*}, Timothy Connell³, Bryan Bowen¹, Jiming Jiang², University of Wisconsin, ¹4181 Camp Bryn Afon Rd, Rhinelander, WI 54501, ²1575 Linden Drive, Madison, WI 53706, ³Portage County UW Extension, 1462 Strongs Ave, Stevens Point, WI 54481.
- 8:30am **(58) Economic Performance of Gem Russet (A8495-1) and A84118-3 as Compared to Russet Burbank Using a Fresh Pack model.** Salaiz, T.S.*, S. L. Love and P.E. Patterson, University of Idaho, Plant Soil and Entomological Sciences Dept., Aberdeen, ID 83210 and University of Idaho, Agricultural Cooperative Extension, Idaho Falls, ID 83402.
- 8:45am **(59) Early Generation Selection for Cold (4°C) Chipping Potato Progenies.** Hayes, Ryan J.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.
- 9:00am **(60) A Comparison of Production and Processing Quality Traits of Chip and Non-Chip Genotypes.** Tarn, T. Richard*, Warren K. Coleman, Henry De Jong and George C.C. Tai., Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.

- 9:15am **(61) Variation of Chipping Quality in Three Genetic Populations Derived from *Tuberosum* x *Tuberosum*, *Andigena* x *Tuberosum* and Diploid x Diploid Crosses.** Tai, George C.C.*¹, Henry De Jong, T. Richard Tarn and Warren K. Coleman, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.
- 9:30am **(62) Fine Screening Potato Germplasm for High Leaf and Low Tuber Glycoalkaloids.** Bamberg, J.*¹, S. Love², D. Corsini³ and K. Deahl⁴, ¹USDA, Agricultural Research Service, US Potato Genebank, 4312 Hwy 42, Sturgeon Bay, WI 54235; ² Research Professor, University of Idaho, R & E Center, Aberdeen, ID 83210; ³Research Plant Pathologist, USDA/ARS, R & E Center, Aberdeen, ID 83210; ⁴ Research Plant Pathologist, USDA, ARS Veg. Lab., BARC-W, 10300 Baltimore Ave., Beltsville, MD 20705.
- 9:45am **(63) Identification and Genetic Location of a Novel Potato Alkaloid.** Sagredo, Boris, Abbas Lafta, Howard Casper, and Jim Lorenzen*, Dept. of Plant Sciences, North Dakota State University, Fargo, N.D. 58105.
- 10:00am **Break** *Ballroom D*
- 10:30am **(64) Mapping Late Blight Resistance and other Agronomic Traits in a *S. microdontum* Population.** Bisognin, Dilson*, Lynn Buszka and David Douches, Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824.
- 10:45am **(65) Cloning Late Blight Resistance from *Solanum bulbocastanum*.** Bradeen, James M.*¹, S. Kristine Naess, Susan M. Wielgus, Jeffrey A. Davis, Geraldine T. Haberlach, and John P. Helgeson, Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706.
- 11:00am **(66) Genetic Variation in Potato with High Levels of Red and Blue Anthocyanins.** Brown C. R.*¹, R. Wrolstad², and B. Clevidence³, ¹USDA/ARS, Prosser, WA, ²Oregon State University, Corvallis, OR; ³USDA/ARS, Beltsville, MD.
- 11:15am **(67) Field Evaluation of Natural and Engineered Potato (*Solanum tuberosum* L.) Resistance Mechanisms for Control of Colorado Potato Beetle (*Leptinotarsa decemlineata* Say).** Coombs, Joseph¹*, David Douches¹, Edward Grafius², Walter Pett², and Dale Moyer³, Michigan State University, ¹Department of Crop and Soil Sciences, ²Department of Entomology, East Lansing, MI, USA 48824, ³Cornell University, Long Island Horticultural Research and Extension Center, Riverhead, NY, USA 11901.

- 11:30am **(68) Development and Characterization of an Adapted Form of *Droopy*, a Diploid Potato Mutant Deficient in Abscisic Acid.** De Jong, H.*¹, L. M. Kawchuk², W. K. Coleman¹, C. A. Verhaeghe², L. Russell¹, V. J. Burns¹ and E. Tremblay-Deveau¹, ¹ Agriculture and Agri-Food Canada Potato Research Centre, P.O. Box 20280, Fredericton, NB, E3B 4Z7, ² Agriculture and Agri-Food Canada Lethbridge Research Centre, P.O. Box 3000, Lethbridge, AB, T1J 4B1.
- 11:45am **(69) Genetic Heterogeneity among Breeding Systems of Potato Species and its Ramifications in Germplasm Conservation.** del Rio, Alfonso H.* and John B. Bamberg, USDA/Agricultural Research Service, Vegetable Crops Research Unit, Inter-Regional Potato Introduction Station, 4312 Hwy. 42, Sturgeon Bay, WI 54235, USA.
- 12:00 **Adjourn**

Thursday Morning, April 26, 2001

Concurrent Session II: -- Pathology

Ballroom E

Presiding: Dr. William Crow, Department of Entomology and Nematology, University of Florida, IFAS, Gainesville, FL.

- 8:30am **(70) Effects of Azoxystrobin (Quadris) Rates on *Colletotrichum coccodes* and *Verticillium dahliae* Colonization in the Russet Burbank Potato.** Davis, James R.* and Ann T. Schneider, University of Idaho, Aberdeen R&E Center, PO Box 870, Aberdeen, ID 83210.
- 8:45am **(71) Below-Ground Potato Plant Architecture in Early-Die Soil: With Special Reference to *Pratylenchus penetrans* (Nematoda).** Bird, G. W.*¹ & J. Chen², ¹Department of Entomology, 243 Natural Science Building, Michigan State University, East Lansing, MI 48824, ²Department of Nematology, University of California-Davis.
- 9:00am **(72) Potentials of Precision Agriculture Technology in Potato Early-Die Management.** Bird, G.W.*¹, M. Otto², N. Hoff³, R. Brook³ & R. Gore¹, ¹Department of Entomology, 243 Natural Science Building, Michigan State University, East Lansing, MI 48824; ²Agribusiness Consultants Inc., Lansing, MI; ³Department of Agricultural Engineering, Michigan State University.
- 9:15am **(73) Soil Fumigation with Telopic (C-35) to Control Verticillium Wilt.** Tsror (Lahkim), L.*¹, O. Erlich¹, M. Aahron¹, Y. Cahlon², A. Hadar², Y. Cohen³, M. Shmueli³, E. Shlevin⁴, E. Ben-Nun⁴, B. Meler⁵, Z. Bigel⁵ and I. Peretz-Alon⁶, ¹Agricultural Research Organization, Dept. of Plant Pathology, Gilat Experiment Station, M.P. Negev, 85280 Israel; ²AgriChem Ltd. Petach Tikva, Israel; ³Dead Sea Bromine LTD., Beer-Sheva, Israel; ⁴Kibbutz Saad, M.P. Negev, Israel; ⁵Kibbutz Alumim, M.P. Negev, Israel; ⁶Maon Enterprises, M.P. Negev, Israel.

- 9:30am **(74) “Introducing Moncoat MZ, a New Potato Seed Piece Protectant.”**
 Schafer, Ron*, Technical Representative, & Frank Fronck, Commercial
 Product Development Representative, United Agri Products, P.O. Box
 1286 Greeley CO 80632.
- 9:45am **(75) Telomere-Associated RFLP Variability among *Phytophthora***
***infestans* Strains Isolated in Oregon.** Mills, Dallice^{1*}, Jessica M.
 Schrank¹, Philip B. Hamm¹, D. A. Johnson². ¹Dept. of Botany and Plant
 Pathology, Oregon St. Univ., Corvallis, OR 97331-2902; ²Dept. Plant
 Pathology, Washington St. Univ., Pullman, WA 99164-6430.
- 10:00am **Break** *Ballroom D*
- 10:30am **(76) Thermal Properties of Potato Cull Piles and Different Genotypes**
of *Phytophthora infestans* in Relation to Overwintering of Potato Late
Blight. Kirk, William W.*, R. Scott Shaw, Brendan A. Niemira, Jeffrey M.
 Stein and Robert L. Schafer, Department of Botany and Plant Pathology,
 Michigan State University, East Lansing, 48824.
- 10:45am **(77) Evaluation of Seed Piece Fungicides and Application Time to**
Control Tuberborne Late Blight. Ludy, R. L.*, M. L. Powelson, B.
 Gunderson and D. Inglis, Department of Botany & Plant Pathology, Oregon
 State University, Corvallis, OR 97331-2902 and Washington State
 University, Mount Vernon Research and Extension Unit, Mount Vernon,
 WA 98273.
- 11:00am **(78) A Technique to Evaluate the Response of Non-Tuber Potato**
Tissue to Infection with *Phytophthora erythroseptica*. Peters, R.D.^{1*} and
 A.V. Sturz², ¹Agriculture and Agri-Food Canada, Crops and Livestock
 Research Centre, P.O. Box 1210, Charlottetown, PE C1A 7M8; ²PEI
 Department of Agriculture and Forestry, Plant Health Research and
 Diagnostics, P.O. Box 1600, Charlottetown, PE C1A 7N3.
- 11:15am **(79) Effect of Fungicide Programs on Early Blight Control and**
Nitrogen Fertilizer Response in Potato. Miller, Jeff S.* and Carl J.
 Rosen, University of Idaho, PO Box 870, Aberdeen, ID 83210 and
 University of Minnesota, St. Paul, MN 55108.
- 11:30am **(80) Influence of Seed-Borne *Helminthosporium solani* on Progeny-**
Tuber Disease Levels. Geary, Brad*, D. A. Johnson and P. B. Hamm.
 University of Idaho, 29603 U of I Ln, Parma, ID 83660, Washington State
 University, P.O. Box 646430, Pullman, WA 99164-6430, Hermiston Ag.
 Research & Extension Center P.O. Box 105, Oregon State University,
 Hermiston 97838.
- 11:45 **Adjourn**

Thursday Morning, April 26, 2001

Concurrent Session III: -- Production/General

Ballroom G

Presiding: Dr. Dennis Corsini, USDA-ARS, Research and Ext. Center, Aberdeen, ID

- 8:15am **(81) Production of Creamer Potatoes in No-Tillage Cover Cropping System.** Carrera, Lidia M.*¹, Ronald Morse², Aref A. Abdul-Baki¹, Kathleen Haynes³, and John R. Teasdale¹, ¹USDA, ARS, ANRI, SASL, 10300 Baltimore Avenue, Bldg 010A, Room 224, Beltsville, MD 20705, ²Department of Horticulture, College of Agriculture and Life Science, Blacksburg, VA 24061, ³USDA, ARS, PSI, Vegetable Lab., 10300 Baltimore Avenue, Building 010A, Room 312, Beltsville, MD 20705.
- 8:30am **(82) Relating Potato Yield and Quality to Variability in Soil Characteristics.** Redulla, C.¹, J. R. Davenport*¹, R. G. Evans², M. J. Hattendorf³, A. K. Alva⁴ and R. A. Boydston⁴, ¹Washington State University, 24106 N. Bunn Road, Prosser, WA 99350, ²USDA/ARS, 1500 N. Central Ave., Sidney, MT 59270, ³Vantage Point, 2057 Vermont Drive, Fort Collins, CO 80525, ⁴USDA/ARS, 24106 N. Bunn Road, Prosser, WA 99350.
- 8:45am **(83) Influence of Seed Size and Density on the Performance of Direct Seedling Transplants from Hybrid True Potato Seed (TPS).** Upadhya, Mahesh D.* and Rolando Cabello, International Potato Center, La Molina, Lima, Peru.
- 9:00am **(84) Steps Underway to Strengthen Metam-Sodium as an Effective Fumigant for Weeds, Disease, and Nematode Control.** Sullivan, David A.*, Executive Director, Metam-Sodium Task Force, 1900 Elkin Street, Suite 240, Alexandria, VA 22308.
- 9:15am **(85) National Ugandan Potato Program Review.** Locke, Kerry A.*, Oregon State University, Klamath County Extension, 3328 Vandenberg Road, Klamath Falls, OR 97603.
- 9:30am **(86) Protein Levels in Potato Breeding Selections and Cultivars.** Corsini, Dennis *, Richard Novy, Annie Marshall, and Joseph Pavek, University of Idaho, Aberdeen Research and Extension Center, PO Box 870, Aberdeen, ID 83210 and 2-3439 E. Cliff Drive, Santa Cruz, CA 95062.
- 9:45am **(87) Physicochemical Properties of Starches during Potato Growth.** Liu, Q^{1*} and R. Yada², Food Research Program, Agriculture & Agri-Food Canada, Guelph, Ontario, Canada N1G 5C9¹ and Dept. of Food Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1².
- 10:00am **Adjourn**

**Symposium
Abstracts**

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(S1) The Challenge to Produce High Quality Certified Seed Potatoes. Davidson, Robert D.*, Colorado State University, Department of Horticulture and Landscape Architecture, Fort Collins, CO 80523-1173.

Producing high quality certified seed potatoes with low disease levels has been the goal of North American certified seed programs and seed growers for well over eighty years. Programs have developed during this time based upon sound science, buyer demands, the ability of the seed growing region to meet these demands, quality control and solid economics. There have been notable successes in the arena of seed production. Controlling diseases, particularly bacterial diseases, through the use of tissue-culture production schemes has been extremely effective. In addition, use of limited generation, flush-out certification systems and improved disease testing technology has reduced certain disease problems even further. Work with cultivar development programs and line selections has improved the quality and yield of the seed product. However, there are new threats to seed production on the horizon. Soil borne diseases and insect problems are on the upswing and will play a role in further development of certification systems. Community diseases such as late blight, PVY and potato leafroll are again causing significant concern. Finally, overall increased costs and the potential for reduced profits are causing certified seed producers to rethink many of their strategies. While these challenges are not insurmountable, they will stress the certification programs and seed growers as adjustments are made.

(S2) Tobacco Rattle (TRV) and Potato Mop-Top Viruses (PMTV) in Europe. Dale, M.F.B., Barker, H. & Brown, D.J.F.*, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, U.K.

TRV and PMTV viruses are transmitted by (Para)trichodorid nematodes and the fungus *Spongospora subterranea* respectively, causing “spraing” disease. Both viruses have long survival periods, up to 10 years for PMTV and several decades for TRV. Symptoms of “TRV-spraing” and “PMTV-spraing” are similar. There are no acceptable chemical controls for the PMTV, whilst oximecarbarnates are used for TRV vector nematode control they have been withdrawn in some areas. The reactions of potatoes to TRV are resistant, susceptible (infected symptomlessly), or sensitive (hypersensitive -spraing symptoms), dependant on virus/potato interactions. Potato cultivars are sensitive or susceptible to PMTV, none are resistant. Not all tubers from PMTV-infected plants become infected, on replanting a few develop into infected plants i.e. is “self-eliminating”. TRV in a sensitive cultivar is self-eliminating. TRV persists in susceptible cultivars, potentially spreading the virus to new areas. TRV in susceptible potatoes can adversely affect yield and quality traits. A pre-plant soil test using a PCR-MD diagnostic is being developed for (Para)trichodorus species and TRV. A PCR-MD has been developed for *S. subterranea* and an ELISA diagnostic is available for PMTV. Lab. tests with engineered viral coat protein mediated resistance (CPMR) proved successful for PMTV. SCRI is identifying molecular markers for TRV resistance.

(S3) The Impact of Soil (and Seed) Borne Diseases without Vectors on Seed Potato Certification. Secor, Gary, A.* and Neil C. Gudmestad, Department of Plant Pathology, North Dakota State University, Fargo, ND 58105.

Seed potato certification was instigated primarily to insure varietal purity. Disease tolerances became part of certification because disease symptoms often masked agronomic features used for variety identification. Certification of seed potatoes requires meeting the requirements of both field and post harvest inspections and tests, including a shipping point inspection conducted by a combination of state and federal certification officials. Meeting tolerances for diseases that are only seed-borne, such as viruses and bacterial ring rot, are required to pass field inspection. Tolerances for disease that are both seed- and soil-borne are left to the judgment of the inspector but may be recorded in inspection documents. However, disease tolerances exist for many diseases that are both seed- and soil-borne in order to issue a shipping point inspection required to complete the certification procedure. This presentation will review seed potato certification rules and regulations for seed-and soil-borne diseases, and the biology and epidemiology of the many diseases in this category. Some of these diseases are Rhizoctonia, Verticillium wilt, Fusarium dry rot, black dot, silver scurf, late blight, pink rot, early blight, scab, bacterial wilt, powdery scab, nematodes and wart.

(S4) Statistical Sampling for Soil-Borne Pathogens in Seed Potatoes. Littell, Ramon C.*, Department of Statistics, Institute of Food and Agricultural Sciences, University of Florida, Box 110339, Gainesville, Florida 32100-0339.

Seed potato certification requires sampling and testing for pathogens. In most cases it is impossible to prove absence of pathogens with certainty. Then the goal is to establish strong statistical evidence of low levels of infection. Adequate sampling is required to show acceptably low levels of pathogens. Sampling and testing for disease detection always presents difficult challenges, but problems are even harder in the case of soil-borne pathogens because of notoriously aggregated distributions in space. Aggregation, or clustering, increases probability rates of non-detection over rates for randomly distributed pathogens. Knowledge of the degree of aggregation obtained from preliminary sampling can assist in computing non-detection rates. If the sampling units are soil cores and analytical methods are highly sensitive, then bulking of samples can improve detection rates.

(S5) Emerging Technologies for Detection of Plant Pathogens: Advantages and Limitations. Mills, Dallice*, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902.

The traditional biochemical and immunological techniques for the detection of plant pathogenic organisms and viruses have been greatly augmented by the development of a number of DNA-based methods during the past decade. Some DNA-based detection methods have the potential for greater specificity and sensitivity than techniques such as the enzyme-linked immunosorbent assay (ELISA), the indirect fluorescent antibody staining assay (IFAS), or nucleic acid probe hybridization. Key to recent major advances in DNA-based technology was the development of the polymerase chain reaction (PCR), an enzymatic process whereby a specific sequence of DNA from the genome of any organism and the RNA from a virus may be amplified several million-fold from a nucleic acid primer set. The design of the primer pair and, therefore, the region of the genome that is amplified may impose certain limitations with respect to the method by which the PCR product may be analyzed, the level of sensitivity and specificity achieved, whether the results can be verified by DNA-based methods, whether different pathogens that can be simultaneously analyzed, the number of samples that can be analyzed, the time required to obtain results, and the cost of assaying each sample. To be discussed are detection techniques as diverse as rep-PCR-mediated genomic fingerprinting, nucleic acid sequence-based amplification (NASBA), reverse transcriptase polymerase chain reactions (RT-PCR), telomere RFLP analysis, and a comparison of the strategies, performances, limitations and advantages of using either TaqMan or Molecular Beacon assays. Factors that interfere with PCR assays will also be discussed.

(S6) Transmission of *Phytophthora infestans* from Potato Seed Tubers to Sprouts: Implications for Management and Certification. Inglis, D. A.* and M. L. Powelson, Washington State Univ. REU, Mount Vernon, WA 98273 and Oregon State Univ., Corvallis, OR 97331.

Potato tubers are the principle means for survival of *Phytophthora infestans* (*Pi*). In-fected tubers in cull piles are generally regarded as a primary source of inoculum for initiating late blight epidemics in many production regions. However, new information on seedborne inoculum leading to transmission of *Pi* from seed tubers to sprouts and early-season establishment of late blight within a field, calls for new approaches in management. Our research, and the results of others, has shown that transmission of *Pi* from seed pieces contaminated during seed cutting and handling operations is driven by inoculum density, cultivar susceptibility, physiological age of seed, and time interval between contamination and seed fungicide treatment. Inoculum which comes into con-tact with recently cut seed pieces can be managed preventively by seed treatment with broad-spectrum fungicides, thereby circumventing transmission. Latent seed tuber infections, however, cannot be controlled with this approach, and measures such as banded applications with cymoxanil at 95% emergence to eradicate new infections and to protect healthy foliage may be useful. Many factors which reduce seed piece decay and promote seed vigor and rapid emergence, also provide *Pi* with the opportunity to survive the soil environment, infect emerging sprouts and spread in the canopy before foliar fungicides can typically be applied. Therefore, adoption of certification standards for late blight may be justified in the future to identify seed lots at risk for latent tuber infections.

(S7) Black Dot: A Recently Recognized Economically Important Disease of Potato. Johnson, Dennis A.*, Brad Geary, and L. Tsrer (Lahkim), Washington State University, University of Idaho, and Gilat Experiment Station, respectively.

Yield reductions ranging from zero to greater than 40% have been documented in replicated, controlled experiments with potato due to *Colletotrichum coccodes*. Tubers greater than 280g in size can be especially reduced. Potato cultivar, fungal isolate and environmental factors affect yield. Below- and above-ground phases of the disease are evident from quantifying the fungus in plant tissues. *C. coccodes* is disseminated through tuber-, soil-, and air-borne inoculum. The fungus can be detected in below- and above-ground plant stems relatively early in the growing season but symptoms usually are not expressed until later in the season. Infected seed tubers increase the incidence of early season plant infections and provide a means of pathogen dissemination. Foliar infections may result from wind blown inoculum and foliage abrasion from blowing sand. Yields were decreased more in growth chambers at daily temperatures of 23C and 28C than at 18C on Russet Burbank and Norkotah Russet plants grown in soil infested with *C. coccodes* when compared with plants grown in non-infested soil. Azoxystrobin reduces *C. coccodes* levels in stems and tubers.

(S8) Powdery Scab: An Emerging Disease on Potato. Christ, B. J.*, Department of Plant Pathology, Penn State University, University Park, PA 16802.

Powdery scab, caused by *Spongospora subterranea* f. sp. *subterranea* has become an increasing problem in North America. Many questions exist on the biology and epidemiology of this disease. We have monitored soil moisture and temperature over the past five years to correlate environmental conditions with levels of powdery scab. High levels of the disease were associated with cool wet growing seasons. We have focused on screening germplasm and cultivars for disease reaction to powdery scab. All trials are conducted on grower's fields that were known to have naturally high occurrence of powdery scab. Randomized complete block designs with 4-6 replications were used. Kennebec was used as a susceptible check in the trial. Resistant lines for tuber symptoms included Norkotah Russet, Russet Burbank, Snowden and NY112. However, tuber severity does not necessarily correlate to severity of root symptoms. For example Snowden was moderately resistant for tuber symptoms but highly susceptible for root symptoms. Other trials have focused on chemical control using the susceptible cultivar Kennebec. Although no significant difference were observed among treatments there were definite trends. For seed treatment trials, Evolve had 22 percent more healthy tubers than the control. In furrow applications of Omega also yielded 18-20 percent more healthy tubers than the no treatment control. Trials to examine best time of applications of a suitable chemical are needed. Other types of management practices need to be assessed in order for developing adequate management practices for powdery scab.

(S9) Potato Wart Disease - Reality and Myth. Proudfoot, Kenneth G.*, Kenneth Proudfoot Consultants Ltd., Box 84, Goulds, NF A1S 1G3.

Potato wart disease results from the infection of the potato plant by the non-mycelial, obligate parasitic soil-borne fungus *Synchytrium endobioticum*. The fungus is native to the high Andes region of Peru and Bolivia where it attacks both cultivated and wild *Solanum* species.

Wart disease and its causal agent were first described by Schilbersky in 1896. The disease was spread from the British Isles to other European countries, and worldwide by the trade in potatoes. The disease is confined to areas where soil temperatures are below 20°C and soil moisture is adequate for the movement of infective zoospores. The fungus is characterized by the formation of a thick walled resting spore which may remain viable for up to 40 years. Spread between countries, or between farms, is primarily through the planting of tubers which had been grown in infested soil. Very limited spread from a focus of infection may occur through the movement of contaminated soil. Infective zoospores remain viable for less than two (2) hours, and their mobility is limited to less than 25 mm. Using various differential varieties, several pathotypes of the fungus have been identified in Europe, North and South America.

Typically the disease occurs more frequently under conditions where crop rotation is not practiced and growers retain their own seed for planting, e.g. subsistence or part-time farming and gardening. Although a pest of quarantine importance, this fungus pales into insignificance compared to the potential threat of such pathogens as the cool tolerant form of the brown rot bacterium, or the virus Y strain causing potato tuber necrosis.

(S10) *Verticillium dahliae* in North American Certified Seed Potatoes - How Important is it? Rowe, Randall C.*, Dept. of Plant Pathology, The Ohio State University/OARDC, Wooster OH 44691.

In an extensive survey of commercial potato seed lots produced across North America, *Verticillium dahliae* was detected in 65 of 224 seed lots tested, a successful isolation rate of nearly 30%. Isolates of the fungus recovered in this survey were assessed by vegetative compatibility analysis. All 162 isolates of *V. dahliae* tested belonged to vegetative compatibility group (VCG) 4. Among these, 64% belonged to VCG 4A, 33% to VCG 4B, and 3% to VCG 4AB. Of 39 isolates tested in the greenhouse, all were pathogenic to potato cv. Superior. In plants inoculated with VCG 4A isolates, disease symptoms developed earlier, were more severe, and plants died earlier as compared to VCG 4B isolates. Results of this survey suggest that: 1) commercial certified seed tubers from diverse locations in N. America are commonly infected with *V. dahliae* and thus may serve as primary sources of the pathogen, 2) potato isolates of *V. dahliae* in North America belong to VCG 4A and 4B and these strains are widely distributed via seed tubers, and 3) VCG 4A isolates are a distinct pathotype of *V. dahliae* that is highly aggressive to potato. The potential importance of these findings to the N. American potato industry will be discussed.

(S11) Silver Scurf, an Emerging Potato Disease. Geary, Brad*, D. A. Johnson, P. B. Hamm, S. James and K. A. Rykbost. University of Idaho, 29603 U of I Ln, Parma, ID 83660, Washington State University, P.O. Box 646430, Pullman, WA 99164-6430, Hermiston Ag. Research & Extension Center P.O. Box 105, Oregon State University, Hermiston 97838, Powell Butte and Klamath Falls.

Silver scurf, caused by *Helminthosporium solani*, has been recently recognized as an important potato disease because of the increased incidence of this disease, likely due to the increased occurrence of resistance to commonly used seed treatments. *Helminthosporium solani*, which is limited to the periderm of tubers, is particularly important on potato tubers sold on fresh markets because of the unsightly blemishes this pathogen produces. Increased water loss through infected areas can result in up to 13% less yield of marketable potatoes, which affect grower returns regardless of processed or fresh markets. Tubers can become infected with *H. solani* in the field or in storage. The primary source of inoculum is the seed-tuber, which has shown a positive correlation between the amount of silver scurf on the seed and the amount on the progeny-tubers. As the severity of seed-tuber infections increase, the amount of silver scurf on the progeny-tubers also increases, indicating the importance of using clean seed. The severity of silver scurf can be lessened through chemical and cultural means. In Washington and Oregon, the fungicide seed treatments of Maxim + Blocker, Quadris, Maxim, and Tops MZ had significantly less silver scurf on progeny-tubers than progeny-tubers from untreated seed. Some cultural methods of minimizing silver scurf include planting seed with minimal amounts of disease, vine kill two to three weeks prior to harvest, do not leave tubers in the ground beyond skin set, disinfect potato storages and store potatoes at lowest possible temperatures under appropriate humidity to reduce spore production and new infections.

(S12) The Contribution of Population Biology and Genetics for Developing Seed Certification Programs for *Rhizoctonia*. Cubeta, Marc A.*, Paulo C. Ceresini and H. David Shew, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7616.

Rhizoctonia disease of potato, caused primarily by the fungus *Rhizoctonia solani* anastomosis group 3 (AG-3), occurs in most potato production areas of the world. Several molecular techniques are available to identify *R. solani* AG-3 in pure culture and various DNA-based techniques are currently being developed for identification of the fungus from plant tissue and soil. For the past four years our laboratory has been using somatic incompatibility, amplified fragment length polymorphism (AFLP) analysis and polymerase chain reaction (PCR)-based single locus genetic markers to examine the genetic diversity and structure of populations of *R. solani* AG-3 on seed tubers from Canada, Maine and Wisconsin and in North Carolina soils (NC). Results suggest that populations of *R. solani* AG-3 exhibit a high level of genetic diversity and have a mixed population structure with evidence for both clonality and recombination. High levels of genetic diversity were detected in introduced seed tubers from Canada, Maine, and Wisconsin (50 different genotypes among a total sample of 58 isolates). Seven of these genotypes were amongst the most frequent genotypes observed in North Carolina commercial potato production fields. The potential utility of molecular-based techniques to better understand aspects of population biology and genetics for predicting ecologically important variation related to disease management will be discussed in the context of developing seed certification strategies for *Rhizoctonia*.

(S13) Dynamics of Ridomil Resistance in Populations of *Phytophthora erythroseptica*, cause of Pink Rot of Potato. Lambert D.H.* and A.I. Currier, University of Maine, Orono, ME 04469.

Many *P. erythroseptica* isolates in Maine are moderately (MR, EC₅₀ ca. 4 µg metalaxyl/ml) or highly resistant (HR) to Ridomil. Pink rot field trials with 'Russet Norkotah' were conducted from 1997 to 2000 to investigate the rate at which Ridomil effectiveness might be lost in pathogen populations containing resistant strains. While effectiveness of foliar Ridomil treatments was variable, standard in-furrow applications achieved 100% control of sensitive strains in all three such trials. No control of HR strains and little or no control of MR strains occurred in the two trials with mixed populations. In untreated areas, the percentage of MR isolates remained constant over 3 yr. (15, 18, and 19%), indicating MR fitness equivalent to the sensitive population. Incidence of tuber infection following 1 yr of oat, barley or soybean ranged from 0.4 to 0.8% vs 11.1% in those plots which followed potato. This low contribution of older and rotation crop inoculum implies that most *P. erythroseptica* inoculum is produced by the most recent potato crop in such rotations and, therefore, that the very high selective pressure of in-furrow treatment would rapidly increase the proportion of resistant individuals. Following a Ridomil treatment which reduced infection by sensitive strains 50%, the incidence of MR tuber isolations increased from 18% in 1999 to 31% in 2000, close to the 30% expected if potato debris was the only significant source of inoculum.

