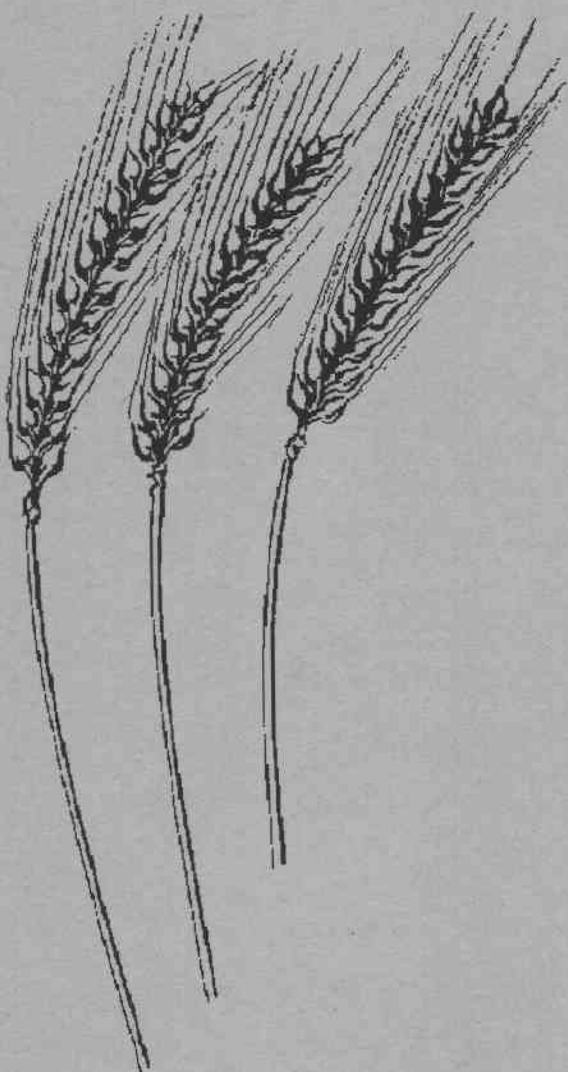
Special Report 1040
June 2002

2002 Columbia Basin Agricultural Research Center Annual Report

In cooperation with
USDA • Agricultural Research Service



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AGRICULTURAL EXPERIMENT STATION

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Agricultural Experiment Station
Oregon State University
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Oregon State University

in cooperation with

Columbia Plateau Conservation Research Center
USDA–Agricultural Research Service

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INTRODUCTION

Staffs of the Columbia Basin Agricultural Research Center (CBARC-Oregon State University [OSU], Pendleton and Sherman Stations) and the Columbia Plateau Conservation Research Center (CPCRC, USDA-Agricultural Research Service [ARS], Pendleton) are proud to present the results of some of their research. This bulletin contains a representative sample of the work in progress at these centers. A collection of bulletins over a 3-year period will give a more complete assessment of the productivity and applicability of research and education. Changes in staffing, programming, and facilities at these centers during the past year are summarized below.

Promotions and Awards

Dr. Richard Smiley was nominated for a national research award from the National Association of Wheat Growers. OSU and USDA have a cooperative public relations program and enter a float in the Dress-Up Parade that is held each year in conjunction with the Pendleton Round-Up. This year the float highlighted the 70th anniversary of the Long Term Experiments and won the First Place Award in the Commercial Category.

Within the USDA staff, Mark Siemens and John Williams were promoted. Certificates of merit were given to Scott Oviatt and Dale Wilkins for outstanding work performance. Bob Correa, Daryl Haasch, Chris Roager, Dave Robertson, and Terry Starr received awards for outstanding work performance. Tami Johlke was recognized for outstanding productivity and quality research support through plant and soil measurements and evaluation of soil conservation systems.

Staff Changes

There were relatively few changes to the OSU staff in 2001. Jason Patmore was hired as a Faculty Research Assistant in the weed science program in February. Dr. Stephen Machado was hired in June 2001 as the Dryland Cropping Systems Agronomist. Dr. Machado came to us from a post-doctoral position in Texas where he was responsible for a large precision farming project.

Temporary employees in the OSU programs included Jan Bailey, Brian Baird, Cathy Brown, Rachel Chambers, Brian Currin, Joel Currin, Shelley Dietrick, Shannon Duff, Jennifer Freston, Jeremy Gregory, Shaun Hacquet, Dustin Larson, Deana McBride, Justin Michael, Russell Montgomery, Scott Montgomery, Timothy Royle, Nicholas Sirovatka, David Sisson, Amie Spratling, Deborah Thompson, Angela Tricker, Andrea Wilson, and Ryan Wuest.

There were several additions and changes in ARS staff during the past year (2001-2002). On June 1, 2001, Dr. Ronald Rickman, soil scientist, retired after 35 years of Federal service. Dr. Hero Gollany, Soil Scientist at the University of Minnesota, was selected to fill the position vacated when Dr. Rickman retired.

Stephanie Boyle, was selected as a part-time Biological Science Aid to study the impact of soil management systems on soil microbiology.

Heather Bennett, Eric Boyle, Kevin Collins, Karin Dallas, Melissa Johnson, Jennifer Levy, Aurora Martin, Angela Sallee, Robert

Sanchez, Christina Skirvin, Terry Starr, Sam Womack and Byron Wysocki worked as temporary employees during the summer and school vacations. David Smith worked in the microbiology program as a volunteer.

New Projects

Dr. Richard Smiley initiated a number of trials in 2001 including: greenhouse pathogenicity testing of unknown fungal isolates from chickpea and lupin, as well as long-term cultures; testing of cold tolerance on Australian wheat varieties at the WSU Dryland Experiment Station, Lind, WA; collaborative efforts with scientists in Rivoal, France to identify pathotype ("race") of PNW cereal cyst nematode; collaborative efforts in Tunisia to determine the molecular and genetic relatedness of Fusarium pseudograminearum with other isolates of the fungus elsewhere in the world.

Dr. Steve Petrie initiated a series of field trials to develop recommended agronomic practices for the production of winter malting barley in the Columbia Basin. He is conducting field studies to examine the impact of various nitrogen fertilizer management strategies on the grain yield and quality of advanced lines of malting barley. Other components of the winter malting barley research include studies designed to identify the optimum seeding rate and date, effect of simulated winter injury and barley response to phosphorus, zinc and chloride fertilization.