(S14) Certification Issues Surrounding Columbia Root-knot Nematode (*Meloidogyne chitwoodi*). Ingham, Russell E.* and Philip B. Hamm, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331 and Department of Botany and Plant Pathology, Oregon State University, Hermiston Agriculture Research and Extension Center, P.O. Box 105, Hermiston, OR 97838.

Columbia root-knot nematode, *Meloidogyne chitwoodi*, infects potato tubers causing galling on the surface and minute, brown spots in the tuber as a response to the presence of adult females. Both symptoms are quality defects that can cause commercial crops to be devalued or rejected if 5-15% of tubers are affected. Large acreage is infested in Idaho, Oregon and Washington and *M. chitwoodi* is also reported from California, Colorado, Nevada and Utah. The nematode survives where soils freeze, infects roots at 6 C or above, and thrives in warm soils, so the potential range of CRKN may be far larger than its current distribution. Northern root-knot nematode, *M. hapla*, is a problem on potato in many areas east of the current range of *M. chitwoodi* and *M. chitwoodi* should be able to exist in those areas if introduced. Since *M. chitwoodi* can develop during seed storage, and infective juveniles are released from infected tubers, the potential for spread in seed is high. All seed should be certified for zero tolerance to *M. chitwoodi* to prevent spread to new areas. Growers with seed fields in regions where *M. chitwoodi* occurs should sample on a small area basis (<10 acres/sample) before planting to ensure detection if present. Tuber inspections for external galling and females in tubers should be conducted at harvest and/or, preferably, before seed leaves storage for shipment. While USDA may conduct shipping point inspections in many instances, it behooves seed producers to be proactive and inspect all seed lots before shipping to affirm that *M. chitwoodi* will not be spread.

(S15) Distribution, Biology and Efficiency of the Vector of Tobacco Rattle Virus Causing Corky Ringspot Disease of Potato in the Pacific Northwest. Mojtahedi, Hassan^{1*}, G. S. Santo¹, P. E. Thomas², J. M. Crosslin¹, and C. R. Brown².
¹Washington State University, Irrigated Agriculture Research and Extension Center, 24106 Bunn Rd. Prosser, WA, and ²USDA-ARS, Prosser, WA.

Paratrichodorus allius was identified in 30% of soil samples collected from potato fields in Washington, Oregon, Idaho. Tobacco rattle virus (TRV) was transmitted to Samsun NN tobacco from only 10% of *P. allius*-infested soil samples. TRV caused typical symptoms on tobacco. Only 0-6% individual *P. allius* from potato fields expressing either severe or mild corky ringspot (CRS) symptoms transmitted TRV to tobacco. All viruliferous populations of *P. allius*, regardless of origin, transmitted TRV to Russet Burbank and Russet Norkotah potato tubers provided the soil moisture level in pot cultures was maintained at or above field capacity. The severity of CRS, however, depended on the virus isolate and vector density. In pot cultures, three *P. allius*/250 cm³ of soil was enough to initiate CRS on potato. Under field conditions, the tubers of Russet Burbank and Russet Norkotah developed 2 mo after planting, and quickly become vulnerable to *P. allius* feeding, and TRV infection. The severity of CRS increased for 35 and 50 days after the first detection of symptoms in Russet Norkotah and Russet Burbank tubers, respectively. *P. allius* populations remained low and unchanged during the growing season. The field observations confirmed our conclusions from greenhouse tests that potato tubers become vulnerable to TRV transmission soon after they are developed and should be protected from *P. allius* invasion for at least 8 weeks.

(S16) An Apparent New Strain of Tobacco Rattle Virus that causes Systemic Symptoms in Potatoes. Thomas, P. E.*¹, K. Thompson², R. E. Ingham³, and J. M. Crosslin⁴, ¹Agricultural Research Service, U.S. Department of Agriculture, ⁴Washington State University, 24106 N. Bunn Road, Prosser, WA 99350-9687, ²Agro Engineering, 0210 Road 2 South, Alamosa, Co 81101, ³Oregon State University, 2082 Cordley Hall, Corvallis, OR 97331-2902.

Systemic foliage infection of potato with tobacco rattle virus (TRV) is rare and has never been reported to occur routinely. Circular areas in which plant emergence was delayed for 4 to 6 weeks after seeding were observed in two potato fields of Colorado, one in 1998 (Cultivar Norkotah Russet) and another in 2000 (Cultivar Russet Nugget). Emerging stems of plants in affected areas were malformed and contained necrotic streaks. Foliage had irregular ringspot and mottle symptoms, and flowering was delayed. Tubers from affected areas had typical TRV symptoms and produced positive PCR assays for TRV while tubers from unaffected areas were free of symptoms and produced negative PCR assays. The foliage, stems, and roots of affected plants routinely assayed negative for TRV by ELISA but positive by PCR analysis. TRV was isolated from some roots by mechanical transmission to tobacco. A single nematode vector species of TRV (*Paratrichodorus allius*) was found in soils in the affected areas. These results implicate TRV as the cause of the disease and indicate that the strain of virus involved routinely moves systemically in plants in its naked RNA form. Studies are underway to confirm this conclusion experimentally. The symptoms putatively caused by the virus provide a striking visual assessment of TRV distribution in contaminated fields that previously was never observed.

(S17) Control of Corky Ringspot in Oregon. Ingham, Russell E., Philip B. Hamm* and Kenneth A. Rykboost, Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331, Department of Botany and Plant Pathology, Oregon State University, Hermiston Agriculture Research and Extension Center, P.O. Box 105, Hermiston, OR 97838 and Department of Crop Science, Oregon State University, Klamath Experiment Station, 6941 Washburn Way, Klamath Falls, OR 97603.

Corky ringspot (CRS) produces corky, necrotic arcs, rings or spots, which are quality defects in tubers that can lead to crop rejection. The disease is caused by tobacco rattle virus (TRV), vectored by stubby-root nematodes (*Paratrichodorus allius*) in the western U.S. In Oregon, this disease is found in isolated fields in the Columbia Basin (CB), Klamath Basin (KB), Central Oregon and Treasure Valley growing areas. Furthermore, *P. allius* is widespread in many fields that do not express symptoms when potatoes are grown. Introduction of TRV into these fields through infected potato or weed seed or movement of soil carrying nematodes with TRV in wind, water or on machinery, presents the potential for CRS to become more widespread. Corky ringspot was suppressed by aldicarb until its suspension in 1989, whereupon many fields expressed high levels of CRS. Metam sodium (MS) applied through chemigation or surface incorporated ethoprop alone, do not control CRS, but combined treatments are effective. 1,3-dichloropropene (1,3 D) has been effective in the CB but requires the addition of ethoprop in the KB. Combinations of MS and 1,3-D have controlled CRS in the CB. Post emergence applications of oxamyl have been effective in the CB if applications begin before tuber initiation. All major cultivars grown in the region are susceptible, but Russet Norkotah expresses fewer symptoms than Russet Burbank, Ranger Russet, Shepody or Century, which are highly susceptible. Resistance is available in some current breeding lines and in several cultivars grown in other regions of the U.S.

(S18) Defending the Profitability of Growing Potato in the Columbia Basin: Development of Corky Ringspot and Columbia Root-knot Nematode Resistant Germplasm. Brown, C. R.^{1*}, H. Mojtahedi², G. S. Santo², P. Hamm³, R. Novy⁴, D. Corsini⁴, S. Love⁵, and S. James⁶, ¹USDA/ARS, Prosser, WA, ²Washington State University-Irrigated Agriculture Research and Extension Center, Prosser, WA, ³Oregon State University-Hermiston Agricultural Research and Extension Center, Hermiston, Oregon; ⁴USDA/ARS, Aberdeen, Idaho, ⁵University of Idaho, Aberdeen, ID, ⁶Oregon State University-Central Oregon Experiment Station, Madras, OR.

Columbia root-knot nematode (*Meloidogyne chitwoodi*) and corky ringspot disease (CRS) together pose serious risks to potato quality and yield in the Columbia Basin of Washington and Oregon. The cost of two fumigation treatments approximates \$ 350 per acre, and the types of fumigants pose environmental problems that will continue to be controversial in the future. Resistance to Columbia root knot nematode has been found in several wild Mexican species, and has been introgressed into advanced backcross generations. Resistance to CRS is ubiquitous in advanced breeding materials. The resistance to CRS has been found to be active against the tobacco rattle virus, and not against the vector, stubby root nematode (*Paratrichodorus allius*). Combined resistance to root-knot and CRS has been selected for the first time in materials that have long tuber shape, high yield, and good frying qualities. The patchy occurrence of CRS, even in fields with severe infection pressure, poses a problem in reliability of screening results. It appears that supplementation of inoculum, by adding soil with pot-grown viruliferous nematodes to field plots, may help to homogenize severity of disease pressure, but timing of inoculation appears to be crucial. There appears to be considerable variation in virulence of nematode-virus isolates from different fields and specific interactions between certain clones and nematode-virus cultures has occurred, meaning that some clones are resistant to one culture, but not another. Similarly, some clones are resistant in one field but not another. Fortunately, strong non-specific CRS resistance has also been found and used to advance the program.

(S19) Development of Russet-Type Germplasm with Resistance to Corky

Ringspot. Love, Stephen L.*¹, Thomas A. Salaiz¹, Joseph J. Pavek¹, and Charles R. Brown². ¹University of Idaho, Aberdeen R & E Center, Aberdeen, ID 83210. ²USDA/ARS, Washington State University IAREC, Prosser, WA 99350.

Corky ringspot (CRS), caused by tobacco rattle virus and vectored by stubby root nematodes (*Trichodorus sp.*), is rapidly becoming a widespread problem in the northwestern U.S. Genes for resistance are present in many European and a few older North American cultivars. No consistent effort has been made to develop resistance in the russet-type cultivars that are predominant in Northwest potato production. This report summarizes eleven years of research to develop russet type germplasm with resistance to CRS. Initial screening of existing USDA/ARS (Aberdeen) germplasm identified two corky ringspot resistant clones, A72630-9 with resistance derived from Bintje and A77567-7 with resistance derived from Multa. Both resulted from crosses between CRS resistant and russet skinned parents. A cross between the A72630-9 and A77567-7 produced A8259-5, a clone with russet skin, oblong shape, yellow flesh, and a high level of CRS resistance. Screening of additional USDA/ARS germplasm identified other sources of resistance, including AC Brador and progeny of Fianna (NZA8904-2), PI407415 (A77715-6), Ukama (A89875-5), *S. andigena* (A8793-6), and complex Polish germplasm (A90586-11). These resistant clones were hybridized with russet parents and 105 progeny clones screened at Egin, ID and Pasco, WA from 1992-2000. Twelve clones with russet parentage have been identified as having high levels of resistance to CRS, combined with good adaptation. Six of these clones have oblong to long shape and russet skin and will be important for developing new cultivars with CRS resistance in combination with russet-type appearance and quality characteristics.

(S20) Reduction and Elimination of Tobacco Rattle Virus from Soils in Alfalfa Cultures. Thomas, P. E.^{1*}, H. Mojtahedi², J. M. Crosslin³, and G. S. Santo⁴, ^{1,3}Agricultural Research Service, U.S. Department of Agriculture, ^{2,4}Washington State University, 24106 N. Bunn Road, Prosser, WA 99350-9687.

Historically, it has been difficult or impossible to eliminate tobacco rattle virus (TRV) from soils once the virus became established with its nematode vector. Numerous experiments conducted in greenhouses or fields of the Columbia Basin indicate that TRV may not survive in pure alfalfa (*Medicago sativa*) cultures. Initially, we observed that TRV could no longer be isolated from parts of a heavily contaminated field 3 years after it was seeded to alfalfa and maintained essentially weed free. In contrast, TRV was routinely isolated from weedy parts of the same field that were not seeded to alfalfa. The nematode vector remained prevalent in the alfalfa field. TRV was markedly reduced but not completely eliminated after 3 years in alfalfa plots that were not maintained completely free of weeds. TRV was occasionally detected at extremely low concentrations, only by PCR procedures, in the roots of eight alfalfa cultivars grown in contaminated soil in greenhouse pots (8 or 16 weeks) or in field plots. However, TRV could not be isolated from such roots by mechanical or by nematode transmission after roots were washed and transplanted to virus free soil. In contrast, virus-free nematodes routinely acquired TRV from the roots of susceptible tobacco plants handled in the same manner. Nematodes that initially transmitted TRV to tobacco lost ability to transmit after maintenance on alfalfa for 3 months in a greenhouse.

(S21) Biology and Distribution of Potato Cyst Nematodes in North America and their Economic Impact on Potato Production. Brodie, B. B.*, USDA, ARS, Dept. of Plant Pathology, Cornell University, Ithaca, NY 14853.

Soil and climatic conditions in all major potato production areas of North America are conducive to the development of potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*) making these nematodes a threat to the entire potato industry. Their life cycle is completed in 38 to 58 days with longer time required at lower soil temperatures. Population increase varies from 10 to 35 fold per growing season with greater increases at lower population densities. There is only one generation per year. Encysted eggs can remain dormant in the soil for many years in the absence of a host. Only *G. rostochiensis* (golden nematode) is present in the United States and only in the State of New York where two pathotypes, Ro1 and Ro2, exist. Both *G. rostochiensis* and *G. pallida* are present in Newfoundland, Canada but only *G. rostochiensis* is known to exist on Vancouver Island. Only *G. rostochiensis* is reported from Mexico but other closely related *Globodera* species are also present. If left uncontrolled, the golden nematode can cause up to 80% loss in yield. Since the initiation of statutory control programs (quarantine and regulations) in North America, no yield losses have been recorded. Indirect losses are manifest in the expenses of managing the statutory programs and in restrictions of activities of other agricultural industries, which lowers the total agricultural income of the infested region.

(S22) The Global Initiative on Late Blight (GILB). Collins, Wanda*, Deputy Director General for Research and GILB Coordinator, International Potato Center, Apartado 1558, Lima 12, Peru. cip-ddg-research@cgiar.org.

The Global Initiative on Late Blight (GILB) was launched in 1996 to bring scientists and development experts from both developing and developed countries together to increase the efforts and resources devoted to this problem. Forty-one participants from developing and industrialized countries met at a project design meeting at the International Potato Center (CIP) in Lima, Peru in 1996. A three-phase, 10-year program was planned with specific priorities for each phase. GILB is coordinated from the International Potato Center, Lima, Peru. GILB operates as a facilitating, rather than a funding or research mechanism in itself, and serves as a focal point for members to decide on common objectives, priorities and to share results. In 1999, three years after its beginning, GILB organized a global conference (GILB'99), entitled *Late Blight: A Threat to Global Food Security*, in Quito, Ecuador. Some 165 participants from 40 countries attended to review the late blight situation in general, and the progress of GILB and its participants towards control of the disease. Because of the progress made in GILB during its first three years of existence towards meeting the initial priorities, and because of changes in the external environment affecting late blight research (such as the rapid advances in molecular technologies), new priority areas were established to guide GILB activities for the next three years. The five priority areas for GILB are Breeding for Host Resistance, Pathogen Studies, Integrated pest management for late blight (IPM-LB), Training and Information.

(S23) Global Initiative on Late Blight (GILB) Linkage Groups. Lizárraga, Charlotte*, Assistant GILB Coordinator, International Potato Center, Apartado 1558, Lima 12, Peru. cip-gilb@cgiar.org.

The Global Initiative on Late Blight (GILB) organized the global conference *Late Blight: A Threat to Global Food Security* (GILB'99), which was held 16 – 19 March 1999 in Quito, Ecuador. The purpose of this conference was to bring late blight experts from all over the world to learn about the global status of the disease, relevant technology development and implementation, and to decide on future concerted action. During workshops and discussions in the later part of the conference, participants expressed the need to be more closely linked to each other in order not to duplicate efforts and to learn what others are doing. GILB'99 was appreciated as a mechanism to do this, but a conference every three years was not judged sufficient to provide the ongoing and close associations necessary for efficiently working together. To meet this need Thematic (Breeding for Host Resistance, Integrated Pest Management, Molecular Studies of the Pathogen, Variation and Evolution of *Phytophthora infestans*) and Regional (Africa, Europe, Latin America, Southwest Asia, and East and Southeast Asia) were formed. These groups are active and have web pages with contact lists, laboratory protocols, databases and other information maintained by GILB (<http://www.cipotato.org/GILB>). Many of them have held initial planning meetings with GILB support.

(S24) Significance of Sexual Reproduction in *Phytophthora infestans* Epidemiology. Miller J. S.*, University of Idaho, PO Box 870, Aberdeen, ID 83210.

Phytophthora infestans is heterothallic, unlike the majority of *Phytophthora* species. When antheridia and oogonia of two isolates of alternate compatibility type come in contact, sexual reproduction leads to the production of thick walled oospores. Oospores can also form in vitro in the absence of both mating types when pathogen cultures become old or stressed, and when isolates are exposed to fungicides or other fungal species. The presence of both A1 and A2 compatibility types in portions of Europe has led to sexual recombination, resulting in a diverse population structure. In North America, evidence for sexual recombination has been found in only a few localities. Two results of most consequence to potato production from sexual recombination are 1) the formation of oospores and 2) the generation of new, aggressive strains of the pathogen. The first consequence is important because oospores can survive in soil in the absence of the host plant. Oospores can also remain viable after exposure to low temperatures. Even though oospore germination levels are typically low, oospores can serve as an early source of inoculum when potato crops are first established in a field. Data supporting the second consequence of sexual recombination have been harder to obtain in North America. However, recent work suggests that oospore progeny can be aggressive, therefore making control of late blight more difficult. Laboratory studies have shown that the US-11 clonal lineage may have been generated from a cross between isolates of the US-6 (A1) and US-7 (A2) lineages. The US-11 is highly aggressive and has caused significant potato crop losses in portions of North America.

(S25) Late Blight in the United States and Canada. Deahl, Kenneth L.* and Richard W. Jones, USDA, ARS, PSI, Vegetable Laboratory, Beltsville, MD 20705.

Late blight caused by *Phytophthora infestans* continues to be a very serious problem throughout the potato production areas of the United States and Canada. In order to develop more effective control strategies for late blight disease management, many scientists have attempted to characterize the genetic and phenotypic variation in various populations of the fungus. Although mating type changes provided the first suggestion of major modification in *P. infestans* populations, variations in metalaxyl sensitivity also indicated dramatic changes in this pathogen. The results based on morphology, pathogenicity, ribosomal internal transcribed region 2 (ITS2) sequence, isoenzyme markers, DNA fingerprints obtained using multilocus probe RG-57, and genetic markers based on analysis of mitochondrial DNA (mtDNA) has permitted further resolution of genetic diversity in populations from different locations in the U.S. and Canada. Knowledge of this pathogen diversity has helped identify potential new strategies for disease management and has assisted in determining where future monitoring of the pathogen is necessary. However, despite all that has been discovered with contemporary analyses of the population variability of *P. infestans* during the last few years, particularly with DNA-based markers, many unanswered questions remain to be investigated in the future.

(S26) Late Blight in Latin America, Africa and Asia. Forbes, Greg*, International Potato Center, P.O. 17-21-1977, Quito, Ecuador.

The dynamics of potato late blight depend on the agro-ecosystem. In many developing countries in Latin America, Asia and Africa, potatoes are grown under sub tropical (generally winter production) or tropical highland conditions. Late blight is particularly problematic in the latter. In the tropical highlands, potatoes are grown year-round and aerial inoculum of *Phytophthora infestans* is present most of the time. For this reason, late blight attacks can occur very early in crop development, frequently just after plant emergence. Therefore, sanitation procedures, the primary components of late blight IPM in the temperate zone, probably have little effect in the tropical highlands. Late blight management in the tropical highlands is based primarily on methods that reduce the rate of disease spread, such as host resistance and fungicides. Host resistance has been used more extensively in developing countries than in the US and Europe. Fungicides are used extensively in most developing countries, but application technologies vary. Average daily temperatures found in the tropical highlands (10 – 14 C) are sub-optimal for late blight development. This reduces the rate of disease spread and thereby enhances the effects of host resistance and fungicides. Low temperatures, therefore, compensate somewhat for the problem of having inoculum present throughout the growing season. Many farmers in the tropical highlands are unaware of germ theory and attribute late blight symptoms to abiotic or even mystical factors. Highly participatory farmer-training models have been modified from other cropping systems to be used with potato farmers in the tropical highlands.

(S27) Potato Late Blight in Ireland and Europe. Cooke, Louise R.*, Applied Plant Science Dept., Queen's University Belfast, Newforge Lane, Belfast, BT9 5PX, UK.

Potato late blight in Ireland, as elsewhere in Europe, belongs exclusively to the new population of *Phytophthora infestans* and is distinct from the more recent new introductions into North America.

Typically, European *P. infestans* populations show little variation for allozyme genotype (*Gpi*, *Pep*), contain both A1 and A2 mating types and metalaxyl-resistant and -sensitive strains (the frequency varying between regions and years). Metalaxyl-resistant strains tend to be A1, but there is no clear association between mating type, allozyme genotype and metalaxyl resistance as in N. America. The A2 mating type is found more often on tomato than potato, in allotment gardens than commercial fields and in northern rather than southern and western Europe. In the Netherlands and Scandinavia, where the A2 mating type is common, oospores occur in the field and may act as primary inoculum. In Ireland, the A2 mating type is rare so oospore formation is unlikely.

Because the Irish climate favors blight epidemics in most years and susceptible potato cultivars are widely grown, control depends on fungicides. In Northern Ireland, metalaxyl-resistant strains occurred in under 50% of isolates in every year since 1995 (except 2000, 57%). It is recommended that systemic fungicides are used early in the program with not more than three applications to limit selection for resistance. After this, formulations containing a translaminar (e.g. dimethomorph) or a non-systemic protectant (fluazinam or mancozeb) may be used, followed by fentin to reduce tuber infection. In practice, most growers use a range of products, although some still rely entirely on protectants and generally apply c. 8 sprays per season.

(S28) Skin-Set: Measurement and Physiology of Resistance to Tuber Skinning Wounds. Lulai, Edward C.*, USDA-ARS, Northern Crop Science Laboratory, Fargo, ND 58105-5677.

Tuber skinning wounds result in costly disease, blemish defects and shrinkage in processing, seed and fresh market potatoes. We have conducted research and developed a body of information on the measurement of skin-set and the physiology of periderm maturation and resistance to skinning wounding. Measurement of the rate of skin-set development among diverse genotypes showed that resistance to skinning developed slowly and varied from year to year. Cultural conditions appeared to be as important as vine killing in affecting the rate of skin-set development. Contrary to anecdotal information, periderm maturation and the development of resistance to skinning wounds were **not** accompanied by skin thickening or large changes in skin tensile strength. Periderm maturation is characterized by a reduction in vapor conductance which is more pronounced in russeted than smooth skinned varieties. This water vapor loss may be important in skin-set development because our results show that the cellular damage incurred upon skinning is restricted to the turgor sensitive cells of the native periderm, i.e. the phellogen. The radial walls of active phellogen cells are thin, fragile, easily fractured and are the source of susceptibility to skinning. After growth ceases, the phellogen becomes inactive, the cell walls strengthen and thicken and are no longer easily broken; thus the skin is firmly held in place. Our current research is directed towards identifying the biochemical processes and regulatory mechanisms responsible for skin-set and related wound-healing.

(S29) Biochemical Changes in Cell Wall Structure Associated with Periderm Maturation. Sabba, Robert P.* and Edward C. Lulai, USDA-ARS, Northern Crop Science Lab, Fargo, ND 58105-5677.

Skinning of potato tubers results in hundreds of millions of dollars of losses to producers every year. Potatoes are susceptible to skinning when they are harvested before periderm maturation (skin-set) is complete. Research in our laboratory has shown that skin-set is dependent on changes in the cell wall structure of the meristematic cell layer of the periderm (phellogen). In particular, radial walls of the phellogen cells thicken during skin-set. The biochemistry of these changes in wall structure are poorly understood. Our research indicates that an increase in un-esterified (acidic) pectins in phellogen cell walls accompanies maturation of the periderm. Staining with ruthenium red indicates that the phellogen cell walls of immature periderm include esterified pectins, but are lacking in un-esterified pectins. Periderm maturation is accompanied by an increase in un-esterified pectins in phellogen walls. Although peroxidases are involved in the cross-linking of many polymers in the cell wall, we could not detect any changes in peroxidase activity (in situ) in phellogen walls that accompanied maturation of the periderm. Development of wound periderm differs from native periderm, in that wound periderm maturation is not accompanied by an increase in un-esterified pectins in the phellogen cell walls. We are continuing to investigate the biochemical changes in phellogen cell walls associated with skin-set development.

(S30) Relating Potato Skinning to Field Measurements of Skin-Set. Pavlista, Alexander, D.*, University of Nebraska-Lincoln, Panhandle Research & Extension Center, 4502 Ave. I, Scottsbluff, NE 69361.

Desiccating potato vines, chemically or mechanically, hastens tuber skin set which is commonly estimated by skinning tubers with an abrasive apparatus. A hand-held torque meter was developed for measuring tuber skin resistance to sheering as a measure of skin set. To demonstrate practical use of the torque meter to growers, sheer resistance must be related to the actual skinning of tubers. In conjunction with desiccation trials, 'Atlantic' and 'Snowden' potato tubers were individually measured for skin sheer resistance followed by skinning. There is a linear relationship between skin sheer resistance and tuber skinning. The regression equations were sheer force (oz*in) = 49-0.19* skinning (%) for Atlantic and sheer force (oz*in) = 54-0.24* skinning (%) for Snowden. As vines desiccated over the three weeks after chemical or mechanical treatments, skinning decreased and sheer force resistance increased. The objective measuring of sheer resistance was directly related to the more subjective measuring of tuber skinning with an R-square of 0.8. The torque meter can be used in the field or office. The major difficulty was maintaining a constant pressure on the tuber skin while applying the torque force.

(S31) Bacterial Wilt of Potato Caused by *Ralstonia solanacearum*: A Growing Threat to Seed and Ware Potato Production. Pradhanang, P.M.* and M.T. Momol, University of Florida, IFAS, NFREC, Quincy, FL 32351-9500

Ralstonia solanacearum is indigenous in the Southern United States, causing bacterial wilt mainly in tobacco, tomato and potato. The US strains of *R. solanacearum* are exclusively biovar 1. Serious bacterial wilt outbreaks have in recent years been rare in Florida potatoes, even in fields continuously planted to the crop. There is little information in the US on survival of the bacterium in the natural environment. Therefore the risks of pathogen establishment and spread are not predictable. Recent outbreaks of bacterial wilt in European countries, caused by *R. solanacearum* biovar 2A (race 3), have confirmed infection of the semi-aquatic weed *Solanum dulcamara* and overwintering in this host under natural conditions. The source of *S. dulcamara* infection is unclear, but may be due to importation of infected ware potatoes and subsequent contamination of canal water used for irrigation of potato. It is not known if *R. Solanacearum* biovar 1 can survive under natural conditions in *S. dulcamera* and other solanaceous hosts indigenous to the US. European law requires official surveys to monitor pathogen distribution in potato imports and exports and around outbreak sites; and that measures be taken to contain the pathogen with a view to eventual eradication. The value of similar measures for control of *R. solanacearum* in US, detection methods, persistence in soil, and modes of transmission is discussed.

**General Session
Abstracts**

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(1) Ploidy Reduction of a Fertile Tetraploid Intermonoploid Somatic Hybrid for Studying Somaclonal Variation. Lightbourn, Gordon* and Richard E. Veilleux, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The disappointing performance of intermonoploid somatic hybrids of potato, expected to be both heterozygous and free of lethal and deleterious alleles, may derive from increased methylation status of DNA or activation of retrotransposons. Both processes are known to be activated by the tissue culture technique. Our objective was to develop unique potato germplasm that will allow us to examine these processes and address their involvement in somaclonal variation that may result from either protoplast fusion (and subsequent plant regeneration) or anther culture. A tetraploid intermonoploid somatic hybrid (SH18C) has been developed by electrofusion of independently derived monoploids. Microsatellite polymorphism was used to distinguish SH18C from somaclones derived from unfused protoplasts. Its tetraploidy was confirmed by flow cytometry. SH18C was male and female fertile in crosses with tetraploid potato cvs. Atlantic and Katahdin. Seedling progeny (SH18C x Katahdin and Atlantic x SH18C) were transplanted to the field in May 2000 in a RCB design with three replications of two families represented by 20-plant plots. Mean yield of hybrid seedlings (720 g/plant) exceeded that of SH18C (453 g/plant) and approached that of Atlantic (800 g/plant). Anther culture of SH18C yielded more than 200 androgenic haploids ($2n=2x=24$). For DNA methylation and retrotransposon studies, we have the original anther-derived monoploids, their tetraploid somatic hybrid and haploids derived by anther culture of the somatic hybrid. For testing the effects of anther culture without confounding with protoplast regeneration, we have available androgenic and gynogenic monoploids derived from a selection of adapted *S. phureja*.

(2) Resistance of *Solanum andigenum* Accessions Maintained at VIR and US Potato Genebanks to Golden Nematode. Kiru, Stepan*¹, Svetlana Makovskaya² and John Bamberg³, ¹N. Vavilov Res. Institute (VIR), B. Morskaya Str. 42, St. Petersburg, 190000, RUSSIA; ²All Russian Plant Protection Institute, Podbelskoe shosse 14, VIZR, Poushkine, St. Petersburg 199606, RUSSIA; ³USDA/ARS, US Potato Genebank, 4312 Hwy 42, Sturgeon Bay, WI 54235 USA.

The best method for combating golden nematode, *Heterodera rostochiensis*, is the creation of varieties resistant to this pest. The cultivated potato species *Solanum andigenum* Juz. et Buk. has a great diversity of forms. Many forms are resistant to golden nematode. In 1998-2000 a joint evaluation of resistance to this pest was done on 115 accessions maintained both at N. Vavilov Institute and the US Potato Genebank, NRSP-6.

Evaluation was made by growing clones in a greenhouse in pots with soil infested with golden nematode cysts (RO2 and RO4) by the test method of the Plant Protection Institute. Fourteen accessions were found to be free of nematode cysts. Eight of these confirm resistance earlier noted by cooperators who screened the same materials from US Potato Genebank. The inheritance of resistance of the selected accessions was tested by evaluating the progeny from crosses with non-resistant cultivars. Resistance of 28 F1 combinations varied from 35 to 78. The most frequent ratio of resistant to infected seedlings was 3:1, suggesting that resistance to nematode is dominant and monogenic. The majority of the selected resistant accessions were originally collected in Argentina.

(3) Analyses of Scab Reaction Evaluation Data from Long Term Field Plots.

Murphy, Agnes*, Xing-Yao Xiong, George C.C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, 850 Lincoln Rd., Fredericton, NB, E3B 4Z7.

Scab results consisting of 994 records from 5 years of trials representing 311 genotypes from 59 male parents and 33 female parents and more than 100 grandparents were statistically analyzed by the "Residual Maximum Likelihood" (REML) method. A random model was assumed for the effects of all parameters: genotypes, years, replicates within years and interactions between genotypes and years.

Data were reassembled according to male and female parents and by the four sets of grandparents for analysis by REML to produce Best Linear Unbiased Predictors (BLUP) estimates. The BLUP estimates of the male and female parents and grandparents were used to examine the relationship between parents and progenies and grandparents and progenies. A sub-sample of the data were analyzed to study the relationship between parents and crosses.

The analyses suggested that BLUP estimates for crosses, parents and grandparents provide reliable evaluation of the breeding value of genotypes. The heritability estimates were all over 60%. The parent/offspring regression analyses of BLUP estimates gave significant and fairly high correlations between observed and estimated values for genotypes to parents and genotypes to grandparents ($R=.64$). Regression equations of cross BLUPS to parent and grandparent BLUPS gave very high correlations between observed and estimated values ($R=.93$ and $.92$ respectively). It was possible to separate resistant and susceptible parents and grandparents based on BLUP estimates.

(4) Genetic Studies of Unilateral Incompatibility between Diploid (1EBN) Mexican Species *Solanum pinnatisectum* and *S. cardiophyllum* subsp.

cardiophyllum. Kuhl, J. C., M. J. Havey, and R. E. Hanneman, Jr.*, Vegetable Crops Research Unit, USDA, Agricultural Research Service, Department of Horticulture, University of Wisconsin, Madison, WI 53706.

Many angiosperms have developed mechanisms to prevent self pollination and inbreeding. The most wide spread system self incompatibility (SI) is gametophytic, where pollen tube growth is inhibited in the style by the action of a single locus (S-locus). Similar inhibition of pollen tube growth can also be observed in interspecific crosses, where successful pollinations occur in only one direction, termed unilateral incompatibility. Unilateral incompatibility was observed in crosses between *S. pinnatisectum* and *S. cardiophyllum* progenies only when *S. pinnatisectum* was used as the pistillate parent. Segregations in the BC₁ family backcrossed to *S. cardiophyllum* revealed two independent putative loci controlling unilateral incompatibility, with both putative loci inherited independent of the S-locus. However, segregation ratios in the second backcross family did not agree with those observed in the first family. Segregation disparity between the two families may be due to distorted transfer of specific alleles or the presence of different mechanisms controlling pistil and pollen recognition systems in the two species.

(5) Wild Potato Germplasm Collecting Expedition to Honduras and Panama.

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Two wild potato species grow in Honduras (*Solanum agrimonifolium* Rydb. and *S. morelliforme* Bitter and G. Muench) and two grow in Panama (*S. longiconicum* Bitter and *S. woodsonii* Correll), but there were no germplasm collections of these species from these countries. We searched in Honduras from August 27 to September 4, and in Panama from September 5 to September 14, 2000. We planned our collections with data from prior herbarium collections and predictors of appropriate habitats from Geographic Information System tools. No germplasm was found in Honduras, but the two sole records were more than 30 years old and the populations may have disappeared. A dry year in Honduras may have inhibited growth of wild potatoes there, but wild potatoes truly are rare in Honduras. We collected germplasm from five populations from Panama. Two of these were the first germplasm collections of *S. woodsonii*, a species only known from Panama, and three were *S. longiconicum*, representing the first Panamanian collections of a species also known from adjacent Costa Rica. We propose a return visit to these countries in February and March, 2002, allowing collections after the rainy season and allowing our collaborators time to plan a longer expedition and seek additional populations of wild potatoes.

(6) Identification of Named Varieties, Advanced Selections, and Accessions with High Antioxidant Activity for use in Breeding Potatoes for Enhanced Human Health Benefits.

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Potatoes are recognized by many consumers as an important source of carbohydrate, but little is known about their antioxidant content. Other crops, for example blueberries, are reported to be very high in antioxidants and have been promoted for this reason. However, the average per capita consumption of blueberries in the U.S. is only about 13.9 oz, compared to 145 pounds for potato. Thus, even moderate levels of antioxidants in potato could benefit human health and provide a basis for promotion of the crop. Therefore, the objective of this investigation was to assess the variability in potato for antioxidant activity.

Some 25 varieties, 69 advanced selections, and 30 accessions were screened for total antioxidant activity. Antioxidants were extracted and allowed to react with the stable radical, 2,2,-Diphenyl-1-picrylhydrazyl (DPPH). This provided an easy and rapid evaluation of the antiradical activities of the potato extracts based on absorbance.

Purple Peruvian, TXNS112, All Blue, ATX9312-1Ru, CORN8, ATX96007-1P/Y, Russet Norkotah, and TXNS296 were identified as significantly higher in total antioxidant activity. Significant differences were found between Russet Norkotah and its strains. In the subsequent screen, several wild relatives of potato were determined to be high in total antioxidant activity. The highest of these was a bulked sample of *S. pinnatisectum*. Of the varieties and advanced selections, NDC4069 and All Blue ranked highest. This variability is evidence for genetic control of antioxidant capacity and provides the opportunity to breed new potato varieties with increased human health benefits.

(7) Aflp Mapping of Genes Controlling Leptine Synthesis in Tetraploid Potatoes.

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Genetic resistance to Colorado potato beetle (CPB; *Leptinotarsa decemlineata* [Say]) that is present in *S. chacoense* is associated with a high content of leptines. A segregating tetraploid population, ND5873 (ND4382-19 x Chipeta), was used to map two genes involved in the synthesis of leptines. These segregated as two complementary epistatic genes that allowed the synthesis of leptinidine and acetyl-leptinidine, respectively. Partial AFLP maps for both parents were developed using 97 individuals from population ND5873 and 577 markers. The total lengths mapped for ND4382-19 and Chipeta were 1883 cM and 1021 cM, respectively. The marker for leptinidine was located at the distal end of simplex-coupling linkage group R37, a homolog of chromosome II. Expansion of the population by 51 +leptinidine individuals allowed us to identify the linkage group that enabled synthesis of acetyl-leptinidine.

Quantitative trait loci (QTL) analysis showed that a factor different from leptine content explained the resistance to defoliation by CPB in four different environments. A major QTL present on chromosome II explained over 20% of the variance in three different environments ($p < 0.0001$). The association between acetyl-leptinidine and CPB resistance was weak. These results indicate the likelihood of a separate important factor for resistance to CPB.

(8) Mapping of Genes Associated to Late Blight, *Verticillium* Wilt and Cold Sweetening Resistance in Potatoes. Saha, M. C.* and J. H. Lorenzen, North Dakota State University, Dept. of Plant Sciences, Loftsgard Hall, Fargo, ND 58105.

Host-plant resistance is an effective and economical means of controlling plant diseases and disorders. Accessions of 10 *Solanum* spp. were screened for resistance to *Verticillium* and cold sweetening. Three exceptional clones of *S. chacoense* and *S. microdontum* were crossed to dihaploid *S. tuberosum* and resulting diploid populations were found to segregate for those traits. The two *S. microdontum* derived populations also segregated for resistance to late blight.

Two mapping populations, one from each species, were used to map these important resistance loci that represent some of the major constraints of the potato industry and cause substantial yield and quality losses. Genomes from each parent have been partially mapped using AFLP markers. Resistance to late blight was evaluated by detached leaf assay and in field trials. Resistance to *Verticillium* was evaluated under both greenhouse and field conditions. Cold sweetening was measured after storing the tubers at 4°C for 60 days. Major loci associated to those traits were identified and placed in the linkage groups. Simple Sequence Repeat (SSR) anchors were used to identify and confirm the constructed linkage groups.

(9) Identifying Resistance to *Phytophthora infestans* Earlier in Breeding. Posch, Danielle M.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.

Late blight (LB) is a worldwide potato disease caused by the pathogen *Phytophthora infestans*. A traditional approach to evaluating for resistance is among breeders' most advanced selections when resistant clones may already have been eliminated due to selection for traits other than LB. The objectives of this research were to determine: 1) if LB resistance can be found in 4x progeny of crosses where one parent has putative resistance, and 2) the utility of clonal selection from B-size seedling tubers when planted in a LB nursery. Crosses were made between 43 4x parents. The A-size seedling tuber from each cross was planted in the single hill (SH) field. In the LB nursery, 55 family plots of B-size tubers were planted in two replications. Susceptible border rows adjacent to each plot were inoculated with *P. infestans* US 8, A2 and foliar disease severity was assessed biweekly using the CIP scale (1=0% infection to 9=100%). Two populations were retained at harvest. Selection from the SH field was based on tuber appearance and having or not having knowledge of LB resistance. Twenty-seven clones were retained knowing resistance, while 46 were kept when LB was not considered during selection. Selection from the LB nursery was based on resistance after 4 weeks. In the LB nursery, normal plants derived from B-size tubers were observed and disease spread was typical. Mean defoliation scores were significantly different across reading dates, except the last two. Segregation was observed between and within families for resistance. Eighteen days after inoculation, all families except one had greater than 50% infection. After 4 weeks, five families had less than 75% infection. Within this population, 87 genotypes from 26 families were selected. Early generation selection for resistance to LB appears possible.

(10) Marker Analysis of Monoploid Potato. Varrieur, John M.* and Richard E. Veilleux, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Genetic maps of monoploids derived through both androgenesis and gynogenesis from the same parent clone would provide valuable insight into genetic differences induced by the haploidization processes. As a preliminary investigation into the degree of polymorphism and the nature of dominant-marker segregation in haploid potato, ten RAPD primers and two AFLP primer combinations were used to amplify bands in 24 androgenically-derived monoploid clones. From these reactions, a total of 66 RAPD loci and 100 AFLP loci were identified and scored, whereby 65 of these loci (49% RAPD and 51% AFLP) were found to produce polymorphic banding patterns. A χ^2 analysis for goodness-of-fit revealed 44% of the polymorphic loci to deviate significantly ($P < 0.05$) from a 1:1 presence to absence ratio expected from the dominant-type RAPD and AFLP markers. No particular RAPD primer or AFLP primer combination was found to generate a disproportionate share of the skewed loci. These results are similar to those found in past diploid and tetraploid potato mapping studies. A complete androgenic map is currently under construction and will provide a spatial representation of the skewed markers therein.

(11) Obtaining Sexual Hybrids Between *Solanum pinnatisectum* (1EBN) and Cultivated Potato Germplasm. Zlesak, David C.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.

The Mexican potato species *S. pinnatisectum* ($2n=2x=24$, 1EBN) possesses many valuable traits worth exploring and introgressing into cultivated potato including resistance to *Phytophthora infestans*, the pathogen of late blight, an aggressive and costly disease. Obtaining sexual progeny by crossing *S. pnt* directly to *S. tuberosum* haploids or cultivars is difficult due to endosperm failure, which, can be explained by the endosperm balance number (EBN) hypothesis. Two breeding schemes using EBN manipulation and $2n$ gametes, which result in $3x$ bridging hybrids are being used for introgression. The first is to cross 1EBN genotypes having unreduced gametes ($n=2x=24$, 1EBN) with haploid-species hybrids (H-S, $2n=2x=24$, 2EBN). Although 31 genotypes having $\geq 11\%$ $2n$ pollen were identified among 10 *S. pnt* accessions, crossing them with H-S clones has not yet been successful. The second approach uses somatically chromosome-doubled 1EBN genotypes ($2n=4x=48$, 2EBN) crossed with H-S hybrids. Forty putatively doubled regenerates from 3 *S. pnt* clones were obtained from tissue culture. Successful hybrids came from 6 doubled regenerates of *S. pnt* clone AS54 (PI 275233) crossed to 6 H-S clones. From 388 pollinations 31 fruits were obtained resulting in 180 seeds ranging from (2 to >100 seeds / cross). Resulting plants segregated morphologically for parental and intermediate types. Hybrid MNDZ-1 from *S. pnt* (AS54-4) \times $2x$, 2EBN H-S breeding line (C301) is known to have had viable endosperm, have *S. pnt* cytoplasm, and be near euploid ($3x$). Future work will focus on screening hybrids for $2n$ gametes and resistance to *P. infestans*, and the continued introgression of *S. pnt* genes into cultivated potato.

(12) Taxonomy of Mexican Diploid Wild Potato (*Solanum* sect. *Petota*) Species: Morphological and Microsatellite Data. Lara-Cabrera, Sabina I.* and David M. Spooner, USDA, ARS; University of Wisconsin-Madison, 1575 Linden Drive, Madison, WI 53706.

Solanum section *Petota*, the potato and its wild relatives, contains over 200 wild species. Most grow in the Andes, but the United States, Mexico, and Central America contain about 30 taxa of diploids, tetraploids, and hexaploids. Chloroplast DNA restriction site data showed 13 of these 30 taxa to form a clade containing only diploid species, but there was low resolution within the clade. Some of these 13 taxa are similar morphologically and we questioned whether they were valid species. We analyzed these taxa, and others in South America that may be related to them, with morphological and microsatellite data. Morphological data showed extensive overlap of putative species-specific characters, but most species could be supported by multivariate techniques, except *S. brachistotrichum*, and perhaps *S. stenophyllidium*, that were harder to define. Mapped nuclear microsatellite markers, developed in *S. tuberosum*, also were used to help define species but provided no support for them. To explore possible causes of discordance of morphological and microsatellite results we sequenced three microsatellite fragments from three species, and compared these to sequences of *S. tuberosum*. Divergence among priming sites explained some cases of non-amplification. There also was divergence of microsatellite flanking sequences, showing non-homology of fragment sizes, explaining morphological and microsatellite discordance. These results show that microsatellites have reduced phylogenetic utility to analyze the United States, Mexican, and Central American diploid wild potato species.

(13) Transgenic Resistance to Colorado Potato Beetle (*Leptinotarsa decemlineata*) Transmitted to Tetraploid Potato through 4x-2x Hybridization. Johnson, A. A. T.*; B. A. Nault and R. E. Veilleux. Department of Horticulture, Virginia Polytechnic Inst. & State U., Blacksburg, VA 24061 and Eastern Shore Ag. Res. Ext. Ctr., Painter, VA 23420.

A highly heterozygous, interspecific diploid potato hybrid (APM-2) that produces 2n pollen by FDR was transformed with a codon-modified *Bacillus thuringiensis cryIIIA* transgene via *Agrobacterium tumefaciens* leaf-disc inoculation. Diploid transformants determined to have either single or multiple copy inserts were regenerated and established in the greenhouse and field. In a no-choice assay, Colorado potato beetle (CPB) adults consumed significantly less leaf area from all APM-2 transformants compared to untransformed APM-2 and cv. Atlantic. Four transformed clones were as resistant to CPB as the commercial cv. NewLeaf® Atlantic (also engineered with a *cryIIIA* transgene). A DAS-ELISA test using antibodies for the CryIIIA protein showed a high negative correlation between leaf area consumed and the amount of CryIIIA protein detected ($r = -0.90$; $p < 0.01$). Tetraploid progeny were generated by 4x-2x hybridization between cv. Atlantic and both single- and multiple-copy APM-2 transformants. In a replicated greenhouse experiment, no significant differences were found for CryIIIA expression estimated by ELISA between the single-insert transformant and 25 of its progeny. However, 17 of 25 progeny derived from the multiple-insert transformant showed significantly lower ELISA readings than the parent, with 8 progeny exhibiting virtually no CryIIIA protein production. The results verify sexual transmission of a transgene through 2n pollen in potato and suggest the possibility of combining transgenic breeding with sexual polyploidization for true potato seed (TPS) cultivar development.

(14) Modified Conventional Breeding Methods to Efficiently Transfer Unique Late Blight Resistance from 2x(1EBN) Mexican Species to 2x(2EBN) and 4x(4EBN) Breeding Lines. Hamernik, A. J.*, M. Ramon, and R. E. Hanneman, Jr., Vegetable Crops Research Unit, USDA, Agricultural Research Service, Department of Horticulture, University of Wisconsin, Madison, WI 53706.

Several 2x(1EBN) Mexican species exhibit extreme late blight resistance, but have not been used in breeding because they do not readily cross with haploids or common cultivars due to EBN differences. Two methods have been developed using sexual hybridization to transfer germplasm from 2x(1EBN) species to the 2x(2EBN) and 4x(4EBN) levels. One uses double pollination techniques coupled with embryo rescue and has resulted in the formation of a *S. pinnatisectum*-*Tuberosum* haploid hybrid. This hybrid, though male sterile, has been successfully crossed as a female to 2x(2EBN) *S. chacoense*, *S. phureja*, *S. sparispilum*, and a 4x(4EBN) cultivar. A second method uses the Mexican species, 2x(2EBN) *S. verrucosum*, as a bridge species with 2x(1EBN) species. The 2x(1 1/2EBN) hybrids should segregate for EBN and therefore be crossable to 2x(1EBN) and 2x(2EBN) lines as well as to 4x(4EBN) parental material, if 2n gametes function. The 2x(1 1/2EBN) hybrids have been successfully crossed with 2x(2EBN) *S. chacoense*, *S. phureja* and *Tuberosum* haploids; with 2x(1EBN) *S. commersonii*, *S. pinnatisectum* and *S. trifidum*, and with a 4x(4EBN) cultivar. The derived hybrids have been crossed extensively with haploids and cultivars. We have demonstrated two modified conventional breeding methods to successfully transfer this resistance to the 2x(2EBN) or 4x(4EBN) level.

(15) Identification of 4°C Chipping in 12 Late Blight Resistant *Solanum* Species.

Hayes, Ryan J.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.

Wild *Solanum* species contain variation for many traits having economic importance. Therefore, species and accessions combining desirable characteristics are useful in breeding new cultivars. Two breeding objectives in cultivar development are late blight (LB) resistance and cold (4 C) chipping. Using wild germplasm with reported LB resistance, the objectives of this research were to determine: 1) if variation for cold (4 C) chipping exists among *Solanum* species, accessions, and genotypes within accessions, and 2) if genotypes having LB resistance and 4 C chipping could be identified for use in co-current introgression. Chip color was evaluated on 665 genotypes from 43 accessions of 12 species having 1, 2 or 4 EBN, and 59 genotypes previously selected for having LB resistance. One chip per genotype was made after 6 mo. storage at 4 C, then scored 1-10 for color; scores ≤ 4 are acceptable. Species differed for mean chip color and percentage of acceptable chipping genotypes and ranged from *S. verrucosum* (4.33-mean / 67%) to *S. bulbocastanum* (9.05 / 0). Accessions within species did not differ significantly for mean chip color. Accessions within *S. berthaultii*, *S. cardiophyllum*, and *S. microdontum* differed significantly for the frequency of genotypes chipping ≤ 4 . The best accessions tested were *S. verrucosum* PI 161173 (4.33-mean / 67%-acceptable), *S. stoloniferum* PI 250510 (4.36 / 64%), *S. pinnatisectum* PI 347766 (4.65 / 35%) and PI 275233 (4.73 / 44%), and *S. megistacrolobum* PI 195210 (5.14 / 29%). Co-current introgression is possible since 4 C chipping was detected within the 59 selected LB resistant genotypes. Sixteen genotypes were identified, 9 from *S. pinnatisectum*, 2 each from *S. verrucosum*, and *S. trifidum*, and 1 each from *S. fendleri*, *S. stoloniferum*, and *S. microdontum*.

(16) Sucrose Esters Derived from *Solanum berthaultii* and Resistance to Potato

Late Blight. Yencho, G. Craig*¹, Mark Clough¹, and Robert Goth², ¹Department of Horticultural Science, North Carolina State University, Vernon G. James Research and Extension Center, 207 Research Station Road, Plymouth, NC 27962, and

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Late blight is a devastating disease of potato worldwide. Several groups have reported that sucrose esters derived from *Solanum berthaultii*, a species resistant to a wide range of insect pests, may also confer high levels of non race-specific resistance to late blight. We used a detached-leaf bioassay that was non-destructive to the whole plant to screen 61 diploid (*S. tuberosum* x *S. berthaultii*) x *S. berthaultii* clones for their non race-specific resistance to *P. infestans*. These clones were segregating for sucrose ester production and have also been mapped with RFLP markers. To determine the correlation between sucrose esters and resistance to late blight, three leaflets from an adjacent leaf were excised and the sucrose ester production of the type B trichomes measured. Our leaf disk studies suggest that there is no correlation between late blight resistance and the presence of sucrose esters on the surface of potato foliage. These results will be discussed in the context of recent studies on RFLP mapping of late blight resistance, and late blight resistant clones resulting from *S. tuberosum* x *S. berthaultii* crosses.

(17) Accelerating the Chromosome Walk Towards Late Blight Resistance with the Help of FISH. Naess, S. K. *, J. M. Bradeen, J. Song, G. T. Haberlach, S. M. Wielgus, J. A. Davis, J. Jiang and J. P. Helgeson, USDA/ARS Plant Disease Resistance Research Unit, Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706 USA.

Late blight is one of the most important diseases of potato world wide. Late blight resistance has been discovered in a number of wild potato species including *Solanum bulbocastanum*. This resistance has been successfully transferred through somatic hybridization and backcrosses to a potato background. Late blight resistance from *S. bulbocastanum* has been mapped to a single location in the genome on chromosome 8 between RFLP markers G02-575 and CT64. We are pursuing map based cloning of the gene or genes responsible for late blight resistance using a *S. bulbocastanum* BAC library. Fluorescent in situ hybridization (FISH), using BAC clones as probes, is being used to correlate genetic distances with physical distances and to confirm that BAC clones discovered through colony hybridizations are in fact from the area of interest.

(18) Analysis of Segregation for Late Blight Resistance in Potato Families Screened at Toluca Valley, Mexico. Novy, Richard*¹, Dennis Corsini¹, Joe Pavek¹, Hector Lozoya-Saldana², and Alejandro Hernandez-Vilchis², ¹USDA-ARS, Aberdeen, ID 83210 and ²PICTIPAPA, Metepec, Mexico.

A primary objective of potato breeding programs is the development of potato cultivars with resistance to the newer, more aggressive, metalaxyl-resistant genotypes of *Phytophthora infestans*. Potato clones with resistance to these newer genotypes of *P. infestans* have been used extensively as parents in breeding programs. The large number of progeny obtained from the intercrossing of resistant parents precludes the screening of families for resistance to all pathotypes of *P. infestans*. Field selections are first made for suitable agronomic characteristics with screening for late blight resistance generally conducted 1 - 2 years later. Consequently, limited information is available to breeders regarding the percentages of resistant individuals and the degree of resistance within these families-important considerations for the breeder.

Data obtained from the screening of 187 families for late blight resistance from 1996 - 2000 at Toluca Valley, Mexico, provide insights into the transmission of resistance from parent to progeny. For example, in comparisons of resistant x susceptible (R x S) parental crosses, *S. bulbocastanum* derived J-line clones are the most useful in transmitting a high level of resistance to a larger number of progeny. The data also suggest that the more commonly used sources of late blight resistance in North American breeding programs, such as Awn86514-2, B0718-2, and J-lines, can act in an additive fashion, with higher levels of resistance observed in R x R than in R x S families. These and other observations on the inheritance of late blight resistance will be discussed.

(19) Variety Selection for Resistance to Abiotic Stresses, A Summary of Ohio's Involvement in the North-Central and Northeast Regional Genetics and Breeding Projects. Kleinhenz, Matthew D.*, E.C. Wittmeyer, Mark A. Bennett, and Richard L. Hassell, The Ohio State University, Ohio Agricultural Research and Development Center and Department of Horticulture and Crop Science, 1680 Madison Avenue, Wooster, OH 44691-4096, 2001 Fyffe Court, Columbus, OH 43210-1086, 2021 Coffey Road, Columbus, OH 43210-1086, Clemson University, Coastal Research Station, 2865 Savannah Highway, Charleston, S.C. 29414-5332.

The North-central 84 (NCR84) and Northeast 184 (NE184) regional genetics and breeding projects began over thirty years ago under different names. They established networks of potato researchers and others partly to increase the availability of varieties adapted to a wide range of production conditions. Ohio began official participation in the projects in 1976 (NCR84) and 1980 (NE184). Since then, thousands of experimental genotypes developed in breeding programs at the USDA and from Maine to Alberta, Canada have been evaluated at OSU research stations and on the farms of grower-cooperators. In 2000, for example, we evaluated 157 genotypes from ten breeding programs associated with the USDA, two Canadian provinces and seven U.S. states. More than twenty-five varieties grown commercially in Ohio first entered the state as experimental selections. And, on average, nearly one-hundred percent of Ohio's annual crop (fresh, chip-stock) is planted to varieties developed and evaluated in the projects. The majority of Ohio's crop is dryland; high nighttime temperatures, low soil moisture availability, and fine to coarse-textured soils are significant production challenges. Genotypes are evaluated using breeder- and market-selected criteria, including those related to chipping and cooking quality. Data on more than one-thousand entries evaluated at the OARDC in Wooster suggest that average annual total and marketable yield have remained relatively similar since 1987, being primarily affected by climatic conditions. Maturity, estimated on more than five-hundred genotypes from the NE184 project since 1990, has been mostly medium-late with a recent trend toward medium to medium-early.

(20) A Potentially Important Role for Anaerobic Carbohydrate Metabolism in Determining Chip Quality of Cold-Stored Potato Tubers. Blenkinsop, Robert W.*, Leslie J. Copp, Alejandro G. Marangoni and Rickey Y. Yada, Department of Food Science, University of Guelph, Guelph, Ontario, N1G 2W1.

The storage of potato tubers at low temperatures (ie., <10EC) initiates a process known as low temperature sweetening (LTS), which results in the conversion of starch to sugars. High levels of reducing sugars lead to undesirable nonenzymatic browning during potato chip frying operations. This is an update of an ongoing study elucidating the biochemical differences in carbohydrate metabolism between a cold-tolerant selection (ND 860-2) and a cold-sensitive cultivar (Novachip) during 4EC storage. Carbohydrate metabolism was evaluated by measuring respiration rate, enzymatic activity (PFK, G6PDH, 6PGDH, ADH), chip color, solids content, weight loss, as well as levels of reducing sugars, NADH, NADPH, ATP, lactate and ethanol. Following three years of study (1997-1999), concentrations of ethanol and lactate consistently showed good correlation with chip color quality. Higher levels of these metabolites in the cold-tolerant selection may be indicative of an overflow pathway of glycolysis; observed trends support the existence of a greater glycolytic flux in the cold-tolerant selection. These trends were further supported by results from the 2000 growing season involving an additional cold-sensitive cultivar (Monona) and two cold-tolerant selections (Wis 1355-1 and V 0056-1).

(21) Impact of Calcium and Nitrogen Applications on 'Burbank' Potato Tuber Size and Tuber Number. Ozgen, Senay*, and Jiwan P.Palta, Department of Horticulture, University of Wisconsin, Madison, WI 53706.

Tuberization in the potato plants is known to be controlled by environmental and nutritional factors. Previous study in our laboratory conducted with inert media and precise Ca concentration in the root zone have demonstrated that tuber size and number markedly influenced by root zone Ca. However can Ca alter tuber size and number in field soil with supplemental Ca, remains unknown. The purpose of the present study was to be determine the influence of supplemental calcium fertilization on tuber size and tuber number. For this purpose, plantlets of *Solanum tuberosum* cv Russet Burbank raised in tissue culture were planted in 20 liter pots filled with sandy loam soil with pH of 6.9 and soil calcium level of 350 ppm. All treatments received same total amount of nitrogen (at the rate of 280 kg/ha). Four treatments were evaluated: (i) nonsplit nitrogen (from ammonium nitrate), (ii) split nitrogen (from ammonium nitrate), (iii) split nitrogen (from liquid nitrogen) + calcium chloride, (iv) split nitrogen (from calcium nitrate). The total calcium was applied at the rate of 168 kg/ha. Treatments were replicated 8 times. Four months after planting tubers were harvested and evaluated. In general all calcium treatments had lower tuber number and greater tuber size as compared to the nonsplit nitrogen control. The percentage of total A grade tuber number as well as the percentage yield from A grade tubers was increased by all calcium applications. These results suggest that calcium content of the soil can influence both potato tuber number and tuber size.

(22) Influence of Supplemental Calcium and Nitrogen Improves Potato Tuber Calcium Concentrations and Internal Quality of 'Russet Burbank' Potatoes. Ozgen, Senay*, Christopher Gunter, Björn Karlsson and Jiwan Palta, Department of Horticulture, University of Wisconsin, Madison, WI 53706.

The potential benefits of supplemental Ca nutrition to potato have been demonstrated over several years in both field and controlled environments. The influence of supplemental Ca and N fertilization on internal quality was investigated using two sources of Ca (calcium nitrate and calcium chloride). Each treatment had five replications and received the same total amount of N at a rate of 225 kg.ha⁻¹ and Ca was applied at the rate of 168 kg.ha⁻¹. Application of N at emergence and hilling (nonsplit) was compared to split application of N and Ca at hilling, two, four and six weeks after hilling. At harvest, approximately 100 tubers from each replication were cut and visually inspected for internal defects in each year. Application of Ca, especially in split schedule and from soluble sources significantly increased tuber tissue Ca concentration. In 1998 the incidences of hollow heart (HH) and internal brown spots (IBS) were very low. The treatment containing calcium nitrate and calcium chloride combination produced the lowest total internal defects. In 1999, application of all Ca sources reduced HH and IBS. Data from these studies show that tuber Ca level is increased by field applications of moderate amount of Ca and tuber quality is impacted by N and Ca application. Seasonal climatic variations also appear to have dramatic influence on the incidence of internal defects.