The ARS re-evaluates its national projects every five-years. This year the Columbia Plateau Conservation Research Center will be evaluating its soil erosion research project and developing new project plans. As stakeholders and interested parties, your suggestions and comments are welcomed. The new project is part of the ARS National Project Soil Resource Management (Number 207). More information on this National Project can be found on the internet at the following location: http://www.nps.ars.usda.gov/programs/programs.htm?NPNUMBER=207.

Drs. Stewart Wuest and John Williams started testing a small run-off measurement device in cooperation with Don McCool of ARS Pullman. If successful, it would allow inexpensive measurements of water infiltration on farmer's fields and make it practical to compare different management and cropping systems options.

Dr. Stewart Wuest and Roger Goller started a project to learn how biopore networks develop under a no-till wheat cropping system. The goal is to determine if undisturbed biopores play a role in high infiltration rates measured under no-till.

Dr. Mark Siemens has initiated a project to develop a new type of harvester that will harvest the crop and prepare the residue for direct seeding in a single pass. The benefits of this machine include eliminating or greatly reducing combine tracks in standing stubble, ensuring timeliness of residue management, and potentially lowering costs by reducing the number of passes made over the field.

An ARS and OSU cooperative project was initiated to develop Fusarium control options for winter wheat production in low precipitation zones.

Facilities and Equipment

OSU began the process of constructing two new storage buildings, one at Pendleton and a second facility at Moro. The Sherman Endowment Fund is contributing to the construction costs for the building at Moro. Major new equipment purchases include:

Kubota 4610 tractor for spraying along with a monitoring system and a pickup for the weed science program. We upgraded the state office building with new entry doors and locks, fresh paint and new landscaping. A new metal roof and gutters were installed on the Farm Manager's residence.

We also purchased a new telephone router, copier, office furniture for the superintendent, agronomist, and plant pathologist, and two ATV's from surplus for use at Pendleton. Dr. Stephen Machado purchased several instruments for his agronomy program including: soil conductivity meter with digital output, Panasonic Toughbook, analysis system, plant water console, vapor pressure osmometer, digital camera, field mapping and data collection GPS 2 package, black box, MapCalc Professional, CropScan, and TDR-based soil moisture measurement device.

The Sherman Endowment Fund purchased a 4-wheel drive ATV for use at the Sherman Station.

Renovation of the ARS Chemistry Lab was completed in 2001. Renovation included removing one wall, adding cabinets, moving existing cabinets to accommodate computer controlled chemical analyzers and installing two chemical storage cabinets. The main office building and annex doors were upgraded with power-assisted openers for handicap access. Rooms 141, 143, 144 and 145 in the annex were painted. Equipment purchases this past year included upgrading four weather monitoring stations for remote access, water quality turbidity sensor, stationary GPS antenna, computer network server, micro pump for a chemical analyzer, spectrophotometer, bailer, pallet storage racks, and swather.

Training

All OSU employees licensed to apply pesticides completed the appropriate re-certification training. Nathan Blake, Jennifer Gourlie and Ruth Whittaker received their public pesticide applicator licenses. Erling Jacobsen and Karl Rhinhart updated their CDL's while Nick Sirovatka and Paul Thorgersen obtained new CDL's. Sandy Ott completed a nuclear gauge training class.

All USDA staff licensed to apply pesticides completed re-certification training. All staff received updates on cardio-pulmonary resuscitation, first aid, ethics, sexual harassment prevention, and civil rights training. Tami Johlke and Bob Correa attended a 1-day Safety & Stewardship seminar. Pat Frank attended a 2-day course on Travel Training. Amy Baker attended a weeklong course on Laboratory Safety and Health. Linda Baugh a attended weeklong course on OSHA Collateral Duty Safety Responsibilities. Steve Albrecht attended weeklong courses for Microlog Software ID Training, L-COR 6400 Training, and a 2-week seminar for New Managers.

Visitors

The Center hosted several special events, including numerous research and planning meetings.

Visitors hosted by the staff at the center included:

Ashok Alva, Research Leader, USDA-ARS, Prosser, WA;
Mark Hodges, OWC, Portland, OR;
Richard Roseberg, SOAREC, Oregon State University, Central Point, OR;
Students from Pendleton High School, Pendleton, OR;