(23) Reduction of Potato Tuber Bruising and Internal Defects by Supplemental Calcium Field Applications. Karlsson, Björn*, Jiwan Palta and Senay Özgen, The University of Wisconsin-Madison, Department of Horticulture, 1575 Linden Dr., Madison, WI 53706.

Supplemental calcium application has been shown in our previous work to improve tuber quality and reduce internal defects. However, the influence of calcium on bruising is not well known. In both 1999 and 2000 we evaluated under field conditions five commercially relevant cultivars (Russet Burbank, Atlantic, Snowden, Superior, Dark Red Norland) for bruising, yield and internal defects. Experimental field plots were supplied with $168 \text{ kg} \cdot \text{ha}^{-1}$ supplemental calcium while control plots were given no additional calcium. Applications were made at hilling and at two additional times during the tuber bulking period other than grower control (nonsplit) which received all applications at hilling. All plots received equal nitrogen. Bruise reduction was seen in both years for most of the cultivars and tuber grades. In 2000, for example, Russet Burbank treated with the combined calcium nitrate, calcium chloride and urea reduced bruising by 25% as compared to control. In 1999, treatments containing calcium nitrate+calcium chloride+urea resulted in half the incidence of bruise for Atlantic as compared to grower control. Furthermore, there were dramatic cultivar differences for the incidence of bruising. Supplemental calcium applications thus present the opportunity of reducing tuber bruising and other internal defects which profoundly affect all levels of the potato industry.

(24) Supplemental Calcium Application During Seed Tuber Production: Impact on Plant Quality and Yield the Following Year. Gunter, Christopher C.* and Jiwan P., Palta, Purdue University - Southwest Purdue Agricultural Program, 4369 North Purdue Road, Vincennes, IN 47591 and University of Wisconsin-Madison, Madison, WI 53706.

Production of high quality seed tubers is of paramount concern to potato growers. High quality seed tubers are required to have freedom from defects and diseases, minimal sprouting and the capability for vigorous growth after planting. Little work has been done to examine the impact of the calcium concentration of seed tubers on the quality of the plant produced by that tuber the following season.

Plots were established at a commercial seed production farm, on silt loam soil, in northern Wisconsin using the following cultivars, Superior, Dark Red Norland, Atlantic, Snowden, and Russet Burbank. Calcium was applied, in a split application, using calcium nitrate (9N-0P-0K-11Ca) at a rate of $168 \text{ kg} \cdot \text{ha}^{-1}$. Control plots received nitrogen only, from ammonium nitrate (34N-0P-0K), delivered at the same rate and timing as the calcium plots.

It was found that the mean calcium content of the seed tuber can be raised following supplemental calcium application, resulting in an increased proportion of high calcium tubers in calcium treated plots. Supplemental calcium can increase mean tuber yield and may influence the growth of above ground stems and foliage produced early in the season. Results of these studies indicate that the odds of obtaining high yield are better if the seed piece contains high calcium and may indicate a positive relationship between calcium and yield when plotted across seasons.

(25) Some Secondary Plant Hormones Isolated from 'Katahdin' Potato Plant Tissues Whose Levels were Influenced by Induction. Malkawi, AA., B.L. Jensen and Alan R. Langille*, Department of Chemistry, Department of Biosystems Science and Engineering, University of Maine, Orono, ME 04469.

'Katahdin' potato plants were grown under "inducing" and "non-inducing" conditions and sampled at 2 day intervals. High performance liquid chromatography, in combination with gas chromatography and mass spectrometry, revealed the presence of several cytokinins and jasmonates in above- and below-ground tissues of the potato plants. Along with the major cytokinin, cis-zeatin riboside, other cytokinin compounds including, trans-zeatin and its riboside and isopentenyladenine were significantly influenced by induction. Likewise, over time changes were observed in levels of tuberonic acid, methyl tuberionate, methyl cucurbate and dihydromethyl jasmonate as a result of subjecting the plant to inducing conditions. The roles that these natural products may play in the development of the potato tuber will be discussed.

(26) Potato EST Sequencing and Analysis: Which Genes Involved in Carbohydrate Metabolism are most Active in Immature Potatoes? Li, Xiu-Qing*, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, 850 Lincoln Road, Fredericton, N.B., E3B 4Z7, CANADA email:LIXQ@EM.AGR.CA.

Immature potato tubers accumulate starch using the sucrose transported to tubers from the photosynthetic organs. Information about which genes involved in carbohydrate metabolism are most active at transcriptional level in the tubers will be useful for understanding the molecular mechanisms of carbohydrate related traits and potato tuber development. Although the northern hybridization approach is suitable for studying gene expression between organs or developmental stages, northern hybridization is not convenient for comparing the relative activity among several genes. Therefore, we are using an EST (expressed sequence tag) approach to investigate which carbohydrate metabolism genes are most active in immature potato tubers. A cDNA library using mRNAs of immature tubers of a diploid potato (*Solanum tuberosum* L.) clone has been constructed using the Uni-ZAP XR vector. DNA sequencing has been conducted using randomly selected cDNA clones. Estimated from EST frequency, the sucrose synthase genes appeared to be the most active genes involved in carbohydrate metabolism in the immature potato tubers.

(27) Aminocyclopropane Carboxylate Oxidase Genes are Cis-Regulated by Abiotic and Biotic Stresses in Potato. Nie, Xianzhou*, Rudra P. Singh, and George C. C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, P.O.Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.

Ethylene (CH₂=CH₂) plays a significant role in plant growth and development. Aminocyclopropane-1-carboxylic acid (ACC) is the immediate precursor of ethylene *in vivo*, and the conversion of ACC to ethylene is catalyzed by ACC oxidase (ACO). This gene has not been cloned from potato. We report here the cloning and sequence of two different full length ACO cDNAs (*ACO1* and *ACOII*) from potato. The sequence data indicate that the two ACO cDNAs share a high homology with each other, and also with known ACO genes from other plant species, including both monocots and dicots. However, the 3' ends of the genes differ significantly with no homology with each other, even though the 5'-UTR and most of the open reading frames and their encoded amino acids have high similarities to each other. Expression analysis showed that the genes are tissue specific, with high expression in leaves and low expression in roots and tubers. In sprouting tubers, *ACO1* in sprouts was induced by heat (40°C) and cold (0°C) stresses, however, *ACOII* was induced in sprout and tuber tissues only by cold (0°C) stresses. Both transcripts were induced significantly in leaves, stems and tubers in the PVA-resistant cv. Shepody challenged with *Potato virus A*. *ACO1* was markedly induced in leaves by wounding, waterlogging and exogenous ACC, but *ACOII* was only slightly induced by these treatments. The results indicate that *ACO1* and *ACOII* are regulated differently in potato plants and tubers, although both of them appear to be induced by biotic and abiotic stresses.

(28) Segregation for Somatic Embryogenesis in Potato. Seabrook, Janet E. A.*, L. Katheryn Douglass and George C.C. Tai, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, CANADA, E3B 4Z7.

Production of somatic embryos (SEs) *in vitro* on potato cultivars and three wild *Solanum* species led to the hypothesis that regeneration of SEs may be under genetic control. Three test crosses were initiated in the greenhouse: Coastal Russet X AF 186-2; Coastal Russet X Lenape; AF 186-2 X Lenape. True potato seedlings from the three crosses were germinated *in vitro*. Five stem internode explants from each seedling were excised and cultured on two successive regeneration media to promote the formation of SEs. Considerable differences in regeneration capacity between seedling explants was observed. Coastal Russet X AF 186-2 cross produced more SE than the other two crosses, and explants from the AF 186-2 X Lenape cross generally only produced < 10 SEs per explant. Data for the number of explants producing SEs and numbers of SEs per explant were highly significant, and evidence suggests that regeneration of SEs is probably under nuclear control.

(29) A New Post-harvest Chemical, 1-Methylcyclopropene, Delays Fry Colour Darkening. Prange, Robert K.*¹, Jin-Cheol Jeong², and Barbara J. Daniels-Lake¹,
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1-Methylcyclopropene (1-MCP) (AgroFreshTM, AgroFresh, Inc., a Rohm and Haas Company, Philadelphia, PA) is a new anti-ethylene compound which may be commercially available in the near future as a post-harvest treatment. It attaches to ethylene binding sites in the plant tissue and blocks ethylene-controlled processes. Potato tubers respond to ethylene in various ways, including a darkening in fry colour. In this study, half of the 'Shepody' tubers were treated 8 weeks after harvest with gaseous 1-MCP for 48 h, using the recommended rate of 0.9 $\mu\text{L}\cdot\text{L}^{-1}$ (AgroFreshTM product specification sheet) and the remaining tubers were left untreated. Storage following treatment was at 9°C either in air only or air + continuous 4 $\mu\text{L}\cdot\text{L}^{-1}$ ethylene treatment. Tubers samples were taken from storage every 3 weeks for 15 weeks. Both air and ethylene-treated tubers pre-treated with a 1-MCP had a whiter fry colour (higher Agron value), compared with tubers not treated with 1-MCP. This 1-MCP effect was not permanent, and was no longer evident after about 3 and 6 weeks in air and ethylene treatments, respectively.

(30) Long-term Exposure to Ethylene Affects Polyamine Levels and Sprout Development in 'Russet Burbank' and 'Shepody' Potatoes. Jin-Cheol, Jeong¹, Robert K. Prange*² and Barbara J. Daniels-Lake², ¹National Alpine Agricultural Experiment Station, RDA, Pyoungchang, Kangwon 232-950, Korea, ²Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, NS B4N 1J5, Canada.

Potato (*Solanum tuberosum* L. cvs. Russet Burbank and Shepody) tubers were exposed to continuous 4 $\mu\text{L}\cdot\text{L}^{-1}$ (166 $\mu\text{mol}\cdot\text{m}^{-3}$) ethylene, commencing after 8 storage weeks, during long-term storage at 9°C over one ('Russet Burbank') and two ('Shepody') storage seasons. Thereafter, tubers were sampled at 3 week ('Shepody') or 5 week ('Russet Burbank') intervals for polyamine content [putrescine, (PUT); spermidine, (SPD); and spermine, (SPM)] and sprout number and weight. During the storage period, 'Shepody' had higher concentrations of all three polyamines and a higher PUT/(SPD + SPM) ratio, compared with 'Russet Burbank'. During storage, all three polyamines in both cultivars increased, with the increase being more rapid in 'Shepody' than in 'Russet Burbank'. Regardless of cultivar and year, exposure to ethylene induced higher spermidine (SPD) content and a lower PUT/(SPD + SPM) ratio, compared with the air treatment. Sprouts appeared later and were smaller on ethylene-treated tubers and were more numerous in 'Russet Burbank'. Our results suggest that these long-term ethylene effects may be due, in part, to enhanced transformation of PUT to SPD.

(31) Effect of Chlorpropham (CIPC) upon Carbohydrate Metabolism During Storage of Chipping Potatoes. Copp, Leslie J.*, Robert W. Blenkinsop, Rickey Y. Yada and Alejandro G. Marangoni, Department of Food Science, University of Guelph, Guelph, ON N1G 2W1.

Two chipping cultivars, Snowden and Monona, with or without Chlorpropham (CIPC) application, were stored in darkness at 12 C and approximately 95% humidity. Chip color, dry matter and protein contents were evaluated over 30 weeks of storage. Tuber concentrations of sucrose, reducing sugars, and major metabolites and enzymes of the pathways of glycolysis, pentose phosphate shunt, anaerobic and oxidative respiration were also monitored during storage. Initially, chip color quality was lower for CIPC-treated tubers, but recovered to exceed that of untreated tubers after approximately 10 weeks of storage. Respiration, as measured by CO₂ production, was significantly ($P \leq 0.05$) suppressed in CIPC-treated tubers. CIPC treatment had no significant ($P > 0.05$) effect on tuber concentrations of protein, dry matter, sucrose, reducing sugars, the assayed enzymes and metabolites of glycolysis (phosphofructokinases, NADH, ATP) or the enzymes of the pentose phosphate shunt (glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase). NADPH, a product of the pentose phosphate shunt, was elevated in untreated tubers, consistent with its role in biosynthetic pathways involved in sprout production. Concentrations of ethanol and lactate, products of anaerobic respiration, were significantly ($P \leq 0.05$) higher in the CIPC-treated Snowden tubers, relative to the untreated tubers.

(32) Biological Agents for Dual Control of Dry Rot Disease and Sprouting of Potatoes in Storage. Slininger, P.J.*, D.A. Schisler, L.P. Meagher, K. D. Burkhead, and R.J. Bothast, NCAUR, USDA-ARS, Peoria, IL.

Chemical sprout inhibitors are applied to over 50% of the potato harvest to extend storage time. In the U.S., CIPC (1-methylethyl-3-chlorophenylcarbamate) is the only synthetic chemical registered for postharvest sprout control of stored potatoes, and it is the most widely used sprout inhibitor world-wide. Due to environmental and health safety concerns, the use of CIPC has become more restricted, and alternative sprout control methods are sought. Six bacteria strains, exhibiting superior dry rot suppressiveness in previous research, were grown on two different liquid culture media and sprayed to Russet Burbank potatoes. In growth chamber and pilot experiments repeated at two storage sites in two successive years, all six isolates demonstrated significant sprout control capabilities when applied after growth on at least one of the culture media supplied. Of the six strains tested, *Pseudomonas fluorescens* bv.V S11:P:12 and two strains of *Enterobacter cloacae*, S11:T:07 and S11:P:08, exhibited highest relative performance levels with sprout control being statistically similar to that of 16.6 ppm CIPC thermal fog after five months storage.

(33) Potato Seed Treatment for Controlling *Rhizoctonia solani* Infection. Naranjo, Patrick*¹, Greta Schuster¹, David Bender², Ron Thomason¹, Jeff Koym², ¹West Texas A&M University, Canyon, TX, ²Texas Agricultural Experiment Station, Lubbock, TX.

Rhizoctonia solani infections cause girdling lesions on potato stems and stolons, and black scurf of tubers. This study evaluated six seed piece treatments reported effective in reducing *Rhizoctonia* infections. TOPS MZ, TOPS 2.5D, Nubark captan, Maxim, Maxim 1/2 rate, and Maxim MZ fungicides were applied to cut seed pieces of 'Russet Norkotah 278' in 2000. Plots were 8 meters by 4 rows in commercial fields with Tivoli sand soil. Each treatment was replicated four times in a randomized complete block design. Stems and stolons were evaluated for *Rhizoctonia* infection sixty days after planting, and tubers for scurf at harvest. In 1999, Maxim controlled the disease most significant but produced smaller tubers than all other treatments. In 2000, Maxim products and Tops MZ treated seed pieces reduced stem and stolon infection in 'Russet Norkotah 278'. All Maxim products increased tuber decay and reduced percent of total plants with infected stolons. There was no significant difference among any treatments when evaluating scurf on tubers or number of tubers infected. In 2000, environmental factors were drier and hotter than in the previous year, which may have influenced the outcome of the yield.

(34) Relative Sensitivity of ELISA and RT-PCR Methods for Early Detection of Potato Leaf Roll Virus (PLRV) in Russet Burbank Potatoes under PEI conditions. Singh, R.¹, X. Nie¹, Robert Coffin*², D. Huestis³, M. Burns², W. Burns², J. Zeng¹, A. Dilworth¹, D. Munn³, ¹AAFC, Fredericton, NB, E3B 4Z7, ²Cavendish Farms, New Annan, PE, C1N 5J5, ³PEI Produce, Summerside, PE.

Techniques to detect current year spread of PLRV are needed. Russet Burbank tubers with varying levels of PLRV infection (0, 30 and 95%) were planted in small plot trials. No aphicides were applied and aphid activity was high in early August. Leaf and tuber samples were collected from 100 individually marked plants in each treatment on August 10, and tubers were collected September 11 and October 13. Paired lab testing was conducted on each plant by splitting individual leaves and tubers longitudinally (half for ELISA and half for RT-PCR). All tests were performed on dormant tubers.

On August 10th, ELISA and RT-PCR did not detect any PLRV in tuber samples planted with 0% infection; but a few positives were observed when tested by RT-PCR-SB (Southern Blot). On September 11th, ELISA still showed no positives, but some were observed using RT-PCR and even more with RT-PCR-SB. Similar observations were noted October 13th using ELISA and RT-PCR.

When leaves and tubers from highly infected plants were tested, data from ELISA and RT-PCR indicated a very high number of positives. The RT-PCR technique indicated that current season spread of PLRV was considerable, whereas ELISA tests indicated negligible spread. To verify changes in virus titres and development of symptoms in progeny, sections of each tuber have been planted in greenhouses for further lab and visual ratings. This will permit comparisons of ELISA on dormant and sprouted tubers.

(35) Determination of a Threshold Absorbance Value of PVY Detection in Sprouts and Leaves by ELISA and Comparison with Visual Field Readings.

Singh, Mathuresh*¹, George Tai², Lynn Moore³ and Sandy Perley³, ¹International Certification Services, 385 Wilsey Rd, Fredericton, N.B., Canada E3B 5N6, ²Agriculture and Agri-Food Canada, Potato Research Centre, PO Box 20280, Fredericton, N.B., Canada E3B 4Z7, ³NB Agriculture, Fisheries & Aquaculture, PO Box 6000, Fredericton, N.B. Canada E3B 5H1.

The current standard for post-harvest testing of seed potatoes is the winter grow-out test. The winter grow-out test, however, does not provide accurate results for varieties such as Russet Norkotah and Shepody. Three varieties, Russet Burbank, Atlantic and Shepody were planted in 3 replicates of 200 tubers in 1999 and 2000. Sprouts from individual tubers were tested for PVY using ELISA. Approximately 10% PVY positive seed tubers were planted in each replicate. Visual field readings were taken on a weekly basis beginning 5 weeks after planting. Leaves from individual plants were tested for PVY 8-9 weeks after planting using ELISA.

The results for the 2 years were combined and analyzed using regression analysis. An absorbance of 0.07 ($A_{405\text{nm}}$) was determined to provide the most accurate comparison of sprout ELISA readings to visual readings with an error of $\pm 2.5\%$. Most of the error can be attributed to negative ELISA readings from sprouts from tubers that produced plants with positive visual readings. An absorbance of 0.07, used as an end point for leaf ELISA, compared most accurately with visual readings with an error of $\pm 2.2\%$.

(36) Viral Mixed Infections in International Potato Clones in the Toluca Valley, Mexico. Roman-Vázquez, Reynaldo¹, Héctor Lozoya-Saldaña*^{1,2}, and Alejandro Hernández-Vilchis², ¹Depts. of Parasitology and Plant Sciences, Autonomous University of Chapingo, Chapingo, México 56230, and ²International Cooperative Program for Potato Late Blight, Metepec, México 52176.

In the 1998 indexation for eight viruses in international potato clones in the Toluca Valley, México, potato aucuba mosaic potexvirus (PAMV) was detected in mixture with potexvirus X (PVX) in one clone and with potato leafroll luteovirus (PLRV) in two more genotypes. In order to confirm the identity of each virus and separate the mixtures, eleven indicator plants and one potato variety were mechanically or insect inoculated with sap from the three clones. Mechanical inoculation of PAMV+PVX (both of which are mechanically transmissible) induced symptoms only in *Datura stramonium* and *Capsicum annuum*. However, ELISA was negative for the two viruses in *D. stramonium* and positive for PAMV in *C. annuum*, *Nicotiana rustica* and *Solanum tuberosum*, which indicates: a) the lack of transmission of the viruses to *D. stramonium*, b) the presence of unknown pathogenic agent (s) in this indicator plant, and c) the effective transmission of PAMV to other solanaceae. Aphid inoculation also induced symptoms in *D. stramonium* and *C. Annuum* and only from sap with PAMV+PLRV (both viruses are aphid transmissible). Again, ELISA confirmed the presence of PAMV only in this indicator species as well as in *N. Tabacum* cv. Xanthi, *N. Occidentalis*, *Lycopersicum esculentum*, and *S. tuberosum*. Transmission was successful only for PAMV in all assays, but this virus has not been detected in the field since 1998.

(37) Is the Resistance of the Potato Cultivar Shepody to Potato Virus A a Hypersensitive Response? Nie, Xianzhou* and Rudra P. Singh, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, NB, Canada E3B 4Z7.

The hypersensitive response (HR) is an active form of defense, characterized by the development of necrosis at the site of infection. This resistance is attributed to *N* genes. Another type of virus resistance termed extreme resistance (ER) elicits few or no visible symptoms and from such plants recovery of virus is very difficult and the resistance is attributed to *R* genes. Both types of resistance are encountered in potato viruses. A HR-like resistance to *Potato virus A* (PVA), originally introgressed from wild *Solanum* spp., is thought to be widely present in many European and North American cultivars. Although the potato cv. Shepody is highly resistant to PVA by manual inoculation, upon graft inoculation and maintenance of the plant at low temperature, it reacts with the production of chlorotic mosaic in leaves and discontinuous necrotic spots and streaks in stems, stolons and tubers. This unique symptomology in the cultivars Shepody and Bake King does not fit the classical HR description, therefore, investigations were carried out to characterize the response further. PVA-Shepody resistance response showed that like *N* gene systems, it is temperature sensitive. Increased expression of pathogenesis-related protein (PR) genes chitanase A and B, glucanase B and PR-10a is highly associated with chlorotic and necrotic symptoms, and increased generation of oxidants is also observed within chlorotic/necrotic areas. Similarly, PVA concentration was significantly higher in visibly chlorotic/necrotic areas than in non-chlorotic/-necrotic areas, suggesting that initiation of the response is virus concentration dependent. The similarity with a HR response is discussed.

(38) Sodium Sulphite Mediated Attenuation of Polyphenolics in Nucleic Acid Extraction for RT-PCR. Singh, Rudra P.*¹, Xianzhou Nie¹, Mathuresh Singh², Robert Coffin³ and Patricia Duplessis⁴, ¹Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, NB, Canada E3B 4Z7, ²Agricultural Certification Services, NB Potato Agency, 245 Hilton Road, Unit 25, Fredericton, NB, Canada E3B 5N6; ³Cavendish Farms, P.O. Box 3500, Summerside, PEI, Canada C1N 5J5, ⁴Crop Diversification Centre North, RR6,17507 Fort Road, Edmonton, Alberta, Canada T5B 4K3.

Phenolic compounds from plant tissues are known to inhibit reverse transcription polymerase chain reaction (RT-PCR) and thus yield unreliable results for virus diagnosis. Some potato cultivars, e.g., Russet Norkotah, contain higher amounts of phenolics, making the virus detection by RT-PCR difficult. Several compounds and treatments have been reported to minimize the production of polyphenolics in nucleic acid preparations. An accidental use of sodium sulphite (Na(2)SO(3)) showed that it can significantly reduce the darkening of plant extracts caused by the oxidation of sap. Therefore, the use of Na(2)SO(3) was investigated for the nucleic acid extraction and RT-PCR detection of potato and cherry fruit viruses from potato tubers and tree bark, respectively. The optimum concentration of Na(2)SO(3) for extraction of nucleic acid was 0.65 % in a range of 0.5 to 1.2 %. Use of Na(2)SO(3) resulted in elimination of the use of DNaseI and Proteinase K previously required for nucleic acid extraction of potato viruses. When compared with commercially available RNA extraction kits (RNesay and Catrimox, Qiagen), the Na(2)SO(3) based extraction yielded higher amounts of RNAs of both potato and cherry viruses and provided reliable detection of potato viruses leafroll, X, Y and S in tubers, and Prunus dwarf and Prunus necrotic ring spot viruses from cherry leaves and bark. With Na(2)SO(3) having been shown to be effective in virus inoculation and serology-based detection procedures, its accompanying elimination of phenolics from both herbaceous and woody plants, makes Na(2)SO(3) a very useful supplement for plant virus work.

(39) Comparative Efficacy of Fosthiazate Formulations for the Management of *Meloidogyne chitwoodi* in Idaho Potatoes. Hafez, S.L.* and Sundararaj P., University of Idaho, Parma Research and Extension Center, 29603 U of I Lane, Parma, Idaho 83660.

Two field experiments were conducted to study the efficacy of Fosthiazate formulations along with Vapam on the control of Columbia root knot nematode (*Meloidogyne chitwoodi*) in a potato field. Experimental design was a randomized complete block with seven treatments of six replications, including an untreated check. Fosthiazate was applied at the rate of 8.6 or 11.5 pt/A in the fall of 99 or spring of 2000 alone or along with Vapam (37.5 gallon). Potato cv. Russet Burbank was planted on March 21, 2000 in the plot size of 15 x 50 feet. The plots were harvested on September 21, 2000 and yield of different size and grades were recorded. In both experiments there was a significant difference in the market yield and nematode infected tubers due to the application of treatments as compared to the control. In the first experiment, maximum marketable yield was recorded in the plots where Vapam was applied in the fall 1999 and fosthiazate in the spring 2000 and no nematode infected tubers were observed. In the second experiment, maximum marketable and total yield was observed in the plot treated with Vapam and Fosthiazate in spring, 2000 before planting. Among all treatments Fosthiazate with Vapam, increased the marketable yield and total yield with the lowest nematode infestation. Percent of nematode infestation ranged from 0-1.9 and 0-17.4 for I and II experiment respectively.

(40) Area-Wide Colorado Potato Beetle Management. Sexson, Deana L.* and Jeff Wyman, University of Wisconsin, Madison, 1575 Linden Dr., Madison, WI 53706.

A geographic area of greater than 45,000 acres of land in Portage County, Wisconsin was designated as an experimental area for area-wide pest management of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). From 1997 to 1999 beetle populations in each potato field within this region were determined by field sampling and mapped in the spring and the fall using GIS computer systems. The distance between current and previous potato fields in a rotation and the style of beetle management were the primary factors affecting distribution within the area. Long distance rotations of greater than 400 meters were an effective cultural control management strategy to limit adult beetle infestations in the spring. The insecticidal management strategy used also aided in the reduction of Colorado potato beetles leaving fields in the fall and entering fields in the spring. To optimize the rotational effect, it is suggested that the number of Colorado potato beetle adults entering overwintering sites in the fall should be determined and used to select the appropriate insecticidal strategies which could be applied the following spring to limit infestation. Area-wide Colorado potato beetle management can be an effective resistance management strategy. Alternations of chemical classes in adjacent fields can reduce the selection pressure on the Colorado potato beetle by particular insecticides, thus delaying the onset of resistance.

(41) The Influence of Seed Growing and Storage Temperatures on the Performance of Five Seed Potato Cultivars. Hornbacher, Andy*, Nora Olsen, Phil Nolte, and Lynn Woodell, University of Idaho, 3793 N. 3600 E., Kimberly, ID 83341 and University of Idaho, 1776 Science Center, Idaho Falls, ID 83402.

Seed potato performance is important for obtaining uniform emergence, desired stem numbers and tuber size profile, and optimum yields. Individually evaluating potato cultivars should provide information to determine if environmental conditions during the seed-growing season influence subsequent seed performance, and to determine the optimum seed storage temperatures to create an ideal seed physiological age for the needs of the end user.

During the 1999 and 2000 growing seasons, air and soil temperatures were measured in 'Russet Burbank', 'Ranger Russet', 'Umatilla Russet', 'Shepody', and 'Russet Norkotah' seed potato fields. Harvested seed tubers were stored at 1) 3.3°C until planting, 2) 3.3°C and 30 days at 7.2°C prior to planting, 3) 3.3°C and 15 days at 15.5°C prior to planting to create three levels of heat unit accumulation. Seed tubers were planted in field trials (RCBD) and evaluated for performance.

In 2000, 'Russet Burbank', 'Shepody', and 'Russet Norkotah' responded to elevated temperature storage treatments with earlier emergence and increased stem numbers. For 'Russet Burbank' stem numbers increased from 2.8 to 3.1, 'Shepody' 1.8 to 2.2, and 'Russet Norkotah' 2.5 to 2.7 with the highest level of heat unit accumulation in storage. Emergence and stem numbers for 'Ranger Russet' and 'Umatilla Russet' were not significantly impacted by storage treatments. No significant alteration in tuber size profile and yield were evident for the cultivars, however, trends were apparent among storage treatments. Seed performance data collected this season (2001) will be compared to 2000 data to evaluate seed-growing environmental influences.

(42) Relationship Between Calcium and Disease. Sanchez, Elsa S.* and Larry K. Hiller, Washington State University, Department of Horticulture and Landscape Architecture, Pullman, WA 99163.

Eight widely used fungicides in potato production are under review by the EPA and may become unavailable. The incidence of disease will increase if alternatives are not found. One approach to this problem would be to increase the natural resistance of tubers by increasing calcium levels. The goal of this study was to determine the relationship between tuber calcium concentration and disease.

Tubers (*Solanum tuberosum* cv Russet Burbank) were produced in a greenhouse in sterile media in the absence of calcium fertilizer. Calcium (calcium nitrate or calcium chloride) at rates of 0, 6000 or 12000 mg Ca/ L was applied to the tubers by dips or pressure infiltration. Tubers were inoculated with *Phytophthora infestans*, *Helminthosporium solani* or *Erwinia carotovora*. Disease progressed for 1 month before severity was visually measured. Calcium levels of the periderm, cortex and pith were determined by inductively coupled plasma-optical emission spectrophotometry.

Calcium had no significant effect on *Helminthosporium solani* or *Phytophthora infestans* disease development. Disease development of *Erwinia carotovora* was higher in the first replication when calcium was applied to tubers using pressure infiltration than when using dips. Disease levels were highest when calcium was applied at a rate of 6000 mg Ca/L. Disease progress was similar on tubers where no calcium or calcium nitrate was applied (both rates). Tubers with calcium applied as calcium nitrate and 12000 mg Ca/L of calcium chloride had similar disease severity. While more research is needed, these results suggest calcium nitrate may decrease disease when applied to tubers by dips.

(43) High Quality Minituber Production by Planting Sprouts Detached from Imported Basic Seed Tubers under Aphid-Proof Screenhouse in a Brazilian Citrus Region. de Souza-Dias, J.A.C.*¹; C.M. de Meo²; A. Greve³; L.J. Paes⁴, ¹Plant Health Center, Agronomic Institute (IAC), 13001-970 Campinas, S.P., Brazil, jcaram@cec.iac.br; ²SAI-Limeira, SP; ³CATI, Campinas, SP. ⁴Limeira Agriculture Secretary. ¹CNPq fellow.

Last year, three orange producers in the citrus region of Limeira, SP, produced seed-potato minitubers from sprouts (Bryan et al., 1981, CIP: 20p.) detached from imported high-grade potato seed (Souza-Dias et al., 1998. Summa Phytopat. 24(1):73.). About 20 thousand sprouts of different varieties, sizing 2-3cm high per 0.3-0.7 cm large, were individually planted in U-shape plastic pots (10 cm x 10 cm), containing 2:1 (v:v) soil:Plantmax (Eucatex, Paulinia, SP), under aphid-free screenhouses, surrounded by over 50 km of orange orchards, free of any potato crop. At planting, 20 g/pot of fertilizer 4-14-8 was added. Regular preventive nutritional and disease treatments were applied biweekly. About 80 days after planting the number of minitubers from 2 to 5 cm in diameter per plant, was: Atlantic: 1 to 2; Agata, Mondial and Monalisa: 2-3 and Bintje: 2-4. Except for Atlantic, foliage and tuber DAS-ELISA in 0.5% of the plants revealed < 1 % of PLRV and PVY. Atlantic showed 2-3 % of PVY even after discarding near 4% of symptomatic plants (PVY+/ELISA). The production cost ranged US\$ 0.05 to 0.10/minituber; but, 50 percent cost reductions are expected. Potato seed growers are initiating contracts with citrus growers and supplying them with sprouts and technical assistance. Minituber production from sprouts has proved to be an economic alternative, for citrus growers to earn income in during the current financial crisis.

(44) The Effects of the Addition of Slow Release Fertilizer on the Yield and Size Distribution of Greenhouse-Grown Minitubers, Hughes, Becky R.* and Candy N. F. Keith, New Liskeard Agricultural Research Station, University of Guelph, Box 6007, New Liskeard ON P0J 1P0 Canada.

Three potato cultivars were grown to produce minitubers in the greenhouse in 1999 and 2000. Two slow release fertilizers, 14-14-14 and 20-7-10, were added to the regular liquid fertility program and a modified liquid fertility program. The effect on yield (number and weight of tubers) and tuber-size varied with cultivar and year. The addition of slow release fertilizer increased the weight produced and the average tuber size of Yukon Gold, whether or not the liquid fertilizer program was continued after the start of the short-day period. The number of tubers produced was significantly increased by the addition of 14-14-14, but not by 20-7-10. The addition of 14-14-14 increased the weight of Shepody produced in 1999, but not in 2000. Over the two years, the addition of 14-14-14 increased the average tuber size as well as the number and weight of large tubers produced in Shepody. The addition of 20-7-10 reduced the number of tubers formed in both Shepody and Kennebec. However, in Kennebec, the addition of either slow release fertilizer significantly reduced the weight produced and the average tuber size in 1999. Given these results, the treatments for Kennebec were modified in 2000. Slow release 14-14-14 with only two applications of liquid fertilizer gave the same yields as the control in 2000, while all other treatments continued to produce less yield.

(45) Metribuzin Sensitivity and Model Evaluation. Thompson, Asunta* and Scott Nissen, San Luis Valley Research Center, Colorado State University, 0249 East Road 9 North, Center CO 81125, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.

Forty-three advanced selections and cultivars were screened from 1996 through 2000, for sensitivity to metribuzin, the active ingredient in the widely used herbicides Sencor and Lexone. Metribuzin is a photosynthetic inhibitor and controls many broadleaf weeds. Unfortunately, some potato cultivars are sensitive, which may result in significant yield loss if unknown. Foliar symptoms of sensitivity include chlorosis, leaf margin necrosis and veinal clearing. The predictive model of Love, Shaffii, Haderlie and Eberlein, where $(1 - (1.142 + 1.076(\log(\text{plant height treated}/\text{plant height control})) - 0.00796(\text{percent foliar injury}))) \times 100 = \text{percent yield loss}$, has been used in evaluating sensitivity of advanced selections and cultivars from Colorado and the southwest, in addition to being evaluated for appropriateness in this high altitude production area. A split-block design and two replications has been utilized each year. Standard production practices, except for the herbicide treatment, have been adhered to. The post emergent treatment is applied when plants are 8-10 inches tall at two rates, a control of 0 lbs. per acre active ingredient, or 1 lb. ai/acre. Foliar damage is assessed 21 days following application and plant height is determined prior to senescence. Total yield is obtained following harvest. Statistical analysis of the relationship between predicted yield loss and actual yield loss resulted in a range of R-square values from 0.40 in 1999 to 0.85 in 1997, indicative of moderate to strong correlation. The overall R-square value for 33 selections and cultivars evaluated from 1996 to 1999 was 0.71, resulting in a correlation coefficient of 84%. Therefore, the predictive model appears to adequately assess sensitivity in the San Luis Valley.

(46) Pacific Northwest Potato Tolerance and Varietal Response to Sulfentrazone. Hutchinson, Pamela J. S.*, Dennis J. Tonks, Corey V. Ransom, Rick A. Boydston, and Claude G. Ross, University of Idaho, Aberdeen, ID 83210, Washington State University, Davenport, WA 99122, Oregon State University, Ontario, OR 97914, USDA-ARS, Prosser, WA 99350; and FMC Corp., Loveland, CO 80537.

Field studies were conducted in the PNW, in 1999 and 2000 to evaluate potato tolerance to sulfentrazone in weed-free trials. Herbicides were applied after hilling and prior to potato and weed emergence. Sulfentrazone was applied alone or in mixtures with metribuzin, EPTC, s-metolachor, dimethenamid-p, or pendimethalin, depending on location. Initial injury from sulfentrazone applied alone ranged from 0 to 8% in Malheur, OR, and 4 to 18% in Aberdeen, ID, depending on rate. Initial injury for mixtures ranged from 0 to 3% and 3 to 15% in Oregon and Idaho, respectively. In Oregon, U.S. No. 1 tuber yield was significantly reduced by 0.42 kg/ha sulfentrazone, while total tuber yield was not significantly affected by sulfentrazone treatments regardless of rate or mixture. Tuber yield was not affected in Idaho regardless of rate or mixture, similar to Prosser, WA trials where sulfentrazone tank-mixed with metribuzin or pendimethalin resulted in early, transient visual potato injury and did not affect tuber yield.

In a separate 2000 Idaho trial, potato cultivar tolerance was evaluated by applying sulfentrazone preemergence at 0, 0.11, and 0.21 kg/ha to 'Russet Burbank', 'Ranger Russet', 'Russet Norkotah', and 'Shepody' potatoes. Initial injury ranged from 5 to 25% depending on rate. 'Russet Burbank' exhibited greatest visual injury during the season, regardless of rate, compared to the other cultivars. Both U.S. No. 1 and total tuber yields were reduced in sulfentrazone-treated 'Russet Burbank' relative to the untreated 'Russet Burbank' control. Tuber yield was not affected in the other potato cultivars.

(47) Norkotah Response to Foliar Applications of Apogee® (prohexadione-calcium). Nissen, Scott J.^{*}, Pamela Hutchinson, and Susie Thompson; Colorado State University, Ft. Collins, CO, University of Idaho, Aberdeen, ID and Colorado State University, San Luis Valley Research Center, Center, CO.

Excessive vine growth with many potato varieties can make disease management and vine kill more difficult. Apogee has been shown to reduce vegetative growth in other plants without affecting yield; therefore, experiments were conducted to determine the effect of Apogee on potato vine growth and tuber yield. Apogee was applied at rates of 0.28, 0.56 and 1.1 kg ai/ha to Norkotah potatoes at two growth stages, tuber initiation and flowering. Applications were made using standard CO₂ backpack equipment calibrated to deliver 187 L/ha at a pressure of 200 kPa. Shoot fresh weight was determined before harvest and tuber yield was determined 21 days after vine kill. Tubers were graded into 5 categories: greater than 10 oz, 6-10 oz, 4-6 oz, less than 4oz and #2+culls. Tuber categories were based on grades of interest to seed producers. Apogee applied at 1.1 kg/ha during tuber initiation reduced shoot fresh weight by 41% compared to the untreated check. There appeared to be a rate response for treatments applied at tuber initiation, but the 1.1 kg/ha rate was the only significant difference compared to the untreated check. Apogee applied at flowering had no effect on shoot fresh weight. Apogee applications had no effect on tuber yield or tuber number for any of the categories evaluated. Apogee may have useful applications in potato production by providing growers with the means to manage vine growth. More research is needed to determine if Apogee could be used to manipulate tuber size for the benefit of seed producers.

(48) Pre-Planting Management to Maximize Short Season Yield Potential. Mikitzel, Loretta J.^{1*} and David Wattie², New Brunswick Department of Agriculture, Fisheries and Aquaculture, ¹Potato Development Centre, Wicklow, NB, Canada E7L 3S4, and ²Bon Accord Elite Seed Potato Centre, Bon Accord, NB, Canada E7H 2K8.

Sprouting seed tubers in light prior to planting (greensprouting or chitting) may increase yield in short growing season areas, such as New Brunswick, Canada. Whole E1 Chieftain, Kennebec and Red Pontiac seed tubers were chitted under natural light for 40 days prior to planting. Half of the tubers were held in the dark for 7 days at 20C before chitting. Control tubers were planted directly from 4C storage. Tubers were hand-cut one week before planting. All chitted tubers emerged faster than control tubers. Warming Chieftain seed at 20C before chitting significantly increased total yields compared with chitting alone and increased total yield by 63 cwt/A over the non-chitted control. After a 73-d growing season, both chitting treatments increased total yields of Kennebec by 100 cwt/A. Both chitting treatments increased Red Pontiac tuber yields by 41% to 260 cwt/A by 73 days after planting. Chitting did not affect total tuber number produced by any cultivar tested. Only Red Pontiac stem numbers per plant were reduced by chitting. Yield increases due to chitting were realized for the three cultivars through higher yields of >51 mm diameter tubers. Significantly fewer oversize tubers (>64 mm dia.) were produced when seed tubers were warmed prior to greensprouting.

(49) Efficacy of Chlorine Dioxide as a Disinfectant in Potato Storages. Woodell, Lynn K. , Gale E. Kleinkopf *, and Nora Olsen, University of Idaho, 3793 N 3600 E, Kimberly, ID 83341-5076 and University of Idaho, PO Box 1827, Twin Falls, ID 83303-1827.

Chlorine dioxide gas prepared from a buffered solution of sodium chlorite by activation with a food grade acid has been shown to effectively control many potato pathogens in laboratory experiments. Fusarium dry rot, bacterial soft rot, silver scurf and late blight organisms can be controlled, even killed under appropriate laboratory conditions.

However, in storage facilities chlorine dioxide gas escapes into the atmosphere surrounding the potatoes during application and is not available to reduce disease inoculum. The active ingredient is also lost from solution on application to potatoes as it reacts with the total organic load. More than twice as much of the active ingredient is lost on contact with the potato surfaces (potato skin, dirt, other organic matter) than by diffusion from the liquid solution alone. Even though the material is applied as per Section 18 label, the active ingredient can escape during application and as it reacts with the potato, consequently, producing inconsistent results including negative control of potato pathogens in storage. Movement of chlorine dioxide gas through the potato pile is restricted through this scrubbing action of the organic load. Application rates to successfully control disease inoculum in vivo (under storage conditions) have not been achieved without significantly increasing the active ingredient application dose.

(50) Response of Russet Burbank Potatoes to Irrigation Frequency with Set-Move Sprinkler Systems. Stark, Jeff* and Brad King, University of Idaho, Research & Extension Center, P.O. Box 870 Aberdeen, Idaho, 83210.

Maintaining optimal soil water availability with set-move sprinkler systems such as wheel lines and hand lines can be a problem if crop water use during the designed irrigation interval exceeds maximum allowable soil water depletion in the root zone. Field studies were conducted with Russet Burbank potatoes at Aberdeen, Idaho in 1997 and 1999 to determine the effects of irrigation frequency on soil water availability and tuber yield and quality. Irrigation intervals ranging from 4 to 8 days were compared on a silt loam soil with a 0.18 m/m water holding capacity. Water applications were equivalent to 100% ET replacement for each irrigation interval. Irrigating at intervals greater than 6 days decreased total yields, while U.S. No. 1 yields decreased at intervals greater than 5 days. Seasonal root zone water content patterns were consistent with the reduced yields at the longer irrigation intervals. Set-move sprinkler systems need to be adequately designed to match irrigation intervals with maximum allowable soil water depletion levels and crop water use rates for potatoes.

(51) Survey of Environmental Conditions and Cultural Practices Associated with Embedded Stone Problems in Chip Potatoes. Halseth, D. E.*, Department of Horticulture, Cornell University, Ithaca, NY 14853.

Chip processors frequently have had problems with embedded stones in early harvested potatoes. These small stones, often no larger than 3 mm in diameter, can break slicing knives and cause a loss in raw product because of improper slicing. There are many suggested reasons for this problem, including soil-type, soil compaction, rainfall events, and harvesting practices. Field samples of 100 tubers were collected at various locations in grower fields (from wheel tracks, wet spots, field headlands, non-compacted beds) and at several stages of the harvesting operation (off windrower, harvester, bulkbody trucks, conveyors). Most samples were collected off of equipment, with a small number hand-dug for compaction comparisons. All samples were inspected for embedded stones before and after washing and again after an abrasive peeling. Results from samples collected during the 1998 – 2000 harvest seasons indicate no significant trends for embedded stones due to variety, nitrogen rates, vine-kill date nor harvester make. While a trend does exist for higher stone numbers in samples from later stages of the harvesting operation, no one harvest operation appears to contribute much more than another, so stone counts often are a function of additive effects of a series of harvesting operations. There does appear to be good correlation with soil type, soil compaction and also to rainfall within two days of digging on specific soil types.

(52) Seed Physiology and Growing Temperature Influences on Early Tuber Set. Olsen, Nora*¹ and Robert E. Thornton^{2,1} Dept. of PSES, University of Idaho, Twin Falls, ID, 83303 and ²Dept. of Hort. and L.A. Washington State University, Pullman, WA 99164.

Many factors can influence early plant growth characteristics such as sprout number, stem number, and stolon and tuber production from planted seed pieces. Some of the factors investigated in these studies included cultivar, season, growing temperature, and seed growing and storage conditions. Seed physiological age or status can be a dominating component of early tuber set influence. Regardless of other factors, in 4 out of 5 controlled growth chambers experiments, early growing temperatures (7°C, 13°C, and 18°C) did not significantly impact sprout number/seed piece. Early growing temperatures, and some of the evaluated seed characteristics, influenced above-ground stem number/plant.

The two imposed seed growing conditions (variations in thermoperiod and photoperiod) did not significantly affect stolon number/plant, stolon fwt/plant, tuber number/plant, or tuber fwt/plant of the plants produced from the seed piece. The evaluated seed storage treatments a) 3.3°C, b) controlled atmosphere (CA), and c) 6.7°C influenced sprout number/seed piece, and in some years aboveground stem numbers, stolon fwt, and tuber number and fwt. A major influence of stolon number/plant was growing temperature with 2 times more stolons produced at the 13°C growing temperature compared to 18°C. Stolon number and fwt was not influenced by the seed physiology evaluated, only growing temperature. Although tuber number/plant was greater at the 13°C growing temperature, tuber fwt/plant was greater at the 18°C growing temperature. A compilation of these studies indicate some influence by seed physiology, but early growing temperatures had a consistently more dominating impact on stolon and tuber development and growth.

(53) Influence Iron and Manganese Concentration in Nutrient Solution on Growth and Mineral Content of the Potato Plants. Chang, Dong Chil*, Sung Y. Kim, Young I. Hahm, *Division of Crop Research, National Alpine Agricultural Experiment Station, RDA, Pyongchang 232-955, Korea.

Potatoes (*Solanum tuberosum* L.) cvs. 'Atlantic' and 'Superior' were grown in glasshouse to study the influence of Mn and Fe on plant growth and mineral nutrition. Potato solution containing 0, 0.5, 10, 50, 100 mg·L⁻¹ of Mn, and 0, 3, 10, 50, 100 mg·L⁻¹ of Fe were supplied to potato plants growing in solution cultures. Visual symptoms by Fe and Mn levels in the nutrient solution were observed in the color of plant tops. During the 45-days of growth, Mn-induced yellowing with green veins of young Atlantic leaves was associated with concentrations of 50 mg·L⁻¹ Mn and higher in nutrient solution. With increased toxicity, young leaves of Superior showed black spotting along the midrib and veins as well as yellowing. In particular, plant growth such as stem height, top fresh weights and stolon dry weights were reduced in 100 mg·L⁻¹ Mn levels. Potato plants grown at 0 mg·L⁻¹ Fe had increased top fresh weights and root dry weights, but showed a delayed tuberization. On the other hand, the middle and lower leaves of potato grown at 100 mg·L⁻¹ Fe showed yellow-green interveinal and marginal necrosis and eventually dried. These toxicity symptoms of Mn and Fe were more increased in severity with Superior than with Atlantic and were associated with mineral contents of potato leaves as follows: As the supply of Mn or Fe increased, T-N content of leaves decreased only at 100 mg·L⁻¹ Mn or 0 mg·L⁻¹ Fe, K increased, but Ca and Mg decreased, whereas P was unaffected.

(54) Improving Nitrogen Efficiency in Michigan Potato Systems. Snapp, Sieglinde* and Don Smucker, Michigan State University, Dept. Horticulture, East Lansing, MI 48824 and Michigan State Extension, P.O. Box 308, Stanton, MI, 48888.

Potato farmers are under increasing pressure to develop and utilize more efficient nitrogen fertilization strategies. In Michigan, these strategies encompass monitoring plant nitrogen status and a range of application methods and fertilizer sources. We surveyed farmer satisfaction with nitrogen monitoring tools and nitrogen fertilization practices, through a state-wide formal survey and grower meetings. We found that growers are reexamining nitrogen fertilization practices. The majority are using less nitrogen fertilizer than they historically used. However, there was mixed reaction to petiole nitrogen monitoring techniques. Ability to predict plant nitrogen response was widely questioned, although many growers and consultants are attempting to monitor plant N status. There is a ways to go in developing optimal plant nitrogen fertilization strategies. Some gains have been achieved in N fertilization efficiency, which growers indicate have reduced input costs as well as limited nitrate losses to deep percolation.

(55) Evaluation of Pre-Sidedress Soil Nitrogen Test (PSNT) for Use in Potatoes Following Red Clover. Sieczka, J. B.* , D. E. Halseth, C. W. Albers, and S. L Childs.

Eight replicated experiments were conducted on commercial potato farms in upstate New York to evaluate the Pre-sidedress Soil Nitrogen Test (PSNT) in fields where red clover (*Trifolium pratense*) was grown the year before. Four experiments were conducted in 1998, three in 1999, and one in 2000. Pre- and at-planting nitrogen rates ranged from 50 to 196 kg N/ha. Sidedress rates ranged from 0 to 224 kg N/ha. Soil cores were taken immediately before sidedressing to a depth of 30 cm from each replication and analyzed for nitrate-nitrogen. The nitrate-nitrogen levels ranged from 8 to 41 ppm where no pre-plant N was applied. PSNT levels of 25 ppm or more are regarded as adequate levels to produce economic corn crops without additional nitrogen. PSNT levels in the potato experiments were not good indicators of response to sidedress nitrogen rate. The total and marketable yields of the no sidedress treatments were not significantly different from the yields of the other treatments tested in any of the experiments. This is consistent with previous conservative estimates of nitrogen contributions of 84 kg N/ha from good stands of clover.

(56) Effect of Planting Depth and Hilling Practices on Yield and Quality of Russet Burbank and Gem Russet Potatoes. Bohl, William H.* and Stephen L. Love, University of Idaho, 132 S. Shilling, Blackfoot, ID 83221, University of Idaho Research & Extension Center, P.O. Box 870, Aberdeen ID 83210.

Previous work has shown that planting Russet Burbank seed pieces 15 cm deep decreased total yield when compared with planting 8 cm deep. In the study reported here, depth of post-planting hilling was investigated. Russet Burbank and Gem Russet potatoes (*Solanum tuberosum*) were planted in 1998, 1999, and 2000. Treatments included a 15-inch non-hilled control, planting at 8 or 15 cm and later hilling to either 15 or 23 cm at emergence or hilling post emergence (PE) after plants formed a rosette approximately 3 to 6 cm in diameter.

Compared with the control, all PE hilling treatments significantly decreased Russet Burbank total and U.S. No. 1 yields. Effect of planting and hilling practices on Gem Russet yield were not as clear. All treatments except plant 8 - hill 15 cm and plant 15 - hill 23 cm PE decreased total yield of Gem Russet. Hilling Gem Russet from 8 to 23 cm, 8 to 15 cm PE, or 8 to 23 cm PE resulted in significantly lower U.S. No. 1 yield when compared with the control.

Hilling treatment had some impact on yield of green tubers for Russet Burbank and the plant 8 - hill 23 at emergence, plant 8 - hill 23 PE, and plant 15 - hill 23 PE treatments reduced green yield. However, planting depth and hilling practices did not significantly affect the green yield of Gem Russet.

Hilling treatments had a distinct impact on vertical tuber distribution in the hill.

(57) Cultural Practice, A Tool in Promoting New Advanced Selections. Groza, Horia^{1*}, Timothy Connell³, Bryan Bowen¹, Jiming Jiang², University of Wisconsin, ¹4181 Camp Bryn Afon Rd, Rhinelander, WI 54501, ²1575 Linden Drive, Madison, WI 53706, ³Portage County UW Extension, 1462 Strongs Ave, Stevens Point, WI 54481.

Two advanced selections from the Wisconsin breeding program have been promoted for processing market, in demonstration trials: W 1355-1 (a cold sweetening resistant chipping line) and W 1348 rus (a dual purpose russet line with good frying characteristics). The industry tuber size requirements are: 88% tubers over 170.1 g (TO1) and 10% tubers over 283.5 g (TO2) for chipping varieties, and 95% tubers over 170.1 g (TO1) and 30% tubers over 283.5 g (TO2) for frying varieties. In order to increase the proportion of larger tubers of these two W-lines cultural practice field trials, including hill spacing on a row and Nitrogen fertilization, have been conducted. Although good correlations were obtained between the hill spacing increase and the proportion of TO1, no significant improvements were recorded among spacing variants of 30.4, 38.1 and 45.7 cm. However the percentage of culls has increased at higher spacing distance for W 1355-1. Among the Nitrogen rates (201.6, 246.6 and 291.4 kg A.I./ha), used in two post emergent applications, the 246.6 kg/ha rate increased significantly the yield of TO2 in W 1348 rus.

(58) Economic Performance of Gem Russet (A8495-1) and A84118-3 as Compared to Russet Burbank Using a Fresh Pack model. Salaiz, T.S.*, S. L. Love and P.E. Patterson, University of Idaho, Plant Soil and Entomological Sciences Dept., Aberdeen, ID 83210 and University of Idaho, Agricultural Cooperative Extension, Idaho Falls, ID 83402.

New potato varieties can provide economic advantages in traditional markets. An analysis was conducted to determine potential economic advantages of two new varieties, Gem Russet and A84118-3 in comparison with Russet Burbank (RB) in the fresh market. Yield and size data from 15 location/years were used to calculate market pack category percentages for each variety. These percentages were then used in conjunction with a 10-yr. average price per pack to calculate a gross return/cwt. Additionally, packaging and production costs and yield were used to calculate net return/acre and total profits based on a 500-acre farm in Idaho. Although differences in total yield were not statistically significant between varieties, both Gem Russet and A84118-3 had higher US1 yields and higher proportions of consumer bags and cartons. These differences resulted in a \$2.19 difference in return per cwt between A84118-3 and RB, and a \$2.10 difference per cwt between Gem Russet and RB. Using the average yields for each variety and 1999 average production costs for Idaho, A84118-3 returned \$1059.44 per acre and Gem Russet returned \$1121.48 compared to \$182.60 for RB. When evaluated for an average size farm in Idaho, the returns from the new varieties greatly exceeded returns from RB. When evaluated using only 1998 prices, the new varieties returned positive profits while RB did not. New varieties can conform better to the specifications of traditional markets allowing the grower to profit even during low price years.

(59) Early Generation Selection for Cold (4°C) Chipping Potato Progenies.

Hayes, Ryan J.* and C.A. Thill, University of Minnesota, Department of Horticultural Science, 1970 Folwell Avenue, St. Paul, MN 55108.

Chip color is a market-limiting trait for potato chipping cultivars; without light colored chips other traits have reduced importance. Storage at 4 C reduces storage losses, but dark chips typically result. Genetic variation for chip color from 4 C storage exists and acceptable genotypes can be selected. Combining this with early generation selection may promote rapid development of 4 C chipping cultivars. The research objectives were: 1) to identify early generations from which to select 4 C chipping genotypes, and 2) to compare differences among early generation groups. Progeny from 4x-4x crosses were field planted as single hills (SH) from greenhouse grown tubers (GT-173 families) and from seedling transplants (TR-97 families). Two populations were created at harvest, a group comprised of 20 random clones per family (3256-GT, 1940-TR) and selected clones lacking obvious tuber defects (189-GT, 204-TR). Progeny were chipped after 6 mo. storage at 4 C. The random group was additionally chipped after 3 mo. One chip per genotype was scored 1-10 for color, ≤ 4 is acceptable. Acceptable chipping progeny were found across both storage durations and propagation methods (32-GT/14-TR, 3mo.) and (32-GT/12-TR, 6 mo.). Six GT progeny chipped ≤ 4 after both 3 and 6 mo., but none in TR. Moreover, chip color means were significantly different (7.94-GT/8.49-TR, 3 mo.) and (8.00-GT/8.18-TR, 6 mo.). Selection is possible after 3 and/or 6 mo. storage in GT or in TR, but with higher false rejection in TR. Progeny chipping ≤ 4 were identified within the selected group (5-GT/3-TR). Co-current selection is possible, but clones combining good tuber characteristics and 4 C chipping were rare. Future goals are to evaluate 4x-2x populations for frequency of desirable progeny and selection efficiency relative to 4x-4x.

(60) A Comparison of Production and Processing Quality Traits of Chip and Non-Chip Genotypes. Tarn, T. Richard*, Warren K. Coleman, Henry De Jong and George C.C. Tai., Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.

Four chipping and three non-chipping genotypes were tested in field trials over two sites and two years. Each experiment had four replicates. One replicate was used for sequential harvests, starting in early August, to record yield components and sucrose and glucose content. In September/October the remaining replicates were harvested and yield components, yield and specific gravity data were collected, and tuber samples were stored at three temperature regimes for determination of sucrose and glucose content and chip color. Sucrose, glucose and specific gravity data from the sequential and final harvests were investigated to determine the effect of sugar levels on chipping quality after the different storage treatments. Yield and tuber size showed no consistent association with glucose content whereas specific gravity had a moderate negative correlation with glucose content. A path regression model was used to study the causal effect of the changes of sucrose content during growth on glucose content in winter storage. The sequential changes in sucrose content measured during growth showed a high degree of determination on the glucose content of potatoes stored at 7°C and 13°C and after reconditioning at 25°C from storage at 7°C. Cluster analysis was used to group genotypes with similar performance patterns.

(61) Variation of Chipping Quality in Three Genetic Populations Derived from *Tuberosum* x *Tuberosum*, *Andigena* x *Tuberosum* and Diploid x Diploid Crosses. Tai, George C.C.*, Henry De Jong, T. Richard Tarn and Warren K. Coleman, Potato Research Centre, Agriculture and Agri-Food Canada, P.O. Box 20280, Fredericton, New Brunswick, Canada E3B 4Z7.

Three populations were created for the comparison of variation of chipping quality in hybrid progenies from different genetic sources. Two hundred progenies of two *Tuberosum* x *Tuberosum* (TT) crosses, 200 progenies from two *Andigena* x *Tuberosum* (AT) crosses and 300 progenies of six diploid x diploid (DD) crosses (advanced progenies derived from haploid *Tuberosum* and primitive cultivated diploid germplasm) were grown in field experiments in 1999 and 2000. Crosses were selected to have at least one good chip parent. Potatoes harvested in 1999 were held in storage with a temperature kept below 13°C until early January, 2000, then stored at 7°C for one month before measuring glucose content and chip color. From the 2000 experiment yield and specific gravity were recorded at harvest, and glucose content and chip color were recorded following storage at 4°C. Data from all progeny and both years were used to compare the genetic variation of chipping quality among the three genetic populations. Variability of progenies in the three populations followed the order DD, AT and TT for glucose content and yield. Glucose content and chip color showed significant negative correlation $r=-.80$. The percentage of progenies with glucose content ≤ 2.0 mmol/l ranked in the order TT (10.05%), AT (7.04%) and DD (5.37%) based on glucose content and chip color score data obtained in 1999.

(62) Fine Screening Potato Germplasm for High Leaf and Low Tuber Glycoalkaloids. Bamberg, J.^{*1}, S. Love², D. Corsini³ and K. Deahl⁴, ¹USDA, Agricultural Research Service, US Potato Genebank, 4312 Hwy 42, Sturgeon Bay, WI 54235; ² Research Professor, University of Idaho, R & E Center, Aberdeen, ID 83210; ³Research Plant Pathologist, USDA/ARS, R & E Center, Aberdeen, ID 83210; ⁴ Research Plant Pathologist, USDA, ARS Veg. Lab., BARC-W, 10300 Baltimore Ave., Beltsville, MD 20705.