Norm McKinley, DuPont, Salem, OR;
Bill Schillinger, Washington State University, Lind, WA;
Ron Palmatier, Rain & Hail LLC, Ione, OR;
Dan Pero, Rain & Hail LLC, Boise, ID;
Steve Parker, Walla Walla, WA;
Benno Warkentin, Oregon State University, Corvallis, OR;
Gary Kiemnec, Eastern Oregon State University, La Grande, OR;
John Ballard, API, Portland, OR;
Tim Snowball, Melbourne, Australia;
Paul Risser, President, Oregon State University, Corvallis, OR;
Stephen Jones, Washington State University, Pullman, WA;
Tim Murray, Washington State University, Pullman, WA;
Terri Lomax, Oregon State University, Corvallis, OR;
Stephen Caruana, Agronomic Analytics, Eugene, OR;
Jack Nelson, USDA-ARS-PWA, Albany, CA;
Dennis Hull, National Weather Service, Pendleton, OR;
Kaoru Ishil, Niigata City, Japan;
Jeremy Red Star Wolf, CTUIR, Pendleton, OR;
Mike Hogue, Portland, OR;
Stephen Machado, Texas A&M University, Lubbock, TX;
Haile Tewolde, Cargill, Inc., Brooklyn Park, MN;
Elizabeth Sulzman, Oregon State University, Corvallis, OR;
Carolyn Yeager, Location Administrative Officer, USDA-ARS, Prosser, WA;
Hal Collins, Microbiologist, USDA-ARS, Prosser, WA;
Melanie Wilson, Secretary, USDA-ARS, Prosser, WA;
Antoinette Betschart, Pacific West Area Director, USDA-ARS, Albany, CA
Bob Matteri, Pacific West Area Assistant Director, USDA-ARS, Albany, CA;
Larry Lofton, Pacific West Area Administrative Officer, USDA-ARS, Albany, CA;
Bob Zemetra, University of Idaho, Moscow, ID;
Norman Sladen, FMC Corp., Pleasant Hill, CA;
Peter Bottomley, Oregon State University, Corvallis, OR;
Dan McClure, Walla Walla, WA;
Larry Lutcher, Morrow County Extension, Oregon State University, Heppner, OR;
Michael Unruh, Geritland, Inc., Mt. Shasta, CA;
Jerry Walker, Milton-Freewater, OR;
Glen Riethmuller, Agriculture Western Australia, Merridin, Western Australia;
Larry Boersma, Oregon State University, Corvallis, OR;
Dan Rasmussen, Athena-Weston Middle School, Athena, OR;
Doug Descamp, Syngenta, Coeur d'Alene, ID;
Gary Ferrell, Blue Mountain Seed, Walla Walla, WA;
Leonard Jenner, Pendleton, OR;
Bruce Mackey, USDA-ARS, Albany, CA;
Barbara Wright, First Presbyterian Church, Pendleton, OR;
Lisa Sprague, USDA-OIG, Portland, OR;
Daniel Smith, Hermiston, OR;
Michael Ferguson, Pendleton, OR;
Hero Gollany, University of Minnesota, St. Paul, MN;
Larry Bishop, Milton-Freewater, OR;
Kathy Ingram, Pendleton, OR;
Bobby Allen, Hermiston, OR;
Bill Jamison, Pendleton, OR;
Evie Liss, Extension Specialist Communication, Oregon State University, Corvallis, OR;
Lavern Weber, HMS, Oregon State University, Newport, OR;
Lori Brogoitti, Pendleton, OR;
Bryan Allstott, PGG – Pendleton, OR;

Kim Campbell, Washington State University, Pullman, WA;
Kevin Presley, Information Technology Consultant, Oregon State University, Corvallis, OR;
Jessica Fisher, Umatilla County Extension, Oregon State University, Pendleton, OR;
Billie Parker, Umatilla County Extension, Oregon State University, Pendleton, OR;
Lowell Fausett, Project and Cost Manager, Oregon State University, Corvallis, OR;
Jeff Newtson, Helix, OR;
John Finnie, Kenton, Manitoba, Canada;
Carolyn Finnie, Kenton, Manitoba, Canada;
Steve Evans, Western Farm Service, Athena, OR;
Judy Rea, OWC, Ione, OR;
Greg Goad, Oregon Wheat Growers League, Pendleton, OR
Ernie Moore, Moro, OR;
Jay Gibbs, Heppner, OR;
Mike Stoltz, Regional Director – Ext. Svc Admin, Oregon State University, Corvallis, OR;
Phillip Zurbrick, Oregon Wheat Growers League, La Grande, OR;
Larry Bennett, Mologa, WA;
Crystal Patten-Doherty, Blue Mountain Community College, Pendleton, OR;
Larry Coppock, Adams, OR;
Jim Loiland, N.R.C.S., Pendleton, OR;
David Close, CTUIR, Pendleton, OR;
James Bronson, CTUIR, Pendleton, OR;
Aaron Jackson, CTUIR, Pendleton, OR;
Alan Wernsing, Athena, OR;
Mathias Kolding, Pendleton, OR;
Betty Klepper, Pendleton, OR;
Sue Waldman, Pendleton, OR;
Tom Darnell, Umatilla County Extension, Oregon State University, Milton-Freewater, OR;
Fred Crowe, COARC, Oregon State University, Madras, OR;
Walt Gary, Walla Walla County Extension, Washington State University, Walla Walla, WA;
Bob Adelman, Pendleton, OR
Nathan Adelman, Pendleton, OR

Seminars

The 2001 OSU/USDA Seminar Series at the Center was coordinated by Chengci Chen. Seminars included the following speakers and topics:

The Australian Competition: Wheat Improvement and Marketing Systems, Dr. Dick Smiley, plant pathologist, Columbia Basin Agricultural Research Center, Pendleton, OR, 31 January.

US Forest Service Passport in Time Projects, Or Getting Back to Reality, Mr. Tom Darnell, OSU Extension Agent, Milton-Freewater, OR, 7 February.

The PNW Soft White Wheat Marketing Initiative, Mr. Mark Hodges, Oregon Wheat Commission, Portland, OR, 8 February.

Research on Euphorbia, a New Industry Crop, in Oregon, Dr. Richard Roseberg, Southern Oregon Agricultural Research & Extension Center, Central Point, OR, 28 February.

Wind Erosion Control Research for Dry Croplands, Dr. William Schillinger, Agricultural Research Station, Washington State University, Lind, WA, 7 March.

Soil Quality --- What does it do for Soil Science, Dr. Benno Warkentin, Department of Crop & Soil Science, Oregon State University, Corvallis, OR, 22 March.

Development and Feasibility of Perennial Wheat, Dr. Stephen Jones and Dr. Tim Murray, Pullman, WA, 18 April.

Biotechnology at OSU, Dr. Terri Lomax, Department of Botany & Plant Pathology, Oregon State University, Corvallis, OR, 30 April.

Basic and Applied Research: Highlights on Field Crops Research, Dr. Stephen Machado, Texas A&M University, Research & Extension Center, Lubbock, TX, 21 May.

Carbohydrate-Based Plant Growth Products, Dr. Haile Tewolde, Cargill, Inc., Brooklyn Park, MN, 21 May.

Soil Water and Carbon Dynamics: 13C and 18O as System Tracers, Dr. Elizabeth Sulzman, Department of Crop & Soil Science, Oregon State University, Corvallis, OR, 31 May.

Machinery and Harvesting Technology, Precision Agriculture in Western Australia, Mr. Glen Philip Riethmuller, Agriculture Western Australia, 8 August.

Chickpeas: A Processor's Perspective, Mr. Gary Ferrel, Blue Mountain Seed, Walla Walla, WA, 26 September.

Estimating Root Zone Soil Water Content Using Limited Soils Information and Surface Soil Moisture Data Assimilation, Dr. Gary Heathman, USDA-ARS, Great Plains Agroclimate and Natural Resources Research, Chickasha, OK, 29 October.