High concentrations of total glycoalkaloids (TGA) in potato are undesirable for humans but have a role in resistance to some insects and diseases. Since many pests eat only the above-ground parts of the plant, and humans eat only tubers, breeding for high TGA levels in leaves and low levels in tubers is an attractive goal. This strategy has been pursued using *S. chacoense*, a species that has leptine glycoalkaloids that are produced only in leaves and not in tubers. When 51 populations of 10 *Solanum* species were tested for types and amount of glycoalkaloids, 15 populations had more in their leaves than tubers (each population was represented by a bulk of the tissue of five plants). Four populations with the highest leaf/tuber (L/T) ratio (about 4, 6, 9 and 18 fold) were selected. Twenty-seven new seedlings for each of these populations were reared for individual tests. The results revealed particularly wide variation of ratios within two of the populations. For example, one extreme genotype of *S. neocardenasii* 502642 had 44-fold L/T difference (532/12 mg%) and one *S. vernei* 458371 genotype had a 38-fold difference (2294/61 mg%). Several glycoalkaloid classes were involved. It should be possible to select and enhance germplasm with TGA other than leptines at very high levels in leaves but low levels in tubers.

(63) Identification and Genetic Location of a Novel Potato Alkaloid. Sagredo, Boris, Abbas Lafta, Howard Casper, and Jim Lorenzen*, Dept. of Plant Sciences, North Dakota State University, Fargo, N.D. 58105.

Foliar alkaloid analysis of ND4382-19 and its progeny ND5873 (ND4382-19 x Chipeta) by GC-MS showed that, in addition to the expected alkaloids (solanidine, leptinidine, and acetyl-leptinidine), there was another unknown compound. Its molecular mass and some of the m/z fragment ions were similar to leptinidine, but the major fragment ion was the m/z 150 peak of solanidine. This pattern suggested that the unknown compound is solanidine-based with mass equal to leptinidine, which has an extra -OH group. The GC-MS fragmentation pattern suggested an -OH at a different position than C-23 as for leptinidine. The exact chemical structure is unknown, and further analysis, such as NMR, will be necessary. Segregation analysis of two populations, ND5873 and NDG116 (ND4382-19 x N142-72), showed that this unknown compound segregated in a 1:1 ratio, indicating that a single locus is responsible for its synthesis. This locus was positioned on chromosome I, with flanking AFLP markers 8.9 and 10.8 cM distant, 23 cM distal to the nearest SSR marker, STM 2020(dp). This unknown alkaloid was present in the foliage and absent in potato tubers. Its presence in leaves did not affect CPB resistance.

(64) Mapping Late Blight Resistance and other Agronomic Traits in a *S. microdontum* Population. Bisognin, Dilson*, Lynn Buszka and David Douches, Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824.

We developed a diploid population with the objectives to map quantitative trait loci conferring late blight (LB) resistance using isozymes and SSR marker and to examine associations between LB resistance and other agronomic traits. The mapping population was a cross between *S. microdontum* (PI 595511) and a susceptible clone. The progeny of 110 clones and the parents were evaluated at the Muck Soil Research Farm, Bath, MI in 1999 and 2000 for foliar late blight reaction using complex races of US8/A2 mating type of *P. infestans*. Disease severity was quantified as the relative area under the disease progress curve based upon the percentage of foliar infection over time. This population was also evaluated at Montcalm Research Farm, Entrican, MI for maturity, tuber number and size, yield, tuber appearance, specific gravity, and chip color. High phenotypic correlation ($r = 0.89$, $P < 0.0001$) was found for LB reaction between years. No correlation was found between LB and maturity. One allozyme and 14 SSR markers were linked with LB resistance in at least one environment. From these markers, 3 mapped to chromosome I, 1 to chromosome VII, 3 to chromosome VIII, and 2 to chromosome XII. One marker was linked with LB resistance in both environments and with maturity, but four other markers were linked with both maturity and LB resistance in one environment. A total of 13 markers were linked with all tuber traits. The use of this information in a marker assisted selection program will be discussed.

(65) Cloning Late Blight Resistance from *Solanum bulbocastanum*. Bradeen, James M.*, S. Kristine Naess, Susan M. Wielgus, Jeffrey A. Davis, Geraldine T. Haberlach, and John P. Helgeson, Department of Plant Pathology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706.

Late blight remains one of the most important potato diseases worldwide. The wild diploid Mexican species *Solanum bulbocastanum* is highly resistant to all known races of late blight but cannot be crossed to cultivated potato. We generated somatic hybrids between potato and *S. bulbocastanum*. The somatic hybrids are fully resistant and resistance segregates in each of three subsequent backcross generations to potato. Late blight resistance maps to *S. bulbocastanum* chromosome 8. Map location, durability, and lack of race-specificity suggest *S. bulbocastanum* resistance differs from previously employed R genes. Using markers linked to resistance, we screened an *S. bulbocastanum* BAC library, recovering multiple BAC clones for each marker. End sequencing allowed the generation of walking probes for contig extension. Nearing completion, the contig is expected to encompass more than 1MB of DNA. Additional mapping efforts, including the identification of individuals recombinant in the late blight resistance region, will allow us to localize the gene or genes responsible to 4 overlapping BAC clones. These clones will be entirely sequenced by our colleagues at The Institute for Genomic Research (TIGR), allowing detailed sequence analysis. Once late blight resistance genes have been identified and confirmed, they will be incorporated into important potato cultivars.

(66) Genetic Variation in Potato with High Levels of Red and Blue Anthocyanins. Brown C. R.^{1*}, R. Wrolstad², and B. Clevidence³, ¹USDA/ARS, Prosser, WA, ²Oregon State University, Corvallis, OR; ³USDA/ARS, Beltsville, MD.

It is customary to think of potato flesh as either white or various degrees of yellow, reflecting qualitative and quantitative variation of xanthophylls in the flesh. Red and blue colors in the tuber flesh are due to another class of compounds, the anthocyanins. The total anthocyanin content of red and blue fleshed potato ranged from 5 to 35 mg/100g fresh weight. As a dried preparation anthocyanin content falls between strawberries and raspberries. Red pigmented potatoes contained predominantly acylated pelargonidin glycosides comprising about 80% of the total, while blue-fleshed potatoes contained these compounds, and, in addition, acylated petunidin glycosides in a 2 to 1 ratio of the former to the latter. Segregation ratios confirmed the single gene control of presence and absence of either blue or red pigmentation in the skin, and the flesh. The extent of pigmentation in the flesh appeared to be under polygenic control. Solidly pigmented potatoes displayed two to three times higher antioxidant potential than white-fleshed potato, placing high-anthocyanin potato in the range of other vegetables of reputed high antioxidant potentials such as kale and broccoli. Antioxidant food supplements have been implicated in benefiting cardiovascular health, preventing certain types of cancers, and retarding macular degeneration of the retina. Potato offers a vehicle to substantially increase consumption of antioxidants especially in snack foods. These potatoes provide a new health-promoting marketing identity for potato.

(67) Field Evaluation of Natural and Engineered Potato (*Solanum tuberosum* L.) Resistance Mechanisms for Control of Colorado Potato Beetle (*Leptinotarsa decemlineata* Say). Coombs, Joseph^{1*}, David Douches¹, Edward Grafius², Walter Pett², and Dale Moyer³, Michigan State University, ¹Department of Crop and Soil Sciences, ²Department of Entomology, East Lansing, MI, USA 48824, ³Cornell University, Long Island Horticultural Research and Extension Center, Riverhead, NY, USA 11901.

The Colorado potato beetle (CPB), is the leading insect pest of potato in northern latitudes. Host plant resistance is an important tool in an integrated pest management program. Field studies were conducted to compare natural (glandular trichomes and high total glycoalkaloids), engineered (*Bt-cry3A*), and combined (glandular trichomes+*Bt-cry3A* and glycoalkaloids+*Bt-cry3A* transgenic potato lines) host plant resistance mechanisms of potato for control of CPB. Twelve different potato lines representing five different host plant resistance mechanisms were evaluated in a choice situation under CPB pressure in Entrican, Michigan and in Riverhead, New York. Treatment plots were planted in the field between alternating rows of a susceptible guard in a randomized complete block design consisting of four replications of ten plants each. Observations were recorded weekly for a visual estimation of percent defoliation by CPB, and the number of egg masses, larvae, and adults. The high glycoalkaloid line, the *Bt-cry3A* transgenic, and the combined resistance lines were effective in controlling feeding by CPB adults and larvae. Effectively no feeding was observed in the high glycoalkaloid+*Bt-cry3A* transgenic line, which was significantly less than one of the *Bt-cry3A* transgenic lines at the New York location. The glandular trichome line suffered less feeding than the susceptible control. Based on these results, the *Bt-cry3A* transgenic, glandular trichome, and high glycoalkaloid lines are effective tools that could be incorporated in a resistance management program for control of CPB.

(68) Development and Characterization of an Adapted Form of *Droopy*, a Diploid Potato Mutant Deficient in Abscisic Acid. De Jong, H.*¹, L. M. Kawchuk², W. K. Coleman¹, C. A. Verhaeghe², L. Russell¹, V. J. Burns¹ and E. Tremblay-Deveau¹, ¹ Agriculture and Agri-Food Canada Potato Research Centre, P.O. Box 20280, Fredericton, NB, E3B 4Z7, ² Agriculture and Agri-Food Canada Lethbridge Research Centre, P.O. Box 3000, Lethbridge, AB, T1J 4B1.

A cultivated diploid potato breeding population has been selected for adaptation to growing, tuberizing and storing (including long dormancy) under New Brunswick conditions. In this population a mutant was discovered which appeared similar to the earlier described *droopy* mutant which is deficient in abscisic acid and is unable to regulate water loss from its leaves. The physiology and genetics of the newly discovered mutant was studied and compared in detail with the description of *droopy*. A major difference between the mutant described here and *droopy* is that our mutant has a relatively long tuber dormancy although similar endogenous abscisic acid levels were observed during storage when compared with the normal genotype. A test for allelism indicated that our mutant is allelic to *droopy*. Classical linkage analyses confirmed previously reported close linkage between the *Dr* and the *S* (incompatibility) loci. The *Dr* locus has been mapped in this study to the top of chromosome I. Several test crosses indicated reciprocal differences in the segregation ratios between *droopy* and normal. In keeping with the *droopy* (*drdr*) genotype, drought stressed leaves of the mutant were incapable of increasing abscisic acid production compared to the normal. This mutant, with its apparent developmentally restricted expression, may be useful in elucidating the genetic and physiological processes associated with such major events as tuberization, response to drought stress and tuber dormancy.

(69) Genetic Heterogeneity among Breeding Systems of Potato Species and its Ramifications in Germplasm Conservation. del Rio, Alfonso H.* and John B. Bamberg, USDA/Agricultural Research Service, Vegetable Crops Research Unit, Inter-Regional Potato Introduction Station, 4312 Hwy. 42, Sturgeon Bay, WI 54235, USA.

Most germplasm in the US Potato Genebank is in the form of botanical seed populations. So, depending on the breeding system, plants within these populations may be highly heterozygous and heterogeneous. Or, if they are facultative selfers, they may be homozygous and perhaps also homogeneous. The population structure in this sense has a great impact on germplasm conservation and use. Specifically, the more heterogeneous plants within a populations are, the more care needs to be taken to avoid losing genes when that population is sampled for original collection, genebank multiplication, or evaluation for economic traits.

This study used RAPD markers to investigate genetic heterogeneity (GH) among 18-24 plants in each of 21 potato populations from 3 species. These represented three different breeding systems observed in *Solanum* species: *S. jamesii* (diploid outcrosser), *S. fendleri* (disomic tetraploid selfer) and *S. verrucosum* (diploid selfer). Plants within all populations of selfing *S. verrucosum* and *S. fendleri* were very homogeneous (GH = 0.036 and 0.082, respectively). In contrast, outcrossing *S. jamesii* populations were all much more heterogeneous (GH= 0.295).

This pilot study demonstrates the usefulness of RAPD markers to gain insights into population structure and thereby optimize the efficiency of germplasm preservation and use. A more comprehensive study is in progress.

(70) Effects of Azoxystrobin (Quadris) Rates on *Colletotrichum coccodes* and *Verticillium dahliae* Colonization in the Russet Burbank Potato. Davis, James R.* and Ann T. Schneider, University of Idaho, Aberdeen R&E Center, PO Box 870, Aberdeen, ID 83210.

Greenhouse studies showed control of the black dot disease caused by *Colletotrichum coccodes* when azoxystrobin (Quadris by Zeneca) was applied to foliage of the Russet Burbank potato at 9.5 ppm. With this treatment, *C. coccodes* lesions were reduced by 80 to 94%, and the colonization of *C. coccodes* in stem tissue was reduced by >99%. Following three additional greenhouse studies, the threshold rate needed to suppress *C. coccodes* was found to range from 1.25 to 2.50 ppm. These results were obtained by either spraying Quadris at six different rates (0.0, 0.7, 1.25, 2.50, 5.00, and 10.00 ppm) to run off, followed by foliar inoculations with *C. coccodes* at 10^5 cells ml⁻¹, or by applying 0.1 ml of each respective treatment to 15 cm pots of naturally infested field soils to which 5.0 ml of 10^5 *C. coccodes* inoculum had also been added. In contrast to the effect on *C. coccodes*, Quadris had no effect on *Verticillium dahliae*, but as *C. coccodes* populations were reduced in Russet Burbank, *V. dahliae* populations increased. When Russet Burbank was grown in pots containing naturally infested field soil, Quadris reduced ($P < 0.05$) the populations of *C. coccodes* in underground stem tissue while *V. dahliae* significantly increased ($P < 0.05$). These results suggest that under these conditions *C. coccodes* is competing with *V. dahliae*.

(71) Below-Ground Potato Plant Architecture in Early-Die Soil: With Special Reference to *Pratylenchus penetrans* (Nematoda). Bird, G. W.*¹ & J. Chen²,
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Under both field and greenhouse conditions, the below-ground architecture of potato plants differed significantly ($P=0.05$) during the first 45 days after planting in the presence and absence of early-die soil. Plants were destructively sampled every five days from 10 to 45 days after seed piece planting. Plant resources were partitioned into basal roots, nodal roots, stolon roots, tuber roots, stolons, tubers, below-ground stems and above-ground tissue. All seven of the below-ground parameters had significantly ($P=0.05$) less dry weight (grams/plant) associated with one or more of the sampling dates when grown in early-die, compared with non-early-die soil. Significant differences ($P=0.05$) in basal and nodal roots were noted as early as 30 days after planting. *Pratylenchus penetrans* (Nematoda) was recovered from both stolon and root tissue as early as 30 days after planting. *P. penetrans* was present in stolon tissue at all subsequent sampling dates when the plants were grown in early-die. A graphic model of the patterns of plant development associated with early-die and non-early-die soil indicated that normal early-season development of basal roots is very important, if not essential for development of a healthy potato plant.

(72) Potentials of Precision Agriculture Technology in Potato Early-Die Management. Bird, G.W.*¹, M. Otto², N. Hoff³, R. Brook³ & R. Gore¹, ¹Department of Entomology, 243 Natural Science Building, Michigan State University, East Lansing, MI 48824; ²Agribusiness Consultants Inc., Lansing, MI; ³Department of Agricultural Engineering, Michigan State University bird@msue.msu.edu.

A potato research project was initiated in 1999 to evaluate the potential of precision agriculture technology on potato early-die (PED) management decision-making. A 62.1 acre Michigan commercial potato field in Montcalm County was geo-positioned on a one-acre grid basis and sampled for *Pratylenchus penetrans* (Nematoda) and *Verticillium dahliae* (Mycota). In 2000, a PED risk map (1-3) was constructed from the resulting data. The map was used to locate five replicates (16 row by 200 ft) of each of three spring applied soil fumigation treatments (0, 37.5 and 75 gpa, metham) randomly selected throughout the site in each of the three PED risk categories ($n = 45$). The pathogens were monitored and tuber yields and quality recorded at harvest. The technology allowed for excellent prediction of tuber yield from the PED risk map, and assessment of the economics and environmental impact potentials of variable rate soil fumigation. In 2000, in a commercial potato field in St. Joseph County, geo-positioned PED risk maps allowed a linear regression model to account for a high degree of the variance within tuber yield.

(73) Soil Fumigation with Telopic (C-35) to Control Verticillium Wilt. Tsrur (Lahkim), L.*¹, O. Erlich¹, M. Aahron¹, Y. Cahlon², A. Hadar², Y. Cohen³, M. Shmueli³, E. Shlevin⁴, E. Ben-Nun⁴, B. Meler⁵, Z. Bigel⁵ and I. Peretz-Alon⁶,
¹Agricultural Research Organization, Dept. of Plant Pathology, Gilat Experiment Station, M.P. Negev, 85280 Israel; ²Agrichem Ltd. Petach Tikva, Israel; ³Dead Sea Bromine LTD., Beer-Sheva, Israel; ⁴Kibbutz Saad, M.P. Negev, Israel; ⁵Kibbutz Alumim, M.P. Negev, Israel; ⁶Maon Enterprises, M.P. Negev, Israel.

Potato early dying caused primarily by *Verticillium dahliae* may reduce yields, especially in susceptible cultivars. Microsclerotia produced by the pathogen infest the soil for more than 15 years. The objective of the present study was to evaluate the efficacy of Telopic (61% 1,3 dichloropropene and 35% chloropicrin) in controlling *V. dahliae* in potato, and its effect on subsequent susceptible crops.

In field experiments conducted at Gilat (1998-1999), disease incidence and colonization levels of the fungus were significantly reduced by C-35 and methyl bromide (MBr) applied with plastic covering, compared to C-35 without plastic and the control. Yields obtained in the controls were 20% lower than in the other treatments. At B'esor (1998), disease incidence was reduced to 0, 0, 86 and 41% in MBr, C-35, Bromopic (BrP) and Fordor, respectively. Yields obtained with BrP, C-35 and MBr were significantly higher than with Fordor and the control. At Alumim (2000), yields were significantly increased by C-35, MBr and BrP, however, C-35 without plastic was similar to the non-treated control. Incidence of infected plants and daughter tubers was significantly lower in C-35, MBr and BrP than in control and C-35 without plastic.

To study the long-term effect of C-35 fumigation on subsequent susceptible crops, eggplant and watermelon were planted immediately after the potato harvest at Gilat. Eggplant yields obtained in the control and C-35 without plastic were significantly lower than in C-35 and MBr. Disease incidence in control and C-35 without plastic was higher both in eggplant and watermelon.

(74) Introducing Moncoat MZ, a New Potato Seed Piece Protectant. Schafer, Ron*, Technical Representative, & Frank Fronek, Commercial Product Development Representative, United Agri Products, P.O. Box 1286 Greeley CO 80632.

Moncoat MZ is a combination product with 1.5% Flutolanil plus 6% Mancozeb formulated as a potato seed piece treatment.

Flutolanil is a new systemic fungicide that is stable in soils within a pH range of 3-11. Flutolanil is in the Benzanilide class of fungicides, and is currently the only active ingredient offered in this class of chemistry. The mode of action of Flutolanil is confirmed to be the inhibition of succinate dehydrogenase complex (SDC), an important enzyme in the complex for respiration. As a result, Flutolanil prevents both fungal growth and penetration from infection cushions. Flutolanil is considered to have a single site mode of action, yet is considered to have a low resistance risk as a potato seed treatment due to the pathogens controlled and is used in Mancozeb combinations.

In several years of testing Moncoat MZ has demonstrated a high level of activity against *Rhizoctonia solani*; both Stem Canker and Black Scurf (on daughter tubers), Dry Rot caused by *Fusarium*, Silver Scurf caused by *Helminthosporium solani* and seed to seed transmission of Late Blight in the cutting and handling process.

(75) Telomere-Associated RFLP Variability among *Phytophthora infestans* Strains Isolated in Oregon. Mills, Dallice^{1*}, Jessica M. Schrunck¹, Philip B. Hamm¹, D. A. Johnson². ¹Dept. of Botany and Plant Pathology, Oregon St. Univ., Corvallis, OR 97331-2902; ²Dept. Plant Pathology, Washington St. Univ., Pullman, WA 99164-6430.

Phytophthora infestans strains isolated in Oregon during 1992-1999 are being subjected to telomere-associated RFLP analysis to evaluate the genetic variability in pathogen populations *vis a vis* other methods of measurement. Total genomic DNA isolated from each strain was digested with *Msp*I and *Hind*III, separated by gel electrophoresis and Southern-blotted. A telomere probe constructed from an *Arabidopsis* telomere DNA sequence was hybridized to the blots to highlight length variation among telomere-associated fragments and create a fingerprint for each strain. The NSYSpc computer program was used to obtain a measure of the relatedness of the fingerprints for within-year and between-year combinations for strains isolated in 1995-1997. Among 18 US8 strains of A2 mating type from the 1995 collection, 17 different genotypes were identified. The most divergent strains had on average 84 percent similarity. Of 35 strains examined from the 1996 collection, there were 18 different genotypes, of which 5 were comprised of 2 or more strains. One genotype had 10 strains and both mating types. The most divergent of the 1996 strains on average were 77 percent similar. Of 23 strains examined from the 1997 collection, 17 different genotypes were detected. There were 9 different genotypes among 10 known US8 strains, and the most divergent strains were 80 percent similar. Although some strains isolated during 1995-1997 have a common genotype, 45 different genotypes were detected, and the most divergent strains on average were 72 percent similar. This method of analysis appears to identify greater genetic variability than has been observed by other methods.

(76) Thermal Properties of Potato Cull Piles and Different Genotypes of *Phytophthora infestans* in Relation to Overwintering of Potato Late Blight. Kirk, William W.*, R. Scott Shaw, Brendan A. Niemira, Jeffrey M. Stein and Robert L. Schafer, Department of Botany and Plant Pathology, Michigan State University, East Lansing, 48824.

The late blight inoculum that initiates crop infection in succeeding years may be started by infected potato tuber(s) surviving winter as seed tubers, volunteer tubers in fields or within culls. The objectives of this study were to evaluate the influence of temperature on survival of different genotypes of *P. infestans* in vitro and to profile thermal characteristics of potato cull piles. *P. infestans* genotypes (US1, US6, US8 and US14) growing on rye agar plates were exposed to temperatures -10 to 50°C for different periods and survival estimated by digital image analysis. Temperature was monitored in potato cull piles (sizes ca. 1, 5, 10, 15 t) at the base, interior and surface of the piles (November - April in Michigan, 1996 and 1997). Base temperature for survival of all genotypes of *P. infestans* in vitro was < -5°C and upper temperature for survival varied with exposure time but was about 45°C. The number of hours of exposure of tubers in cull piles above and below the estimated lethal thresholds was calculated. Tubers within cull piles were occasionally exposed to temperatures below -5°C but rarely to temperatures above 45°C. Tubers in culls in both years failed to produce sprouts the following year suggesting that tuber death had occurred as a result of temperature exposure. Ambient temperature information gathered during winter months in potato growing regions would enable risk of a late blight epidemic initiated from cull piles to be estimated based on survival of host and pathogen.

(77) Evaluation of Seed Piece Fungicides and Application Time to Control Tuberborne Late Blight. Ludy, R. L.*, M. L. Powelson, B. Gunderson and D. Inglis, Department of Botany & Plant Pathology, Oregon State University, Corvallis, OR 97331-2902 and Washington State University, Mount Vernon Research and Extension Unit, Mount Vernon, WA 98273.

Seed piece treatments with activity against *Phytophthora infestans* (Evolve MZ, Maxim MZ, Seed Treatment for Potatoes or Tops MZ) were evaluated in the field in Corvallis, OR and Mount Vernon, WA. Treatments were applied to cut seed pieces immediately following inoculation with 0, 100, 400 or 800 sporangia/seed piece using US-8 or US-11 in Oregon and Washington, respectively. Across inoculum densities, all fungicides were equally effective in protecting seed pieces from *P. infestans* as indicated by 99 (OR) and 96% (WA) emergence and 3 (OR) and 6% (WA) seed piece decay. Without seed treatment, an increase in inoculum density resulted in a decrease in emergence and an increase in seed piece decay. Time of treatment (0, 1.5 or 3 days post inoculation) was evaluated with Tops MZ and Tops 5D using the genotypes and pathogen inoculum densities discussed above. A significant 3-way interaction (inoculum density x timing x fungicide) was observed. When seed pieces received no inoculum, application time and fungicide had no impact on emergence (99%) or seed piece decay (1%). With inoculum densities of 100 to 800 sporangia/seed piece, Tops MZ was effective in protecting seed pieces if applied immediately following inoculation (99% emergence) compared to Tops 5D (24% emergence). Emergence was less than 30% for both Tops MZ and Tops 5D when seed treatment was delayed 1.5 or 3 days following inoculation. Results were similar in Washington. Transmission of *P. infestans* from seed pieces to the foliage was not observed.

(78) A Technique to Evaluate the Response of Non-Tuber Potato Tissue to Infection with *Phytophthora erythroseptica*. Peters, R.D.^{1*} and A.V. Sturz², ¹Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, P.O. Box 1210, Charlottetown, PE C1A 7M8; ²PEI Department of Agriculture and Forestry, Plant Health Research and Diagnostics, P.O. Box 1600, Charlottetown, PE C1A 7N3.

A technique was developed to evaluate the responses of roots, stolons and stems of different potato cultivars to infection with *Phytophthora erythroseptica*, causal agent of pink rot. Tissue culture plantlets of 20 different potato cultivars commonly grown in Canada were transplanted into flats of vermiculite and then inoculated with zoospore suspensions of isolates of *P. erythroseptica* from Prince Edward Island and Maine. Plantlets were maintained at 18°C (14 h photoperiod) and rated for disease severity (1-5 scale where 1 = healthy plant; 5 = dead plant) 10 days following inoculation. Potato cultivars differed significantly ($P = 0.05$) in disease severity following inoculation. No cultivars were immune to infection. Symptoms ranged from mild root necrosis and chlorosis of basal leaves, to spreading stem lesions, wilting and plant death. Plantlets of the cultivars Goldrush and Yukon Gold were the most susceptible to infection and disease development while those of 'Butte' and 'Russet Burbank' were the least susceptible. Most of the cultivars assessed were moderately susceptible to infection and the subsequent development of disease. An association was noted between cultivar field maturity and cultivar response to infection with *P. erythroseptica*; plantlets of cultivars with late-season maturity were more disease-resistant than those with early or mid-season maturity. Isolates of *P. erythroseptica* used for inoculations did not differ significantly ($P = 0.05$) in pathogenicity and no isolate × cultivar interactions occurred. The screening protocol described would be useful as part of a breeding program to assess potato germplasm for resistance to *P. erythroseptica*.

(79) Effect of Fungicide Programs on Early Blight Control and Nitrogen Fertilizer Response in Potato. Miller, Jeff S.* and Carl J. Rosen, University of Idaho, PO Box 870, Aberdeen, ID 83210 and University of Minnesota, St. Paul, MN 55108.

The use of azoxystrobin (Quadris) for early blight control often results in vines remaining greener longer in the growing season. This observation has led to the suggestion that N fertilizer could be applied at lower rates when Quadris is used in a fungicide program since high N rates are often used to compensate for early blight. This study was conducted to determine if the use of Quadris affects N fertilizer requirements for potato. Plots were established in 1999 and 2000 at Becker, MN on a Hubbard loamy sand as a complete factorial, split-plot arrangement using a randomized complete block design with four replications. Fungicide treatments were used as the whole plot factor and included an untreated control, Bravo, and Bravo rotated with Quadris. Fertility treatments were used as the sub-plot factor and included nitrogen applied at three levels (150, 225, and 300 lbs/A N) and two timings (pre-hilling and all season). Early blight was problematic in 1999 and both early and late blight were severe in 2000. Significant interactions were observed between fungicide and fertility treatments for disease control in both study years. Control of diseases with fungicides was generally more effective at higher N rates. In 1999, an interaction was not observed between N rate and fungicide treatment for yield and tuber quality. However, a significant interaction did occur between fungicide and N rate in 2000 for yield where yields increased linearly with N rate using Bravo, but increased quadratically with N rate using Quadris/Bravo. Timing of N application had no effect on yield in 1999, but all season N application tended to depress yield compared to N applied pre-hill in 2000.

(80) Influence of Seed-Borne *Helminthosporium solani* on Progeny-Tuber Disease Levels. Geary, Brad*, D. A. Johnson and P. B. Hamm. University of Idaho, 29603 U of I Ln, Parma, ID 83660, Washington State University, P.O. Box 646430, Pullman, WA 99164-6430, Hermiston Ag. Research & Extension Center P.O. Box 105, Oregon State University, Hermiston 97838.

Silver scurf of potato, caused by *Helminthosporium solani*, is a disfiguring disease of the tuber periderm that reduces marketability, particularly in fresh-marketed potatoes. Results of studies to determine if a relationship occurs between infected seed- and infected progeny-tubers suggest a relationship exists, however, not all studies agree. Results from this study further substantiate the importance of the disease level on seed tubers. In 1997 and 1998 (Washington), and in 1999 (Oregon), the level of *H. solani* was determined on both seed tubers in numerous seed lots, and then from the progeny (harvested) tubers from each seed lot. In 1999, disease levels were determined on successive generations of certified seed (generation 1, 2, and 3) as well as the subsequent progeny tubers from each generation. There was a positive significant correlation between the severity of silver scurf on the seed and on the corresponding progeny tubers in all three years. As the severity of seed tuber infections increased, the amount of silver scurf on the progeny tubers also increased. Therefore, the use of silver scurf free seed is an important step when growing potatoes for the fresh market. However, disease severity of seed tubers did not account for the entire amount of disease increase on progeny tubers, indicating other factors also contribute to disease levels.

(81) Production of Creamer Potatoes in No-Tillage Cover Cropping System.