Dynamics of C, N, and P in Soil-Water-Air-Plant Continuum, Dr. Hero T. Gollany, Department of Soil, Water, and Climate, University of Minnesota, St. Paul, MN, 1 November.

Liaison Committees

The Pendleton and Sherman Liaison Committees were led by chairpersons Kay Simpson and Ernie Moore, respectively. These Liaison Committees provide insightful guidance and recommendations on research directions, staffing needs and facilities and equipment needs. These committees provide a crucial communication link between growers and the research community. We encourage you to contact the Liaison Committee chairs with your concerns and suggestions for improvements regarding any aspect of the research centers.

Expressions of Appreciation

The staff wishes to express their appreciation to individuals, associations, and corporations who have given special assistance for the operation of experimental plots on or associated with the center during this past year 2001-2002. The Oregon Wheat Commission continued to provide crucial funding to the OSU programs at the center and we gratefully acknowledge their generous support. We want also to express our sincere appreciation to those individuals, groups and corporations who provided additional equipment, supplies, funds, and labor to help us carry out our mission. These include:

- Agrium
- BASF Corp.
- Bayer Corp.
- Leonard (Buckshot) Carter
- Community Corrections Work-Release Program
- E.I. du Pont de Nemours
- FMC Corp.

- Richard Lieuallen
- Terry Mayberry
- Monsanto Co.
- Richard (Mac) McDonough
- Rohm and Haas
- Tom Neidlinger
- Paul Pargeter
- Neil Pattee
- Pendleton Grain Growers
- Al Sartini
- Stubbs Seed Service
- Zeneca Ag Products.

We want to express our appreciation and thank those who donated labor, supplies, equipment, or funds for the Pendleton Station Field Day. These include:

- Agri-Check
- American Cyanamid Co.
- Aventis Crop Science
- Bank of the West
- BASF Corp.
- Bayer Corp.
- Columbia River Bank
- Community Bank
- E. I. du Pont de Nemours
- Farm Credit Service
- FMC Corp.
- Inland Chemical Service
- Inland Empire Bank
- Kuo Testing Labs
- Monsanto Co.
- Pendleton Bus Co.
- Pendleton Flour Mills
- Pendleton Grain Growers
- Pendleton Main Street Cowboys
- Pioneer Implement
- Rohm and Haas
- The McGregor Co.
- UAP Northwest
- Walla Walla Farmers Coop.
- Western Farm Service
- Wheatland Insurance
- Wilbur-Ellis

We also want to acknowledge and thank the donors who provided buses, meals and other services for the Sherman Station Field Day at Moro, including:

- Columbia River Bank
- Farm Credit Services
- Gustafson
- Klamath First Federal
- Mid Columbia Bus Co.
- Mid Columbia Producers
- Monsanto
- Morrow County Grain Growers
- Pioneer Implement
- Richelderfer Air Service
- Safeway
- Sherman Aviation
- Sherman High School
- Wasco Electric Coop.
- Wilbur-Ellis.

The local county agricultural agents throughout north central and northeastern Oregon have provided invaluable local assistance in locating research sites, coordinating activities with farmer-cooperators, and providing input to our research programs. These tireless individuals include Mary Corp, Tom Darnell, Jeff McMorran and Don Horneck in Umatilla County; Gordon Cook and Darrin Walenta in Union/Baker/Wallowa Counties; Larry Lutcher in Morrow County; Sandy MacNab in Sherman County; Brian Tuck in Wasco County; and Jordan Maley in Gilliam County in Oregon. County agricultural agents in Washington have also been key members of our team and we wish to thank Roland Sherman in Columbia County; Bill Schillinger in Adams/Lincoln County; Walt Gary in Walla Walla County; and John Burns in Whitman County.

We wish to express special thanks to the 38 farmers who allowed us to work on their property during the past year (see separate listing). They have performed field operations, loaned equipment, donated chemicals, forfeited yield, and adjusted their practices to accommodate our experiments. The locations of these off-station plot sites are shown on the map that follows.

We would also like to thank Lori Spencer, a master of science degree student, WSU Tri-Cities, Dept. of Environmental Science and Regional Planning, and the Umatilla Soil & Water Conservation District, Bev Kopperud, Ray Denny, and Felicity Dye for their continued support.

We truly appreciate the support and encouragement of growers, organizations, and businesses with a mission common to ours: to serve in the best manner possible the crop production and resource conservation needs of our region. We welcome your suggestions on how we may continue to improve in our endeavors towards reaching this goal.

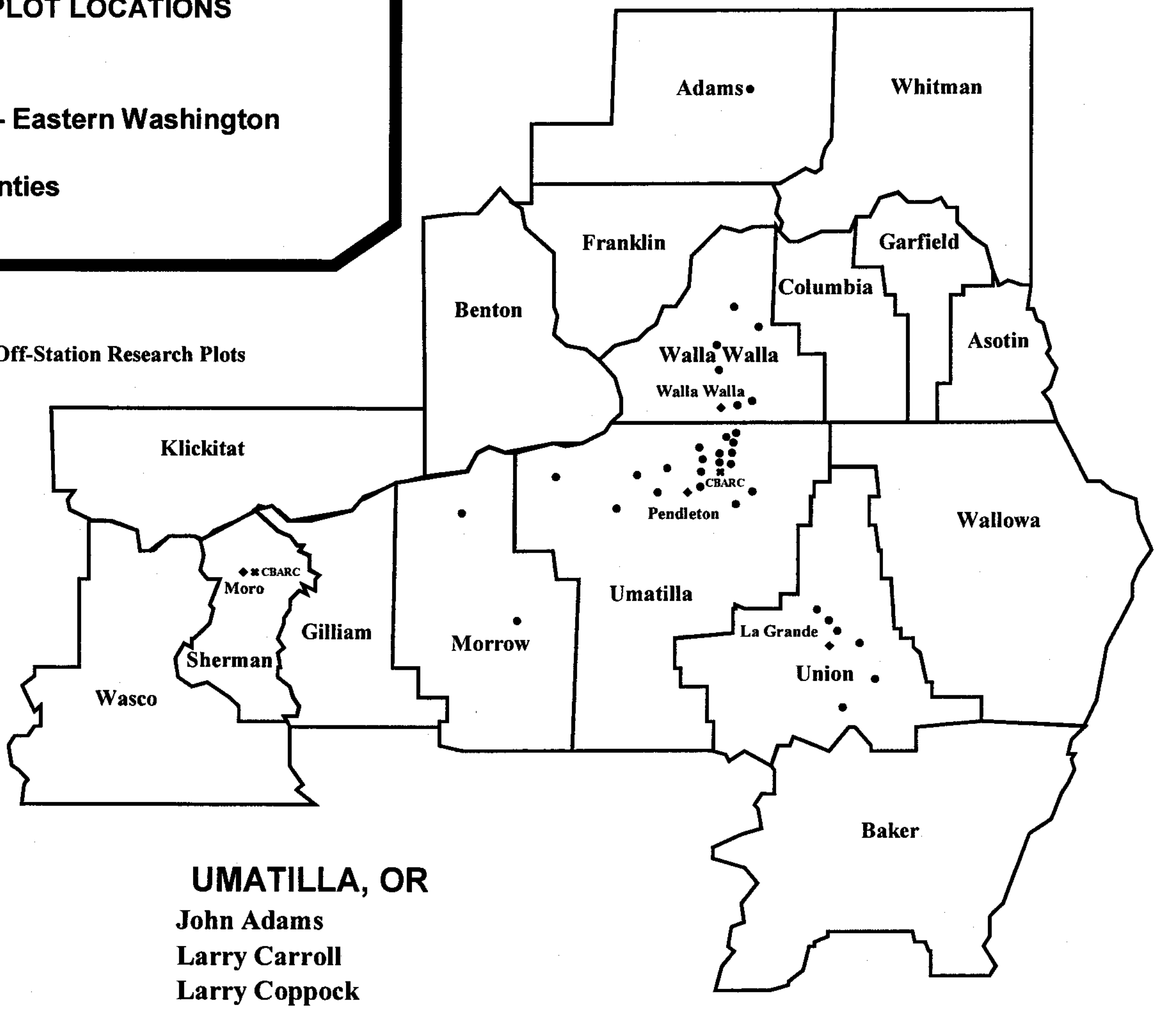
Steve Petrie
Superintendent
OSU-CBARC

Dale Wilkins
Research Leader
USDA-ARS-CPCRC

RESEARCH PLOT LOCATIONS

Eastern Oregon - Eastern Washington

Counties



UMATILLA, OR

John Adams
Larry Carroll
Larry Coppock
Cooperating Landowners on Gerking Flat
Tom Darnell
Berk Davis
Pat Davis
Mary Ann Davis
Duff Farms
Greg Goad
Alan Gradwahl
Phil Hawman
Chris Holdman
Mark Kirsch Family
Bill Lorenzen
Kent Madison
Dan McCarty
Eric Nelson
Gary Nibler
Harold Nibler
Clint Reeder
Paul Reeder
Leon Reese
Sherman Reese

ADAMS, WA

WSU Dryland Experiment Station
(Bill Schillinger)

MORROW, OR

Chris Rauch

UNION, OR

Rodney Case
John Cuthbert
Roger Davis
Bill Howell
Fred Wallender
Tim Wallender

WALLA WALLA, WA

Mike Barnum
Allen Ford
Dwelley Jones
Mark Sherry
Guy McCaw
Dave Morel

RESEARCH CENTER PUBLICATIONS

Albrecht, S.L., K.W. Skirvin, N.C. Roager, A.A. Baker, H.S. Oviatt, R.W. Rickman and C.L. Douglas, Jr. 2001. Changes in nitrogen mineralization with beef feedlot manure amendments in semiarid Oregon Soils. Agronomy Abstracts. Am. Soc. Agron. Madison, WI. [CD ROM]

Ball, D. A. and F. L. Young. 2001. Integrated management of jointed goatgrass in winter wheat. In: 2001 Columbia Basin Ag. Res. Ctr. Annual Rpt. OSU Ag. Exp. Stn. Spec Rpt. 1026. pp. 56-60.

Ball, D.A. and D. Singh. 2001. Catchweed bedstraw control in grass seed crops. In: 2000 Seed Production Research Report, OSU Ext / CrS 115: 54-58.

Bassinette, J.P., R.S. Karow, S.W. McDonald, K. Rhinhart and R. W. Smiley. 2001. Statewide cereal variety testing program. Oregon Agr. Expt. Stn. Spec. Rpt. 1026:22-41.

Bezdicek, D., M. Fauci, S. Albrecht and K. Skirvin. 2002. Soil carbon and C sequestration under different cropping and tillage practices in the Pacific Northwest. pp. 101-107. Proc. Northwest Direct Seed Cropping Systems Conference. Jan. 16-18, Spokane, WA.

Cook, R.J. and R. Smiley. 2001. Wheat yield responses to seed treatments. Wheat Life 44 (10):32-34.

Evans, J.O., D.A. Ball, and G.A. Wicks. 2001. Contrasting jointed goatgrass emergence patterns under uniform fallow-tillage across the western United States. Proceedings West. Soc. Weed Sci. 54:16.

Hanson, D.E., D.A. Ball and C.A. Mallory-Smith. 2002. Herbicide resistance in jointed goatgrass (Aegilops cylindrica): simulated responses to agronomic practices. Weed Tech. 16: 156-163.

Hanson, D.E., D.A. Ball and C.A. Mallory-Smith. 2001. Modeling herbicide resistance development in jointed goatgrass. Proceedings West. Soc. Weed Sci. 54:66.

Hubbard, R., W. Honeycutt, S. Albrecht, G. Brink, B. Eghball, S. McGowan, K. Sistani and B. Wienhold. 2001. A USDA-ARS nationally coordinated project to determine N mineralization from animal manure – soils. Agronomy Abstracts. Am. Soc. Agron., Madison, WI. [CD ROM]

Honeycutt, C.W., R.J. Wright, M.D. Jawson, B.J. Wienhold, B. Eghball, K.R. Sistani, G.E. Brink, T.S. Griffin, S.L. Albrecht, J.M. Powell, R.A. Eigenberg, R.K. Hubbard, S.L. McGowan, B.L. Woodbury and H.A. Torbert. 2001. Nitrogen Mineralization from Animal Manure: USDA-ARS Nationally coordinated research. Second International N Conference.