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Conservation tillage conserves soil and together with cover crops improves soil fertility and controls weeds. We evaluated an alternative production system using raised beds, cover crops, and no tillage in creamer potato (*Solanum tuberosum* L.) production. The experiments were conducted in two locations, Beltsville, MD, and Blacksburg, VA. The experimental design was a split plot with nine cover crops as main plots, and three potatoes clones (B1145-2, B1491-5, B1492-12) as subplots. The cover crops were rye (R), crimson clover (CC), brassica (BR), Austrian winter peas (AWP), R + CC, BR + CC, CC in flat beds, and bare soil both in flat and raised beds. Yields, weed biomass and disease resistance were recorded. Yields at both locations were significantly influenced by the cover crops. Highest yields at both locations were obtained with R + CC mixture reaching 22 and 15.3 t.ha⁻¹ in MD and VA, respectively. B1145-2 was the highest yielding clone at both locations. The performance of the remaining eight cover crops varied greatly between locations. There were significant clone x cover crop interactions at both locations. These results suggest that use of cover crops and no-tillage appear to be a viable and economic system. However, optimum performance of cultivars depends on selecting the appropriate cover crop for the location.

(82) Relating Potato Yield and Quality to Variability in Soil Characteristics.

Redulla, C.¹, J. R. Davenport*¹, R. G. Evans², M. J. Hattendorf³, A. K. Alva⁴ and R. A. Boydston⁴, ¹Washington State University, 24106 N. Bunn Road, Prosser, WA 99350, ²USDA/ARS, 1500 N. Central Ave., Sidney, MT 59270, ³Vantage Point, 2057 Vermont Drive, Fort Collins, CO 80525, ⁴USDA/ARS, 24106 N. Bunn Road, Prosser, WA 99350.

There is a void in our understanding of the causes of within-field spatial yield variability in potato. To begin to fill this void, a study was conducted from 1997 to 2000 on a commercial farm in eastern Washington. Selected center-pivot irrigated fields were soil-sampled on 0.4-ha grids before potato (*Solanum tuberosum* L.) planting. The soil samples were analyzed for nitrate-N, ammonium-N, P, K, organic matter, pH, texture, and other chemical properties. Four to five days before commercial harvest, a 3-m length of potato row was harvested at each original grid point using a one-row digger. The potatoes were weighed, sorted into 5 different size classes by weight, and evaluated for specific gravity. Correlation and stepwise regression analyses were done on the data from three fields which had been conventionally (uniformly) fertilized. The soil variable which had the highest r with yield differed among the three fields. Highest correlation coefficient with the yield variable was with sand in one field ($r = 0.33$, $P < 0.01$), with clay in a second field ($r = 0.20$, $P = 0.04$), and with pH the two other fields ($r = -0.22$, $P = 0.04^*$ and $r = -0.18$, $P = 0.12$). Stepwise linear regression analyses with yield as the dependent variable revealed that soil textural class, pH, and OM contributed the largest partial R² of the model although the highest model R² obtained was < 0.42 indicating other soil, environmental or pest variables contribute to the spatial variability of potato yield and quality.

(83) Influence of Seed Size and Density on the Performance of Direct Seedling Transplants from Hybrid True Potato Seed (TPS). Upadhya, Mahesh D.*and Rolando Cabello, International Potato Center, La Molina, Lima, Peru.

Studies conducted by CIP and the collaborating NARS on the economics of potato production from true potato seed (TPS) as a propagule has shown that the crop raised from direct seedling transplants give highest cash returns. Therefore, efforts at CIP have been directed towards the production of hybrid TPS families which will give high tuber yields from crop raised through directly transplanted seedlings. The studies have also shown that the proportion of different fractions based on size and density in a sample of hybrid TPS produced under different agroclimates and production protocols vary considerably. Furthermore, the proportions of different fractions is also affected by the genotypes of the maternal parents used for the production of hybrid TPS (Upadhya, Thakur and Cabello, unpublished). Studies were, therefore, undertaken to study the emergence, survival after bare root transplanting and the final yield of the crop raised from the different fractions of TPS based on density and size. The data indicated that although the density does not give significant difference, the size of the TPS show significant effect on the performance. The larger size ($> 1/16''$) gives the best results irrespective of the density as compared to small size ($< 1/18''$). The data will be presented and discussed highlighting the importance of TPS size in the breeding of the parental lines as well as developing the agronomic protocols for the production of hybrid TPS.

(84) Steps Underway to Strengthen Metam-Sodium as an Effective Fumigant for Weeds, Disease, and Nematode Control. Sullivan, David A.*, Executive Director, Metam-Sodium Task Force, 1900 Elkin Street, Suite 240, Alexandria, VA 22308.

Metam-sodium has served the needs of agriculture as a broad-based fumigant to control weeds, disease, and nematodes since the 1950s. Since that time, metam-sodium has been widely used, including in niche markets, such as the carrot industry in California and potato applications in the Pacific Northwest. The phase-out of methyl bromide has prompted a renewed interest in metam-sodium to meet broader agricultural needs. The Metam-Sodium Task Force is comprised of the three U.S. producers of metam-sodium and offers this paper to summarize the important benefits of metam-sodium specific to the potato industry. Enhanced application and sealing methods will be described, as well as the demonstrated improvement in product retention in the soil.

(85) National Ugandan Potato Program Review. Locke, Kerry A.*, Oregon State University, Klamath County Extension, 3328 Vandenberg Road, Klamath Falls, OR 97603.

The potato plant provides an abundant, nutritious food source, which is appreciated by Ugandans who have experienced a crop produced with healthy seed. The biggest obstacle to the National Ugandan Potato Program is adequate funding. This is a complex, long-term undertaking that requires a long-term, dependable funding source. The main potato production constraint is an available source of healthy, improved seed. Disease free seed from the International Potato Center, in Peru is being evaluated for productive characteristics at the Kalengyere Research Station, Kabale, Uganda. A multiplication program to increase improved lines for seed production is being coordinated with progressive growers in the Kabale District. The greatest threat to their success is bacterial wilt, *Ralstonia solanacearum*. A foundation seed program to produce disease free seed and a system to monitor the increase of healthy seed needs to be implemented. Adequate linkages between research, extension and the university need to be in place and functioning to have a strong, sustainable program. The potential for Ugandan potato production and the needs for an abundant food source are great. This is an exciting and challenging time for the National Ugandan Potato Program!

(86) Protein Levels in Potato Breeding Selections and Cultivars. Corsini, Dennis *, Richard Novy, Annie Marshall, and Joseph Pavek, University of Idaho, Aberdeen Research and Extension Center, PO Box 870, Aberdeen, ID 83210 and 2-3439 E. Cliff Drive, Santa Cruz, CA 95062.

The protein levels of 379 second field generation potato breeding selections were measured by the Comassie Blue procedure in 1995 to determine the range of protein present in cultivated potato grown under irrigated conditions in the northwest. One objective was to select low protein clones suitable for use in protein restricted diets. These selections were derived from a broad range of potato germplasm including cultivated diploids, *S. andigena*, and hybrids with wild species. The mean percent protein on a fresh weight basis (FWB) was 0.95%, and the median was 0.94%. Only 12 selections were below the standard deviation from the mean of replicated Russet Burbank control plots ($0.70\% \pm 0.08\%$). The three highest selections had over 1.4% protein. In 1996 the clones with highest and lowest protein levels were retested, and 90 cultivars in the USDA/ARS (Aberdeen, ID) collection were also screened for protein levels. The mean % protein for the cultivars was 0.82% and median was 0.79% FWB. Atlantic, Lenape, Pilica, Russet Nugget, and Suncrisp were among the highest with over 1.1% protein FWB. Crestone Russet, Granola, Agria, Centennial Russet, and Ptermigan were the lowest at less than 0.6% protein FWB. In subsequent years of testing, Crestone Russet and Granola continued to show protein levels as low as those of the 3 lowest protein breeding selections.

(87) Physicochemical Properties of Starches during Potato Growth. Liu, Q^{1*} and R. Yada², Food Research Program, Agriculture & Agri-Food Canada, Guelph, Ontario, Canada N1G 5C9¹ and Dept. of Food Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1².

The characterization of physicochemical properties of starch during potato growth is critical to the development of new starch products. Desired functional properties may be achieved by controlling the growth period, without further physical or chemical modification of the starch. In this study, starch was extracted from three potato cultivars (Shepody, Snowden and Superior) during growth. The physicochemical properties of starches were characterized by different analytical techniques. Gelatinization and retrogradation of starches were measured using differential scanning calorimetry. Granule size and size distribution were determined by optical microscopy. High performance size-exclusion chromatography was employed to analyze molecular chain size and size distribution of starches. Starch crystalline structure was evaluated by x-ray diffraction. Rapid viscosity analysis was also employed to measure starch paste viscosity and changes during heating. Results indicate that physicochemical properties of starches varied among the potato cultivars as well as during growth. Different granular size, starch molecular size and size distribution, and chemical composition in starch could be major factors influencing starch functional properties. The mechanism of starch biosynthesis during potato growth is also explored in this study.

**Poster
Abstracts**

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(P1) Evaluation of Clonal Susceptibility to Variation in Tuber Shape, French Fry Yield, and After-Storage Processing Quality Across Production Regions.

Knowles, N.R.*, R.E. Thornton, N. Fuller and L. Knowles, Dept. of Horticulture & Landscape Architecture, P.O. Box 646414, Washington State University, Pullman, WA 99164-6414.

In the Pacific Northwest, clones from the early and late Tri-State and Regional Variety Trials are evaluated for postharvest quality and storage potential with a focus on identifying varieties for the 'out-of-field' and 'after-storage' processing windows, respectively. Variable growing environments across WA, ID and OR interact with genotype to affect tuber morphology and storability. Among other attributes, a low degree of variation in tuber morphology and after-storage processing quality is desirable in a variety developed for the Tri-state area; however, measures of clonal plasticity in these characteristics are lacking. Methodologies have been developed to estimate the impact of region of production and tuber shape on yield of French fries. Number and fresh weight of fries (7.6 cm long or greater) can be estimated based on curvilinear relationships with length to width (L/W) ratios of 227- to 284-g tubers, a premium size desired for processing. Based on these models, yield of French fries (percent by no.) ranged from 67 to 78% across 16 clones, when averaged over production sites. In the 2000 trials, Russet Burbank had the most resistance to change in L/W ratio, resulting in fry yields that varied only 1.2% (by no.) across production sites. At the other extreme, A89384-10 had the greatest variation in usable fry yield, ranging from 57 to 78% across tri-state production sites. Clonal susceptibility to loss of processing quality after 60 days storage at 7 and 9 C was evaluated as a percentage of that at harvest. Analysis of the spread of variation in processing quality (after storage at 7 C) for clones produced across production sites provides an objective assessment of clonal stability during storage.

(P2) The Corrosive Effects of Purogene and Oxidate. Norikane, Joey H.^{1*}, William W. Kirk², and Roger Brook³, ¹USDA/ARS, Department of Agricultural Engineering, Michigan State University, 220 Farrall Hall, East Lansing, MI 48824, ²Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824, ³Department of Agricultural Engineering, Michigan State University, East Lansing, MI 48824.

Purogene, a chlorine dioxide solution (Bio-Cide International, Norman, OK), and OxiDate, a hydrogen peroxide solution (BioSafe Systems, Glastonbury, CT), are used to control potato storage pathogens. These chemicals are strong oxidizers, but they are also corrosive. A series of tests were conducted to evaluate the corrosive effects of Purogene and Oxidate on seven common construction and application materials. Stainless steel, low carbon steel, copper, brass, polyvinyl chloride (PVC), and galvanized sheet metal were cut into 38mm square samples with an 8 mm hole in the middle of one side for mounting. The samples were suspended in Erlenmyer flasks from hooked glass rods and immersed in 700 ml of test solution. There were five treatments for the Purogene test, de-ionized water (control), 0.001M citric acid, and 100, 200, and 400 PPM total available chlorine dioxide Purogene solutions. There were also three Oxidate treatments, which were de-ionized water (control) and solutions of 50:1 and 100:1 mixing ratios. There were five replicates of each material in each of the test treatments. The samples were weighed on an analytical balance to determine rates of material loss. The 400 PPM Purogene solution was the most corrosive of the chlorine dioxide treatments, but according to the literature, the annual loss rates for all materials tested were low enough for a "good" corrosion resistance ratings. The preliminary results of the Oxidate tests show that there is corrosion, but at lower levels than the Purogene tests.

(P3) Efficacy of Purogene and Oxidate Disinfectants Added to Potato Storage Humidity Water for Pathogen Control. Norikane, Joey, H. ^{1*}, Roger C. Brook², and William W. Kirk³, ¹USDA/ARS, Department of Agricultural Engineering, Michigan State University, 220 Farrall Hall, East Lansing, MI 48824, ²Department of Agricultural Engineering, Michigan State University, East Lansing, MI 48824, ³Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824.

Potato storage pathogens can cause serious economic losses in potatoes stored for seed, table stock or processing markets. Humidification systems are commonly used to prevent water loss from stored tubers. Losses are greatest in storages maintained between 42 and 55°F. Potato pathogens on the surface of tubers could potentially be controlled by addition disinfectants to humidification water. Purogene (Bio-Cide International, Norman, OK) and OxiDate (OxiDate, BioSafe Systems, Glastonbury, CT) have been recommended for this use, but the efficacy of this method of treatment needs to be demonstrated. Testing is currently being conducted at Michigan State University to evaluate this approach. In a temperature controlled storage chamber, three racks (2 ft. x 6 ft. x 6 ft.) were equipped with individual humidification and monitoring systems and sealed with plastic tarps. The racks were humidified with de-ionized water (control), 50 PPM total available chlorine dioxide as per the Purogene label, and 100:1 dilution as per the Oxidate label. Four replicates of 30 potato (cv Pike) tubers were inoculated with dry rot (*Fusarium sambucinum*), soft rot (*Erwinia carotovora* var *carotovora*) or late blight (*Phytophthora infestans*) and placed in plastic baskets in October 2000. The baskets were then loaded into the racks and sealed. Humidity and temperature were monitored and maintained at 95% relative humidity and 49°F. The test solutions were applied daily to maintain the target humidity. Samples were taken from the racks at 1-month, 3-month and 6-month intervals for evaluation. Preliminary results from the testing will be presented.

(P4) Vydate® C-LV "over and under" Control of Nematodes and Insects in Potatoes. Drake, G. E.*; N. D. McKinley, DuPont Crop Protection Products, Stine-Haskell Research Center, Newark DE.

Vydate® is the registered trade name for oxamyl, an oxime N-methyl carbamate, introduced by E. I. du Pont de Nemours Inc. in 1969 as a nematicide with insecticidal and acaricidal properties. Oxamyl effectively controls most nematode species and a wide range of sucking and piercing insects and mites on many fruits, field crops, and vegetables including potatoes. Oxamyl has pronounced and unique systemic characteristics. Applied to the soil in irrigation water, it is absorbed and translocated upward; sprayed on the foliage it is moved downwards into the root system for plant protection. This feature allows the use of oxamyl for the combined control of nematodes and foliar feeding pests via drip and overhead irrigation systems.

Vydate® C-LV is a new formulation currently being introduced into the potato market in the Pacific Northwest including the states of Oregon, Washington, Idaho, and Colorado. Vydate C-LV can be applied through low-pressure irrigation systems including drip (trickle) systems. Application rates are at 1, 1.5, and 2 lb ai/A. Nematode species include root-knot, (including Columbia root-knot nematode), sting, pin, lesion and ring. Insects controlled include Colorado potato beetle, flea beetles, potato leafhopper, and tarnished plant bug, and aphid species (including green peach aphid). Field and laboratory data have shown that oxamyl does not rapidly kill green peach aphid but inhibits feeding, slowly killing the insect and thus preventing the spread of potato leaf roll virus. At the use rates recommended through center pivot irrigation mite suppression is also achieved.

(P5) Ethylene Generation from Potato Tissue is Free Radical-Mediated, Dependent on Tuber Age, and Correlated with Loss in Wound-Healing Ability.
Kumar, G.N.M., L. Knowles and N.R. Knowles*, Dept. of Horticulture & Landscape Architecture, P.O. Box 646414, Washington State University, Pullman, WA 99164-6414.

Freshly-cut discs of tuber tissue failed to generate detectable levels of C(2)H(4) unless 1-aminocyclopropane-1-carboxylic acid (ACC) was supplied exogenously. Moreover, the ability of discs to convert exogenous ACC to C(2)H(4) declined with advancing tuber age. The conversion of ACC to C(2)H(4) was not affected by 1-aminocyclobutane-1-carboxylic acid (ACBC), a specific inhibitor of ACC oxidase (ACCO). ACBC effectively inhibited ACC-induced C(2)H(4) synthesis in apple tissue however. The free-radical (FR) scavenger, n-propyl gallate, inhibited the ability of tuber tissue to convert ACC to C(2)H(4) by as much as 80% but was completely ineffective on apple tissue. These results indicate that C(2)H(4) production from exogenously supplied ACC is primarily FR-mediated in potato tissue, in contrast to the enzymatically-mediated (via ACCO) conversion of ACC to C(2)H(4) in apple tissue. The ability of freshly wounded potato tubers to produce FRs on the wound surface declined with advancing tuber age, along with the ability to convert exogenous ACC to C(2)H(4), providing further evidence of a FR-mediated mechanism for C(2)H(4) generation from ACC in potato discs. The loss in FR-producing ability of tissue with tuber age was concomitant with a decline in wound-healing ability and we speculate that the two may be related, as FRs facilitate the polymerization of phenolics during wound periderm formation. Differences in the ability of tuber tissue to produce C(2)H(4) from ACC may thus provide a sensitive, indirect marker of wound-induced FR production and perhaps wound-healing potential.

(P6) Physiological and Biochemical Markers of Seed-Tuber Productivity.
Knowles, N.R., Lisa Knowles* and G.N.M. Kumar, Dept of Horticulture & Landscape Architecture, P.O. Box 646414, Pullman, WA 99164-6414.

While the productivity of seed potatoes is greatly influenced by differences in tuber physiological age, our inability to define the physiological/biochemical bases of 'old' and 'young' remains a major obstacle to predicting and perhaps even controlling the yield potential of seed potatoes. With funding from the Washington State Potato Commission and Alberta Agricultural Research Institute, we are identifying markers of age and determining their efficacy for predicting productivity in short- and long-season growing areas. Seed-tubers possessing a broad range in growth and yield potential were produced in storage to facilitate the identification of productivity markers. Storage degree-days (DD) interacted with storage temperature, seed source (region of production) and cultivar to affect plant establishment and overall productivity. For example, yield of U.S. No. 1 tubers from seed-tubers that had accumulated 900 DD above 4 C at the beginning of storage fell from 6 to 38%, depending on these treatments. Hence, storage DD alone did not adequately describe seed age and productive potential. Seed Source (WA or Alberta) affected tuber physiological status at harvest, which in turn altered the responses to aging treatments during storage. By the end of storage, aging treatments had effected significant changes in tuber respiration, soluble sugars, indices of lipid peroxidation, tuber volatiles, proteinases, proteinase inhibitors, and enzymes associated with oxidative stress. Changes in these potential markers will be discussed in relation to age-induced differences in growth and yield potential.

(P7) Optimum Soil Water Potential and Drip Tape Position for Potato (*Solanum tuberosum* L.) Drip Irrigation. Shock, Clinton C.*, Eric P. Eldredge, Lamont D. Saunders, and Erik G. B. Feibert, Oregon State University, Malheur Experiment Station, 595 Onion Ave., Ontario, OR.

The optimum soil water potential to start irrigation for potato on silt loam in Malheur County is -50 to -60 kPa for sprinkler or furrow systems. Optimum soil moisture and drip tape position for drip irrigation are not known. Two drip tape positions and a range of soil water potential were tested on 'Umatilla Russet' potato in 1999 and 2000. Factorial designs used randomized complete blocks with five replicates. On a two-row flat-topped bed, either two drip tapes were positioned one on each potato row, or one tape was positioned halfway between the two potato rows. In 1999, irrigation levels of -30 and -60 kPa soil water potential were compared, and in 2000, -15, -30, -45, and -60 kPa were compared. Watermark sensors measured the soil water potential, and a CR10 datalogger recorded the sensor data and controlled the irrigation valves every 6 hours. Soil water potential stayed nearly constant in the wetter treatments. Less water was applied than the AgriMet potato Et estimate, possibly because of reduced evaporation from the soil. With irrigation at -45 or -60 kPa, applied water was much less than Et. Tuber yield, grade, and processing quality were better with irrigation at -15 or -30 kPa than at -45 or -60 kPa. One drip tape for two rows of plants was less productive than a drip tape for every row in 1999. The optimum potato irrigation criterion for drip systems may be wetter than for sprinkler or furrow systems.

(P8) Utilization of Controlled Release Fertilizers in Chip Potato Production. Hutchinson, Chad M.* and D.P. Weingartner, University of Florida/IFAS, Hastings Research and Education Center, P.O. Box 728, Hastings, FL 32145.

Best management practices (BMP) are being implemented to reduce potential nitrate run-off from 23,000 potato acres in St. Johns, Flagler, and Putnam counties of Florida. A BMP under consideration is the use of controlled release fertilizers (CRF). A field experiment was conducted at the Hastings REC to determine if a chip potato crop could be produced using CRFs. Treatments included a non-fertilized control and fertilizer treatments of Osmocote 19-6-12 (NPK); Osmocote Plus 15-9-12; Scott's Topdress Special 22-5-6, and a standard 14-2-12 non-CRF. All fertilizers were applied at 168, 224, and 280 kg N/ha with standard fertilizer treatments applied in a split application. *Solanum tuberosum* var. Atlantic was planted February 25 and harvested and graded June 2, 2000. Total and marketable yields in all treatments were significantly higher than the non-fertilized control. Potatoes fertilized with 168 kg/ha CRF produced an average marketable yield of 32 MT/ha, 73% more than the non-fertilized control. Total nitrogen in leaf tissue ranged from 6.3% in the standard fertilizer treatment to lows of 4.8% in the Osmocote Plus treatment and 2.9% in the non-fertilized treatment. All nitrogen values from fertilized plants fell within state recommended limits. The positive results justify the further refinement of CRF use and the quantification of nitrate leaching with CRF fertilization.

(P9) Crop Tolerance and Weed Control with Flumioxazin and Sulfentrazone in Pacific Northwest Potato Production. Boydston, Rick A.*, Corey V. Ransom, and Pamela J. S. Hutchinson, USDA-ARS, Irrigated Agriculture Research and Extension Center, 24106 N. Bunn Road, Prosser, WA 99350; Malheur Experiment Station, Oregon State University, 595 Onion Ave., Ontario, OR 97914; and University of Idaho, Box AA, Aberdeen, ID 83210.

Sulfentrazone and flumioxazin were tested for weed control in potatoes near Aberdeen, ID, Ontario, OR, and Paterson, WA. Herbicides were applied after the final hilling and preemergence to potato and weeds. Flumioxazin applied at 0.05 to 0.13 lb/a controlled hairy nightshade and common lambsquarters well, but redroot pigweed control was marginal in Idaho and Oregon. Redroot pigweed control improved as flumioxazin rate increased in Oregon. Flumioxazin did not control tame oats, barnyardgrass, or large crabgrass. Little or no potato injury was observed when treating with flumioxazin in Idaho and Oregon, but flumioxazin slightly injured potatoes when applied at 0.13 lb/a in Washington. Sulfentrazone applied at 0.06 to 0.25 lb/a controlled common lambsquarters, redroot pigweed, and hairy nightshade greater than 90% at all locations. Sulfentrazone controlled barnyardgrass greater than 90% at 0.19 and 0.25 lb/a in Oregon. Tame oats and large crabgrass were not controlled by sulfentrazone. Sulfentrazone visually injured potatoes at 0.19 lb/a or more in Oregon and Washington, but potato tuber yield was not reduced compared to potatoes treated with herbicide standards. Tank mixes of sulfentrazone or flumioxazin with standard preemergence applied herbicides improved control of annual grass weeds and redroot pigweed.

(P10) Foliar Resistance to Late Blight in Potato Clones Evaluated in National Trials in 2000. Haynes, K.G.*, C.A. Thill, G. Secor, W.E. Fry, D.S. Douches, W.R. Stevenson, and D.P. Weingartner, USDA/ARS, Beltsville, MD 20705, University of Minnesota, St. Paul, MN 55108, North Dakota State University, Fargo, ND 58105, Cornell University, Ithaca, NY 14853, Michigan State University, East Lansing, MI 48824, University of Wisconsin, Madison, WI 53706; and University of Florida, Hastings, FL 32145.

With the emergence of new and more aggressive strains of *Phytophthora infestans* and the release of new potato cultivars, an evaluation of potato clones for resistance to late blight is necessary. Thirty-three potato clones (19 cultivars, 14 selections) were evaluated in 2000 for late blight resistance at six U.S. locations, along with eight late blight differentials. The US-8 strain of *P. infestans* was present at all locations except NY, which had the US-11 strain. Percent infected foliage was recorded at approximately weekly intervals following the onset of disease at each location. Area under the disease progress curve (AUDPC) was calculated. Clones were ranked for mean AUDPC within location and the non-parametric stability statistics, mean absolute rank differences and variance of the ranks, were analyzed for phenotypic stability. There were significant genotype x environment interactions on the variance of the ranks of these clones. Only one clone, Q237-25, made a significant contribution to this interaction. The most late blight resistant clones were B0767-2, Q237-25, B0692-4, and A90586-11. AUDPC was minimal in the late blight differential LBR(8) across all locations except ND. In agreement with results from previous years, genotype x environment interactions on the rankings of AUDPC appear to be minimal for most clones evaluated: where significant, only a few clones account for the interaction.

(P11) Potato Variety Trials in Ontario 2000. Currie Vanessa* and Dr. J. A. Sullivan, Department of Plant Agriculture, University of Guelph, Guelph, Ontario, Canada N1G 2W1.

In 2000, potato variety trials were conducted at the University of Guelph Cambridge Research Station to identify promising new varieties for the Ontario market. Trials included new commercial cultivars, advanced clone and adaptation tests from AAFC Fredericton and the North Central Regional Potato Variety Trial (NCRPVT). Plots were 5m - 7.6m long, 1 row wide, planted in a RBD with 4 replications. Cultivars are evaluated for yield and processing qualities. Envol, Adora, and Agata yielded 125%, 75% and 92% of Eramosa, respectively. Salem and Eva were considered midseason maturity. Eva was scab susceptible. Fabula yielded 124% of Yukon Gold. Caesar yielded 90% of Yukon Gold. MSE149-5Y yielded 121% of Yukon Gold. Calwhite and Aquilon yielded 174% and 129% of Shepody. MSE228-1 yielded 138% of Shepody. All chipping varieties yielded higher than Snowden. Roselys was more attractive than Bris du Nord and Chieftain.

AAFC Fredericton advanced selection trial included 9 clones, mostly suited for chipping. All yielded higher than Snowden. F94032 and F94036 produced high quality chips. Adaptation trial results showed good potential for F96028, F96040, F96001, and F96015. G9314-14, G9335-110 both yielded higher than Snowden. G9206-2R yielded 47% of Chieftain.

In the NCRPVT, ND4093-4Rus performed well. V0168-3 yielded 103% of Russet Burbank. ND3196-1R was very attractive. MSA091-1, W1355-1, MSE018-1 show promise and will be evaluated for storage chipping quality.

(P12) Comparative Growth Analysis of Russet Norkotah and Russet Norkotah Strains. Miller, J. Creighton, Jr.^{1*}, Jeff W. Koym¹, Douglas C. Scheuring¹, Gretta Schuster², and George J.C. Fernandez³, ¹Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133, ²Division of Agriculture, West Texas A&M University, Canyon, TX 79016-0001, ³Department of Applied Economics and Statistics, University of Nevada Reno, Reno, NV 89557-0105.

Several Russet Norkotah mutant strains released by Texas A&M University and Colorado State University are rapidly replacing standard Russet Norkotah. In 2000, 38% of the "Norkotah" seed acreage in the United States was planted to one or more of these strains. It is well established that the strains can potentially, and usually do, out-yield standard Russet Norkotah. The strains are somewhat later in maturity and thought to require lower inputs of nitrogen than standard Russet Norkotah. However, the developmental physiology of the strains relative to each other and Russet Norkotah is not well understood. To accomplish this, a two-year study which included standard Russet Norkotah, TXNS102, TXNS112, TXNS223, TXNS278, TXNS296, CORN-3, and CORN-8 was conducted to investigate the temporal patterns of development of individual plant parts (stolons/roots, tubers, stems, stem leaves, branches, and branch leaves). The number of plant parts and allocation of dry matter was monitored over the entire growing season. Significant differences in the temporal allocation of dry matter were found between standard Russet Norkotah and the strains and between CORN-3 and the other strains. These and other differences will be presented.

(P13) *S. phureja-s. stenotomum* Contributes High Specific Gravity and Internal Tuber Quality under High Temperature Growing Environments to 4X-2X Hybrids. Sterrett, S.B.*, M.R. Henninger, G.C. Yench, and K.G. Haynes, Virginia Polytechnic and State University, Painter, VA 23420; Rutgers University, New Brunswick, NJ 08903; North Carolina State University, Plymouth, NC; and USDA/ARS, Beltsville, MD 20705.

'Atlantic' is the number one chipping variety grown in the mid-Atlantic states despite its susceptibility to internal heat necrosis. A lack of tetraploid germplasm genetically unrelated to 'Atlantic' with high specific gravity has hindered the breeding effort in developing new chipping varieties for this area. The purpose of this study was to determine if the high specific gravity diploid *Solanum phureja-S. stenotomum* population under development in the USDA potato breeding program can contribute to this breeding effort. Twenty-six 4x-2x hybrids, 'Atlantic' and one breeding selection were evaluated in NC, VA and NJ in 1999 for specific gravity and incidence and severity of internal heat necrosis. 'Atlantic' was not a parent in any of these hybrids. Eleven of the 26 4x-2x hybrids were significantly higher in specific gravity and had significantly less internal heat necrosis than 'Atlantic'. Of these, 10 chipped acceptably out of 50°F storage in December in Maine. Two of the 4x-2x hybrids had significantly more internal heat necrosis than 'Atlantic'. Broad-sense heritability and a 95% confidence interval for specific gravity and incidence and severity of internal heat necrosis was estimated as 0.88 (0.78, 0.94), 0.91 (0.82, 0.95) and 0.89 (0.79, 0.94), respectively. These results indicate that *S. phureja-S. stenotomum* has the potential to expand the genetic base for new varieties for the mid-Atlantic region that are high in specific gravity and free from internal heat necrosis.