Park, K., C.A. Mallory-Smith, G.W. Mueller-Warrant and D.A. Ball. 2001. Growth characteristics of sulfonylurea-resistant and –susceptible downy brome biotypes. Proceedings West. Soc. Weed Sci. 54:12.

Petrie, S.E. 2001. Soil pH and nutrient availability. Proceedings of the Pacific Northwest Vegetable Association Annual Meeting.

Petrie, S.E. and B.D. Brown. 2001. Late season N applications for irrigated hard red wheat protein enhancement. Agron. Abst.

Rainbolt, D. R., D. C. Thill, and D. A. Ball. 2001. Response of rotational crops to BAY MKH 6561. Weed Technology. 15: 365-374.

Rainbolt, C.R., D.C. Thill, D.A. Ball and J.P. Yenish. 2001. Managing volunteer following herbicide resistant crops. Proceedings West. Soc. Weed Sci. 54:90.

Rickman, R.W., C.L. Douglas, Jr., S.L. Albrecht, L.G. Bundy and J.L. Berc. 2001. CQESTR: A Model to Estimate Carbon Sequestration in Agricultural Soils. Journal of Soil and Water Conservation. 56(3):237-246.

Rickman, R.W., C.L. Douglas, Jr., S.L Albrecht. and J.L. Berc. 2001. CQESTR-Predicting Carbon sequestration in agricultural cropland and grassland soils. Chapt. 16. Agricultural practices and policies for carbon sequestration in soil. CRC Press. pgs. 177-181.

Rickman, R.W., C.L. Douglas, Jr., S.L. Albrecht and J.L. Berc. 2002. Tillage, crop rotation, and organic amendment effect on changes in soil organic matter. Journal of Environmental Pollution. 116(3):405-411.

Siemens, M.C., D.E. Wilkins and R.F. Correa. 2001. Evaluation of a residue management wheel for hoe-type no-till drills.

Siemens, M.C., D.E. Wilkins and R.F. Correa. 2001. Evaluation of a residue management wheel for hoe-type no-till drills. Oregon Agric. Exp. Sta. Spec. Rep. 1026:61-64.

Siemens, M.C., R.F. Correa and D.E. Wilkins. 2002. Flexible ground-driven residue management wheel. United States Patent No. US 6,345,671 B1.

Singh, D. and D.A. Ball. 2001. Grass seed variety yield trials for northeastern Oregon. *In* 2000 Seed Production Research Report, OSU Ext / CrS 115: 52-54.

Smiley, R.W. 2001. Survey of nematodes in eastern Oregon and Washington field crops. Oregon Agr. Expt. Stn. Spec. Rpt. 1026:65-76.

Smiley, R.W. 2001. Principles for Controlling Root and Crown Diseases of Small Grain Cereals. OSU-CBARC Pathology Tips. 4 p.

Smiley, R.W. 2001. Seed Treatments for Small Grain Cereals. OSU-CBARC Pathology Tips. 8 p.

Smiley, R. and K. Kidwell. 2001. Hessian fly damage on spring wheat. Oregon Wheat 53(5):11-12, 14.

Smiley, R. 2002. Soilborne crop pathogens under direct seeding: Nematodes. pp. 152-164. *In* Proc. Northwest Direct Seed Cropping Systems Conf., Spokane, WA.

Smiley, R. 2002. Soilborne crop pathogens under direct seeding: Fusarium. pp. 140-151. *In* Proc. Northwest Direct Seed Cropping Systems Conf., Spokane, WA.

Smiley, R.W. 2002. Controlling Diseases of Cereals in Eastern Oregon. *Oregon Invests*! http://oregoninvests.css.orst.edu/index.html (an OSU-CAS accountability database)

Smiley, R.W. 2002. Assessing the Importance of Root-Lesion Nematodes on Field Crop Production in Eastern Oregon. *Oregon Invests*! http://oregoninvests.css.orst.edu/index.html (an OSU-CAS accountability database)

Smiley, R.W. 2002. Improvement of Wheat through Genetic Resistance to Cereal Cyst Nematode. *Oregon Invests*! http://oregoninvests.css.orst.edu/index.html (an OSU-CAS accountability database)

Smiley, R.W. 2002. Educational Programs for Diseases of Field Crops in Eastern Oregon. *Oregon Invests*! http://oregoninvests.css.orst.edu/index.html (an OSU-CAS accountability database)

Smiley, R., R.J. Cook and T. Paulitz. 2002. Controlling Root and Crown Diseases of Small Grain Cereals. OSU Ext. Publ. EM 8798. 6 p.

Smiley, R., R.J. Cook and T. Paulitz. 2002. Seed Treatments for Small Grain Cereals. OSU Ext. Publ. EM 8797. 8 p.

Smith, D. and S. Albrecht. 2001. Fluorescein diacetate hydrolysis as a method of determining soil microbial activity in Columbia Basin silty loam soils. Oregon Agric. Exp. Sta. Spec. Rept. 1026:111-117.

Stoltz, M. and R.W. Smiley. 2002. Stop Fungicide Applications for Physiological Leaf Spot on Wheat. *Oregon Invests*! http://oregoninvests.css.orst.edu/index.html (an OSU-CAS accountability database)

Walenta, D.L., J.P. Yenish, F.L. Young, E. Gallandt and D.A. Ball. 2001. Jointed goatgrass seed production in spring wheat. Proceedings West. Soc. Weed Sci. 54:66.

Wilkins, D.E., D.J. Wysocki and M.C. Siemens. 2001. Effect of fertilizer placement and soil water on emergence of yellow mustard. Oregon Agric. Exp. Sta. Spec. Rep. 1026:77-83.

Williams, J.D. and C.L. Douglas, Jr. 2001. Nutrient loss from dryland winter wheat fields on the Columbia Plateau. *In* Proceedings of 2001 American Water Resources Association Conference, 12-15 Nov. 2001. Albuquerque, NM.

Williams, J.D. and C.L. Douglas, Jr. 2001. Soil erodibility in long-term crop systems: Preliminary results following two years of monitoring. *In* Proceedings of the International Symposium; Soil Erosion Research for the 21st Century. ASAE, Honolulu, HI.

Williams, J.D. and S.B. Wuest. 2001. No-till influence on hydrology and stream morphology in dryland crop areas. Oregon Agr. Expt. Stn. Spec. Rpt. 1026:84-95.

Wuest, S.B. 2001. Soil biopore estimation: Effects of tillage, nitrogen, and photographic resolution. Soil and Tillage Research 62:111-116.

Wuest, S.B. 2001. Earthworm, infiltration, and tillage relationships in a dryland pea-wheat rotation. Applied Soil Ecology 18:187-192.

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USDA-ARS METEOROLOGICAL MONITORING IN NORTHEASTERN OREGON

H. Scott Oviatt and Dale E. Wilkins

Abstract

In order to collect accurate and reliable meteorological data for research purposes, a well-designed monitoring plan must be implemented. The Agricultural Research Service Columbia Plateau Conservation Research Center (ARS-CPCRC) meteorological monitoring network was designed and developed in order to provide researchers access to high-quality weather data in a "near-real-time" platform. The system was designed such that, in the future, the general public will also be able to access this data in near real time via the internet.

The design and implementation of an accurate and standardized meteorological station for research data collection was a key element in the development of the ARS-CPCRC monitoring network. Each research location provides unique topography, slope orientation, agricultural practices, influenced by microclimates that need to be measured at points representative of the overall research area.

The design, installation, operation, and cost of a representative station in the ARS-CPCRC meteorological monitoring are described.

Key Words
Climate, data acquisition, meteorology, meteorological calibration, real-time data, weather data

Introduction

The ARS-CPCRC at Pendleton, Oregon needs to collect accurate meteorological data. These data are used in creating and verifying mathematical models, determining water use efficiency, studying climatic effects on soil erosion, and studying plant stress associated with developing sustainable soil and water conservation systems. Additionally, the short-term and long-term effects of weather patterns can significantly impact crop yields, and land-use decisions. In order to support these research goals, and to assist in developing a better understanding of local weather patterns, a meteorological monitoring network has been developed.

System Design

The ARS-CPCRC meteorological monitoring network consists of four remote weather stations continuously collecting meteorological data for use in ARS research projects. The stations are located on cooperator properties near Pendleton, Oregon. Figure 1 provides a map indicating the location of each station in the ARS monitoring network.

Although located less than 20 miles apart, each site is necessary due to the rapidly changing weather patterns in this area. The influence of the Blue Mountains to the south and east induce dramatic changes in temperature and precipitation due to upslope/downslope winds and orographic lifting.

The goal of the monitoring program is to provide a uniform (standard) monitoring station design that incorporates identical sensors and measurement techniques, and allows direct comparison data collected at different locations. Each station collects additional site-specific parameters guided by the research objectives for the project.

A description of the physical location of each site is provided below. Included are the geographic coordinates and the elevation of the monitoring station. The four stations described in this report are as follows:

Duff Site – Located on land farmed by Duff Ranches. Abbreviated as **DNEW**, located in the Wildhorse drainage just north of Oregon Highway 11, Helix Highway. The physical site location is: Latitude - 45° 43.4' North, Longitude - 118° 39.5' West, and Elevation: 428.0 m above sea level (asl).

Lorenzen Site – Located on land farmed by Mr. Bill Lorenzen. Abbreviated as **LOR** located in the upper reaches of Little Greasewood Creek, approximately 3.5 miles southwest of Helix. The physical site location is Latitude: 45° 48.8' North, Longitude: 118° 41.3' West, and elevation 544.6 meters asl.

Reeder Site – Located on land farmed by Mr. Clinton Reeder and Mr. Paul Reeder. Abbreviated as **RDWS**, located at the junction of Helix Highway (Oregon Highway 335) and Athena Highway (Oregon Highway 334), approximately 2 miles south of Helix. The physical site location is Latitude: 45° 49.0' North, Longitude: 118° 38.6' West, and elevation: 546.0 m asl.

Reese Site – Located on land farmed by Mr. Leon Reese. Abbreviated as **RPSET**, located off Interstate 84 on Rhode Road, approximately 1.5 miles northwest of the REW interchange (elevator), Exit 198. The physical site location is Latitude: 45° 44.0' North, Longitude: 119° 03.0' West, and elevation: 314.0 m asl.