(P14) Human Serum Albumin Production in Transgenic Potato Tubers. Farran, Inma* and Angel M. Mingo-Castel, Instituto de Agrobiotecnología y Recursos Naturales (UPNA/ CSIC), Campus Arrosadía s/n, 31006-Pamplona, Spain.

Among all proteins of clinical relevance, human serum albumin (HSA) is the most extensively used human protein world-wide. In order to express HSA in tubers of transgenic potato plants, cDNA of mature HSA was obtained and later cloned under the B33 promoter of patatin (a specific tuber promoter). The recombinant albumin (rHSA) amino terminal was fused to a tuber signal peptide (protease inhibitor II).

An *Agrobacterium tumefaciens* transformation of potato (cv. Desiree) leaves was performed. Transgene insertion was assessed through PCR. Transcription and expression in greenhouse potato tubers were verified by Northern and Western blots, and the levels of HSA were measured using ELISA. A total of 81 transgenic lines (PCR +) were scored for HSA. Most of them (near 80%) stored rHSA in its tubers, the higher content reaching 0.2% of tuber soluble protein. SDS-PAGE relative mobility of rHSA was identical to HSA. Recombinant HSA was localized in the apoplast of potato leaves. Tuber rHSA was purified through FPLC (fast performance liquid chromatography) and the right processing of rHSA signal peptide was verified by amino terminal sequencing.

The possible influence of cultivar patatin levels on the transgene expression was also studied. Transgenic line Pas58 (cv. Desiree), which showed a 90% decrease in patatin levels (Hofgen, R. & Willmitzer L., 1992), was transformed. Surprisingly, the levels of recombinant HSA were significantly lower than the original levels of cv. Desiree.

(P15) Acquisition, Retention, and Transmission of Tobraviruses by Trichodorid Nematodes. Karanastasi, E., S.A., MacFarlane, U. Wyss, & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, Scotland, UK.

Tobacco rattle (TRV) and pea early-browning (PEBV) tobnaviruses are naturally transmitted by plant parasitic nematodes belonging to the *Trichodorus* and *Paratrichodorus* genera. It was presumed that trichodorids acquire virus particles while ingesting sap from virus infected root cells. After acquisition, the particles are retained by the nematodes, adsorbed on the cuticle lining the wall of the pharyngeal lumen, and subsequently are released into further root cells, along with secretions emanating from the pharyngeal glands.

The present study revealed how tobnaviruses are acquired by trichodorids, and that differences exist amongst the sites of retention of distinct tobnavirus strains in the pharyngeal tract of different trichodorid species. Furthermore, immunogold labelling of the coat protein of several tobnavirus strains provided unequivocal evidence of the identity of tobnavirus-like particles present within the pharynx of vector and non-vector trichodorid species. Subsequently, it was elucidated how tobnaviruses successfully establish an infection in cells fed upon by nematodes, despite the fact that trichodorids customarily kill cells from which they withdraw cytoplasm and/or organelles. These results provide new insight of vector trichodorid-tobnavirus-plant interactions.

(P16) Magnetic Capture of Nematodes Using Antiserum and Lectin Coated Dynabeads. Chen, Q., L. Robertson, J.T. Jones, V.C. Blok, M.S. Philips & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee Dd2 5da, Scotland, U.K.

Effective integrated management strategies require simple, rapid and reliable identification and quantification of plant parasitic nematodes present in soil. However, these nematodes are small and extremely difficult to identify. A new approach was developed using polyclonal antibody or lectin coated magnetic beads (Dynabeads) to recover target nematodes from samples. Lectins and antisera that bound specifically and reproducibly to the whole surface of *Globodera rostochiensis* and *Meloidogyne arenaria* were identified and were bound to Dynabeads to extract nematodes from test solutions. When using antisera, the efficiency of extraction was related to strength of binding of the antisera to the nematode (as determined by immunofluorescence microscopy), and several factors affected the extraction efficiency when using lectin-coated beads. A panel of monoclonal antibodies against a virus vector nematode, *Xiphinema index* is being used to develop this technique. This study expands the use of Dynabeads from cell and molecular biology to parasitology and revealed that Dynabeads coated with a probe of suitable specificity can be used to extract target nematodes. The technique is being developed for use in a "non-expert system" for identifying virus-vector trichodorid species.

(P17) Lectin Attachment to *Paratrichodorus anemones* (Nematoda). Holeva, R. C., Q., Chen, R., Neilson, J. T. Jones, & D. J. F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, U.K.

Lectins of *Arachis hypogaea* (PNA), *Bauhinia purpurea* (BPA), *Canavalia ensiformis* (ConA), *Dolichos biflorus* (DBA), *Glycine max* (SBA), *Griffonia simplicifolia* (GS-I, GS-II), *Lycopersicon esculentum* (LEA), *Maclura pomifera* (MPA), *Solanum tuberosum* (STA), *Triticum vulgare* (WGA) and *Ulex europaeus* (UEA-I) were screened for binding to surface glycoconjugates of *Paratrichodorus anemones*. The lectins were labelled with fluorochrome (FITC), and the fluorescence examined using incident fluorescence microscopy. Binding specificity was shown by inhibition with the appropriate sugars. All lectins, except PNA, DBA, GS-I and UEA-I, bound to the head region, indicating that specific binding sites were not present or accessible along the entire nematode cuticle. Furthermore, LEA and STA were the only lectins that produced a strong fluorescence on the entire surface coat of *P. anemones*. Consequently, they were selected as probes for the magnetic capture of target nematodes from mixed soil samples using Dynabeads. Polyclonal antisera is being produced to be used as an alternative probe for immuno-magnetic capture. Currently, these two approaches are being investigated for their applicability in detecting *Paratrichodorus* and *Trichodorus* nematodes, and for use in a "non-expert system" for detection, identification and quantification of virus-vector trichodoridae species.

(P18) OPEN

(P19) Molecular Diagnostics of Virus-Vector Trichodorid Nematodes and their Associated Tobacco Rattle Virus (TRV). Boutsika, K., V.C. Blok, M.S. Phillips & D.J.F. Brown*, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK.

TRV occurs worldwide but is particularly prevalent in Europe and North America. The virus is transmitted from plant to plant by soil-inhabiting ectoparasitic nematodes belonging to the genera *Paratrichodorus* and *Trichodorus*. A RT-PCR assay, utilising primers that reliably distinguish TRV and also serologically distinguishable strains of TRV, was developed that reliably detects the presence of TRV in individual trichodorids. Furthermore, the ribosomal DNA repeats unit is one of the most informative genomic regions for evolutionary and diagnostic purposes, of a wide range of organisms. It has been successfully used to distinguish nematode species. A PCR method utilizing ribosomal DNA primers derived from nematode 18S, 5.8S and 26S genes has been developed which reliably and consistently distinguishes individual *P. pachydermus*, *T. similis* and *T. primitivus*. Amplification products were sequenced and the complete sequence of the 18S gene and ITS1 and 2 regions from several trichodorid species have been obtained. Species specific primers have been successfully designed.

(P20) Subtractive Hybridization for the Isolation of Common Scab Resistance Genes from the Potato. Goyer, Claudia*, Patrice Audy, Henry De Jong, Russ King, Agnes Murphy, George Tai, Richard Tarn, Agriculture and Agri-Food Canada, Potato Research Centre, P.O. Box 20280, 850 Lincoln, Fredericton, NB E3B 4Z7, Canada.

Common scab is characterised by shallow, raised or deep-pitted brownish lesions on the tubers. This disease causes important economical losses every year in temperate regions of North America. Although several approaches have been developed to limit common scab damages on potato crop such as crop rotation, irrigation and soil acidification, breeding for resistance is still the most valuable strategy for managing potato scab. The present genetic base for scab resistance in North American varieties is very narrow. Preliminary genetic studies using scab resistant diploid *S. chacoense* and *S. phureja* in early 70's proposed two independent loci for scab resistance, one locus with one or more dominant allele(s), the second when it is homozygous recessive. Recent genetic studies supported the hypothesis that scab resistance is relatively simply inherited. The aim of this research project is to cloned common scab resistance gene(s). Potato lines with high contrast for scab resistance has been identified, crosses were performed and the progeny was tested in greenhouse and in the field. Resistant and susceptible individuals were selected and mRNA was isolated. Subtractive hybridization enriching differentially expressed genes between susceptible and resistant plants are currently carried out. Common scab resistance gene(s) could be used to evaluate parental breeding lines and hybrids for disease resistance and could be transferred to available commercial cultivars.

(P21) Control of Black and Silver Scurf on Potato Seed Tubers. Tsrur (Lahkim), L.^{1*}, O. Erlich¹, M. Aharon¹, M. Lavy² and I. Peretz-Alon², ¹Department of Plant Pathology, Gilat Experiment Station, Agricultural Research Organization, Ministry of Agriculture, M.P. Negev, ISRAEL, 85280; ²Maon Enterprises, M.P. Negev, ISRAEL.

Black and silver scurf on potato caused by *Rhizoctonia solani* and *Helminthosporium solani*, respectively, are considered blemish diseases that reduce tuber quality. Although they usually do not cause yield losses, silver scurf causes weight loss in stored potatoes.

Field experiments were conducted in southern Israel to determine the efficacy of fungicides in controlling black and silver scurf. Pencycuron, tolclofos-methyl, flutolanil and fludioxonil, sprayed either in furrow at planting or on seed tubers (in low volume), significantly reduced black scurf incidence on daughter tubers. A lesser reduction in disease incidence resulted from dusting seed tubers with mancozeb and propineb, or low volume spraying with iprodione and carboxin, or furrow treatments. A correlation between levels of infection on seed tubers and disease levels on daughter tubers was observed.

In field experiments where control of silver scurf was evaluated, all tested fungicides were significantly more effective when applied as seed tuber treatments than by spraying in furrow. Low volume seed spraying with fludioxonil, prochloraz and azoxystobin, or dusting with mancozeb and propineb, significantly reduced silver scurf incidence on daughter tubers. Treatments of low volume sprayed agents combined with low dosages of mancozeb dusting were also effective. Imazalil formulations were moderately effective. Fluazinam did not reduce disease incidence. In a separate experiment in which imazalil was sprayed (low volume) onto seed tubers at different timings, both prior to and post-storage, or only after storage, disease incidence was significantly reduced. In previous experiments pre-storage treatments had been more effective.

(P22) Characterization of Isolates of *Phytophthora erythroseptica* from Prince Edward Island According to Metalaxyl Sensitivity and Allozyme Genotype. Peters, R.D.^{1*}, A.V. Sturz², B.G. Matheson², W.J. Arsenault¹, and A. Malone¹, ¹Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, P.O. Box 1210, Charlottetown, PE C1A 7M8; ²PEI Department of Agriculture and Forestry, Plant Health Research and Diagnostics, P.O. Box 1600, Charlottetown, PE C1A 7N3.

Pink rot of potato, caused by *Phytophthora erythroseptica*, has become a concern for potato growers in North America, particularly when wet conditions prevail at harvest time. The recovery of metalaxyl-resistant strains of *P. erythroseptica* in the U.S. in the 1990s, prompted an assessment of pathogen populations on Prince Edward Island. Tuber samples with symptoms of pink rot were collected from 14 fields in 1999. Fifty-eight field isolates recovered from infected tubers were used to generate 97 single zoospore isolates. All isolates were plated onto a clarified V8 agar medium amended with selected concentrations of metalaxyl (mefenoxan) to determine sensitivity. All field and single zoospore isolates of *P. erythroseptica* from Prince Edward Island were highly sensitive to metalaxyl ($EC_{50} < 0.5 \mu\text{g/ml}$) while reference isolates from Maine were either moderately-resistant ($EC_{50} = 10 \mu\text{g/ml}$) or highly-resistant ($EC_{50} = 500 \mu\text{g/ml}$). Inoculation of tubers from field plots receiving foliar applications of metalaxyl indicated that the chemical could inhibit disease development caused by metalaxyl-sensitive strains of *P. erythroseptica*, even after 4 months in storage. In contrast, metalaxyl-resistant strains of the pathogen were able to infect and colonize these tubers. Allozyme banding patterns at the glucose-6-phosphate isomerase (*Gpi*) locus were identical (*Gpi* 91/91) for all isolates of *P. erythroseptica* in the collection and were useful for distinguishing these isolates from genotypes of *P. infestans* recovered from potato tubers infected with both pathogens.

(P23) Characterization of Late Blight in Uruguay. Deahl, Kenneth L.*, M.C. Pagnani, F.M. Perez, B. Moravec, and L.R. Cooke, USDA, ARS, PSI, Vegetable Laboratory, Beltsville, MD 20705, INIA, Plant Pathology, Canelones 90200, Uruguay, and The Queen's University of Belfast, Belfast, Northern Ireland.

Isolates of *Phytophthora infestans* were obtained from late blighted plants from several potato-growing regions of Uruguay in 1998 and 1999. Of these, 25 representative isolates were characterized in terms of allozyme genotype, mating type, mitochondrial haplotype, pathotype and metalaxyl resistance. Allozyme analyses revealed that the Uruguayan isolates were monomorphic and homozygous at the loci coding for glucose-6-phosphate isomerase and peptidase (*Gpi 100/100*, *Pep 100/100*). All isolates were of the A2 mating type and mitochondrial haplotype IIa. Metalaxyl-resistant isolates constituted 93% of the total. Most of the isolates displayed broad-spectrum virulence and five carried virulence to 10 of the 11 R-genes tested. Despite the absence of R-genes in commercially-grown potato cultivars, virulence phenotypes were extremely complex. It was concluded that the Uruguayan *P. infestans* isolates resemble isolates from neighboring South American countries, notably Brazil, in terms of mating type and allozyme genotype and belong to the new populations of the pathogen now predominant in many countries.

(P24) Partial Characterization of *Phytophthora infestans* Isolates from Chile. Secor, Gary A.*, Viviana V. Rivera and Fernando Riveros, Department of Plant Pathology, North Dakota State University, Fargo, ND 58105 and INIA Intihuasi, Apartado Posta; 36-B, LaSerena, Chile.

Chile has a thriving potato industry that exports both seed and commercial potatoes throughout South America and other continents. The success of their industry is partly due to natural geographic boundaries that provide a biological isolation. Chile is bordered by the Andes Mountains, the Pacific Ocean, the Atacama Desert, and the Antarctic. The seed potato industry is primarily concentrated in the South, where temperatures are cool and there are few diseases. The commercial industry is primarily concentrated in the northern desert region. In this region, late blight is a constant threat because of the continuous cropping of potatoes, irrigation and morning fog from the ocean. The primary fungicide used for the past ten years has been metalaxyl, which is typically used season long. Over 200 naturally occurring isolates were collected from grower fields in 1998 and 1999. The isolates were tested for mating type, genotype, and metalaxyl sensitivity. All isolates tested were the A1 mating type, US-1 genotype. None of the isolates were sensitive to metalaxyl, and EC50 values ranged from 200 to over 400 ppm. Additional tests are being conducted to determine R-gene composition and DNA homology among the isolates.

(P25) Potato Late Blight: Pathogen Population Dynamics across Canada in 2000.

Platt, H.W. (Bud)* and F. Daayf, Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, Box 1210 (440 University Ave.), Charlottetown, P.E.I., Canada C1A 7M8.

Late blight of potatoes is caused by the fungus *Phytophthora infestans*. While the disease is mainly found on potato foliage and tubers, causing extensive plant damage and crop loss, the fungus can attack other solanaceous plants such as tomato. Recently, with the introduction of new strains, the fungus has become more aggressive and the air and water-borne sporangia are surviving and causing more severe disease under conditions that previously reduced disease progress and the survival of these short-lived spores. Furthermore, almost all commercially cultivated potato varieties are susceptible to the disease and the fungicide, metalaxyl, has become less effective due to the occurrence of metalaxyl-resistant strains of the fungus.

The fungus exists as two different mating types (A1 and A2) which when in contact with each other in plant tissue can result in the formation of sexually produced oospores. Each of these spores are new or unique strains and are able to survive long periods of time 'outside' of living plant tissues (e.g. in soils over-winter) and can then cause disease. This is a major problem for producers as almost all of the disease prevention and management methods currently used against late blight deal with the short-lived sporangia and not the long-lived oospores. In addition, the number of new strains of the fungus found in the pathogen populations have been increasing and late blight outbreaks have been increasing in home garden and commercial production of both tomato and potato. Results of recent investigations on pathogen populations in Canada will be presented.

(P26) Sensitivity to Metalaxyl, Sexual Compatibility, and Aggressiveness of

***Phytophthora infestans* in Venezuela.** Rodriguez, G. Dorian*, Universidad Centroccidental "Lisandro Alvarado", P.O. Box. 400 Barquisimeto, State of Lara, Venezuela. rdorian@delfos.ucla.edu.ve.

Venezuela grows ca. 20,000 ha of potato and most of the seed used is imported from Canada, Germany and Holland. Late blight is the major disease of the crop and no information about characteristics of the pathogen, except that related to physiological races, is known. To initiate this characterization, 27 isolates from potato and one from tomato were collected in five states and analyzed for sensitivity to metalaxyl, sexual compatibility, and aggressiveness. The first test was performed on Frozen Vegetable-Agar or V8 Juice-Agar media, and the LD50 was used to differentiate the isolates. The compatibility test was run using two known A1 isolates. The aggressiveness test was done in a greenhouse with potato plants and with a selection of six isolates using a suspension of 2.5×10^4 sporangia/ml. Analysis of variance, area under disease progress curve (AUDPC), and infection rate (r), were used to evaluate the aggressiveness. Variability in the reaction to metalaxyl was found: 57% of the isolates were sensitive ($\leq 5 \mu\text{g/ml}$) to the fungicide, 25% were moderately sensitive ($>5-7 \mu\text{g/ml}$), and 8% were insensitive ($\geq 8 \mu\text{g/ml}$). All the isolates were of the A1 compatibility type. On the other hand, there were significant differences ($P < 0.001$) in the aggressiveness among the isolates. The isolate Pi016 was sensitive to metalaxyl and less aggressive ($r=0.177$; AUDPC=648,7 percent-day), while the isolates Pi004 and Pi006 were more insensitive and also more aggressive ($r=0.183$; AUDPC=1,053 percent-day and $r=0.326$; AUDPC=956 percent-day, respectively). Insensitivity and aggressiveness were associated with the locality. The A2 compatibility type has not been found.

(P27) Effects of Temperature and Fungicide Applications on Stem Lesions of *Phytophthora infestans* on Potato. Shepherd, C. P.*, R. M. Geddens, M. D. Stidham, DuPont Crop Protection Products, Stine-Haskell Research Center, Newark DE.

The label for Curzate® 60DF has been amended for 2001 to allow early post-emergence applications, in combination with an appropriate contact fungicide, to control early-season infection of potato late blight, caused by *Phytophthora infestans*. An aspect of interest in the early-season epidemiology of this disease is the appearance of stem lesions, often in the absence of foliar disease symptoms. The symptomatology, development and sporulation of stem lesions were evaluated by artificial inoculations of potato plants, maintained at different temperatures, with a US-8 isolate of *Phytophthora infestans*. Compared to foliar lesions at the same temperature, stem lesions were more difficult to detect, tended to expand more slowly (especially at lower temperatures), persisted longer and sporulated over a longer period of time. The impact of Curzate® 60DF on stem lesion growth and sporulation at various temperatures was also evaluated. Two sequential post-infection applications (4 to 5-leaf stage and again 7 days later) of Curzate® 60DF combined with Manzate® 75DF reduced both stem lesion growth and sporulation. We conclude that stem lesions are an important feature of early-season late blight biology, their characteristics differ from those of foliar lesions and disease control programs must be designed to effectively control early-season stem lesions.

(P28) Bioproduction of Stable Protein/Antimicrobial Peptides for Disease Control. Jones, Richard W.*, USDA, ARS, Vegetable Laboratory, Rm. 311, Bldg. 010A, BARC-West, Beltsville, MD 20705.

Effective control of foliar potato diseases has relied principally upon use of resistant varieties and fungicide applications. New methods for developing resistant varieties have come through engineered resistance. New sources of fungicidal compounds are being developed in our laboratory using antimicrobial peptides produced through engineering of micro-organisms. An antimicrobial peptide was overexpressed in the bacterium *E. coli* as a fusion protein, coupled to the carboxy terminal region of prosystemin protein. In laboratory experiments the protein/peptide completely inhibited *Phytophthora infestans* zoospore and sporangial germination at 150 nanograms per microliter. The same concentration led to elimination of lesion formation on detached leaf assays. Optimizing expression of this protein/peptide combination can lead to new compounds for application in disease control.

(P29) Combining Host Plant Resistance with Managed Fungicide Applications to Control Potato Late Blight (*Phytophthora infestans*). Kirk, William¹, Kimberly Felcher^{2*}, David Douches², J. Stein¹ and R. Hammerschmidt¹, Michigan State University, East Lansing, ¹Dept. of Botany and Plant Pathology, ²Dept. of Crop and Soil Sciences.

Field experiments were conducted over four years with commercial potato cultivars and advanced breeding lines differing in susceptibility to late blight to determine their response to managed fungicide applications. Reduction of total fungicide was achieved by application of fungicides with less active ingredient, reduced application rates or a combination of these approaches. When environmental conditions were most favorable for the development of late blight, the lowest application rate of fungicides [33 % MRAR] provided unsatisfactory disease control. Under less conducive conditions effective control of late blight was achieved from 33 to 66% MRAR. RAUDPC values for Snowden (susceptible) and MSG274-3 (resistant) varied from year to year and tended to increase as disease severity values (DSV) increased. Therefore, an arbitrary scale of resistance based on RAUDPC values will not be satisfactory for predicting the efficacy of different fungicide application programs. The advanced selection, MSG274-3, was the most resistant line tested requiring minimal chemical protection.

A companion experiment was conducted over two years to determine the response to reduction of total fungicide input, achieved by applying reduced amounts of fungicide at increased application intervals. In Snowden 10 and 15-day application intervals did control late blight even at 100% MRAR. At 5-day application intervals, all application rates of fungicide reduced foliar late blight in Snowden to RAUDPC<10. The advanced selection MSG274-3 was highly resistant and required minimal chemical protection.

(P30) Gavel 75 DF Fungicide for Control of Potato Late Blight. Harrison, W. Edd*, Douglas C. Lisk and Harvey A. Yoshida, Rohm and Haas Company.

Gavel 75 DF is a new protectant fungicide, developed by Rohm and Haas Company, that has shown excellent control of late blight on potatoes, as well as control of early blight. Registration for use on potatoes is expected in time for the 2001 season. In addition to the U.S., Canada and Mexico are expected to grant simultaneous registrations as part of a joint NAFTA review.

Gavel fungicide contains the new active ingredient zoxamide along with mancozeb. Zoxamide belongs to the benzamide class of chemistry, and controls diseases caused by oömycetes, a class of fungi that includes *Phytophthora infestans*, the late blight fungus. It stops fungal growth by inhibiting cell division, preventing the fungus from reproducing. This unique mode of action for late blight control makes Gavel fungicide an excellent resistance management tool. The product also provides rainfastness due to its ability to adhere to the waxy cuticle of plant foliage.

Gavel is best used as a protectant spray starting at the first signs of disease or reports of disease in a locality. Research determined that Gavel should be used in a 5 to 7 day schedule when late blight is present and conditions favor disease; it can be used in a 7 to 10 day schedule when disease pressure is low and environmental conditions do not favor disease development. Potato trials have not shown any adverse effects to foliage or tubers following season-long application.

PAA Nominees for Vice-President

Larry K. Hiller

Larry K. Hiller earned a BS (1963) in Ag Education and MS (1964) in Horticulture from Iowa State University. He received a PhD (1974) from Cornell University in Vegetable Crops. From 1964 to 1968 he worked on an Iowa State University/USAID agricultural assistance project in Uruguay, South America. Larry has held a vegetable/potato research and teaching appointment in the Department of Horticulture and Landscape Architecture at Washington State University since 1973. His potato research focuses on tuber quality and internal disorders. Research interests have included fertility and water management, irrigation scheduling and temperature variables during early tuber growth, growth regulators, tuber and plant growth rates, and potato cultivar differences. He has also been involved in cooperative programs on potato herbicide evaluation and weed control, fertilization practices and management, and minimum tillage practices for potatoes. He teaches introductory and upper level horticultural classes, vegetable crops and seed production, and potato physiology.

Larry has been a member of the PAA since 1974. He has been very active in the Physiology Section since 1974 (Secretary 1984; Vice-Chair 1985; Chair 1986-87; Director 1992-94) and the Production & Management Section as a charter member (Sec-Treas 1992; Vice-Chair 1993; Chair 1994; Director 1996-98). He was Co-Chair for the 1990 Plenary Symposium sponsored by the Physiology Section "Carbohydrate metabolism in developing and stored potatoes" and the 1998 Plenary Symposium sponsored by the Production & Management Section "Future challenges for potato nutrient management." Larry was Co-Chair of the 75th (1991) Annual Meeting in Spokane and served on the Local Arrangements Advisory Committee (1991-96, Chair in 1991-92). Other committee activity has included the Symposium Review and Rules Committee (1992-95), International Relations Committee (1982-84, Chair 1983-84), and the Outstanding Paper Awards Committee (1996-99). He was a member of the Graduate Student Outstanding Paper Awards Committee (1992-99), elected to a Director position at the 1999 meetings, appointed to the Constitution & By-Laws committee (1999-present), is the state rep for membership recruitment, and is currently an Associate Editor for our journal. Larry has been active since 1992 in the European Association for Potato Research and has consulted on potato programs in a number of other countries.

Gregory Porter

Greg Porter received his B.S. (1980) and M.S. (1982) degrees in Plant & Soil Sciences from the University of Maine. He received his Ph.D. (1985) from Pennsylvania State University in Agronomy. He has had a research and teaching appointment at the University of Maine since 1985 and is currently Professor of Agronomy within the Department of Plant, Soil & Environmental Sciences. His principal areas of research and service include: potato variety development, fertilization practices and soil fertility, soil management using organic matter additions and crop rotation, and crop physiology. He teaches upper-level classes in crop management, crop physiology, and statistics/experimental design. He has

participated in the Northeast Regional Potato Variety testing program (NE107, NE184) since 1985 and coordinated many of its activities. Since 1995, he has served as coordinator for The University of Maine's interdisciplinary Potato Cropping Systems Project. His PAA activities include: Director (1998-present); Finance Committee member (1989-94) and chair (1995-1999), Journal Redesign Committee (1996-98), Editorial Committee (1989-96), Associate Editor (1996-1998), Senior Editor (1998-present) Physiology section (Secretary 1994; Vice-chair 1995; Chair 1996), Production Management Section (Secretary 1990 and 1998; Vice-chair 1999; Chair 2000), Local Arrangements Committee member (1995) and Transportation subcommittee chair (1995), Ad-hoc Committee on Space Issues and Office Relocation (1995-1998). He has been a PAA member since 1980 and is also a member of the American Society of Agronomy and American Society of Plant Physiologists.

PAA Nominees for Director

Gale Kleinkopf

Dr. Kleinkopf received a B.Sc. in Agricultural Chemistry from the University of Idaho in Moscow and his Ph.D. in Plant Physiology from the University of California at Davis. He is Superintendent of the Research and Extension Center at Kimberly and is a Professor in the Plant, Soil and Entomological Sciences Department at the University of Idaho. He has been working in the area of potato physiology since 1975 and for the past 10 years has been Director of Operations of the Potato Storage Research Facility in Kimberly. His research effort has centered on maintaining seed quality in storage and on the effectiveness of naturally occurring sprout suppressants. He has developed management practices for storage of new varieties and is currently working on the interaction of sprout inhibitors and tuber quality in long term storage. Two of his papers covering this work were nominated for best paper of the Year during 1998. Dr. Kleinkopf has been a member of the Potato Association of America since 1975 and has held offices in the Physiology and the Production and Management Sections. He has been a member of the Local Arrangements Committee for two PAA meetings. He raised over \$65,000 from potato industry sources in support of the last PAA meeting held in Idaho. Dr. Kleinkopf is a member of the American Society of Agronomy and the Scientific Research Society of America. He is also active as a community volunteer serving on the Chamber of Commerce, City Council and as Mayor.

Robert Davidson

Rob Davidson received a B.Sc. in Microbiology and Botany and an M.Sc. in Plant Pathology from Montana State University. In 1994 he completed a Ph.D. degree in Plant Pathology from Colorado State University. He is currently the Manager of the Colorado Potato Certification Service, running the state certified seed potato program with over 17,000 acres entered annually. He also is the State Extension Seed Potato Specialist and has an Agricultural Experiment Station appointment. Rob's primary research focuses on improving the quality of seed potatoes by reducing the impact of seed borne diseases and pests. He has been a member of the PAA for many years, serving in several different capacities. He has been particularly active in the Certification and Pathology sections serving on many committees and was Chair of the Certification Section in 1991 and 1993, and Chair of the Pathology Section in 1994. Rob was on the Local Arrangements Committee for two PAA Annual Meetings; one held in Fort Collins, Colorado in 1988 and, more recently, as Co-Chair for last year's meeting held in Colorado Springs, Colorado. Rob is also active with the National Potato Council and served as the liaison between the PAA Certification Section and the NPC Seed Committee. He was part of the group that established the NPC Seed Potato Certification Sub-Committee, creating a linkage between the U.S. seed potato certification agencies and the NPC. He is currently a member of the National Potato Promotion Board Seed Export Task Force seeking to improve chances for international export of U.S. certified seed potatoes.

St. Johns County Convention Center