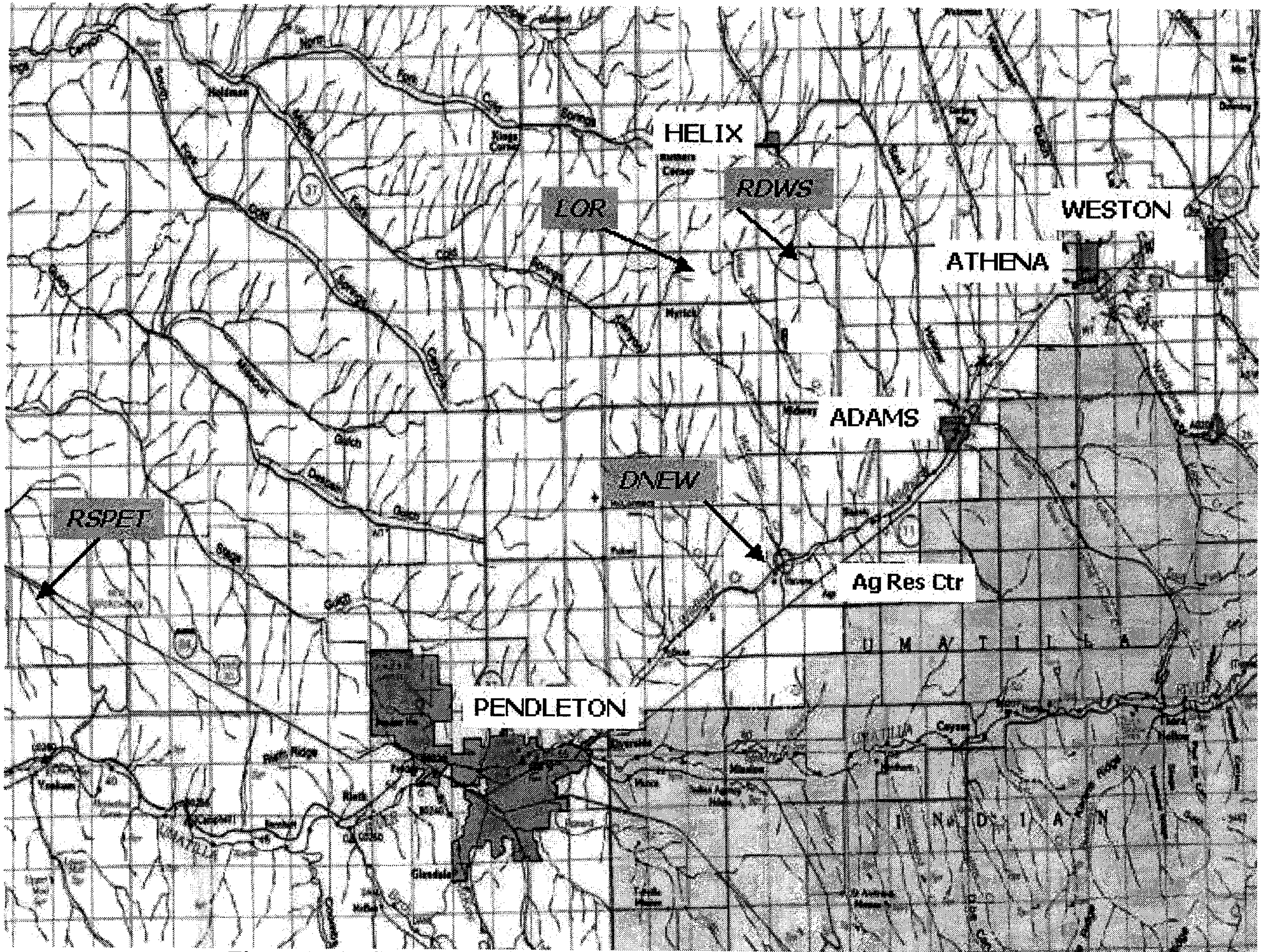

Figure 1. ARS meteorological monitoring network site locations (June 2002).

The monitoring network was designed to use state-of-the-art measurement instrumentation in association with highly reliable data acquisition systems. Through the use of cellular telephone modems, ARS personnel are able to view real-time data, and collect stored data from each station manually or automatically. At a specified time each day, the data are retrieved automatically via computer and cell phone telemetry. Once the data are downloaded, they are screened through the use of a comparative spreadsheet. The spreadsheet evaluates each data point to ascertain consistency with the values immediately before and after. The data are additionally verified and screened manually and visually by an ARS staff member with expertise in meteorological monitoring and data analysis.

Each monitoring site is configured to measure and collect meteorological data representative of the vicinity where research is conducted. The purpose of the measurements is to provide a weather database that can be used to complement the research data collected. The data are then used during the research program, as well as to provide a historical climatic database for that area.

The meteorological parameters measured at each station include; wind speed, wind direction, air temperature, relative humidity, 1 in soil temperature, and 4 in soil temperature, solar radiation, and precipitation. Table 1 provides the information for each parameter measured, including the sensor type, measurement units, component accuracy, manufacturer, and sensor placement in relation to the ground (soil surface).

At certain stations, additional variables are logged and collected depending upon the requirement of the research at the location. The outputs of individual sensors are digitally recorded in the SI units listed in Table 1. The data are stored in hourly averages and daily averages. Hourly and daily averages are derived from an average of each 1-sec scan (3,600 for each hour, and 86,400 for the daily averages). Additionally, daily maximum, daily minimum, and daily totals (where applicable) of parameters are collected and stored. For the maximum and minimum values, the time of occurrence is also recorded for comparative reference between parameters/stations.

Figure 2 shows a photograph of a meteorological station installed at one of the sites and is typical of the stations installed at the other three research locations.

Table 1. ARS meteorological equipment specifications

Variable	Equipment or sensor type	Measurement units	Component accuracy	Sensor Manufacturer[1]	Measurement height (above ground surface)
Digital data acquisition	Analog/digital conversion	Output in engineering units	±0.075% of full-scale range (analog input)	Campbell Scientific, Inc. Model 23X	-
Wind speed	Reed switch anemometer	Meters per second (0-50)	0.25 meters per second or 1.5% of full-scale	Met One, Inc. Model 014A	3 m
Wind direction	Potentiometer wind vane	Degrees (0° - 360°)	±3.0°	Met One, Inc. Model 024A	3 m
Air temperature	Bridge circuit thermistor	Deg C (-40° - +60°)	±0.5°C at -40°C ±0.2°C at +20°C	Vaisala, Inc. Model HMP45C	2 m
Relative humidity	Bridge circuit hygristor	Percent (0-100%)	±3.0% under field conditions (90%-100%)	Vaisala, Inc. Model HMP45C	2 m
1" soil temperature	Bridge circuit thermistor	Deg C (-40° - +60°)	Typically <±0.1°C over -24°C to +48°C range	Campbell Scientific, Inc. Model 107	2.5 cm below soil surface
4" Soil temperature	Bridge circuit thermistor	Deg C (-40° - +60°)	Typically <±0.1°C over -24°C to +48°C range	Campbell Scientific, Inc. Model 107	5 cm below soil surface
Solar radiation	Black and white pyranometer	Langleys per day (0 – 1100)	Absolute error = ±5.0% Max ±3.0% Typical	Eppley Model 8-48 LiCor Model 200X	2 or 2.5 m
Precipitation	Tipping bucket	Totalized rain (inches)	±1.0% up to 10 mm/hr ±5.0% up to 30 mm/hr	Texas Electronics Model TE525	1 m

[1] ARS reference to products, vendors, or manufacturers is for specific information only and does not endorse or recommend that product(s) or company to the exclusion of others that may be suitable.

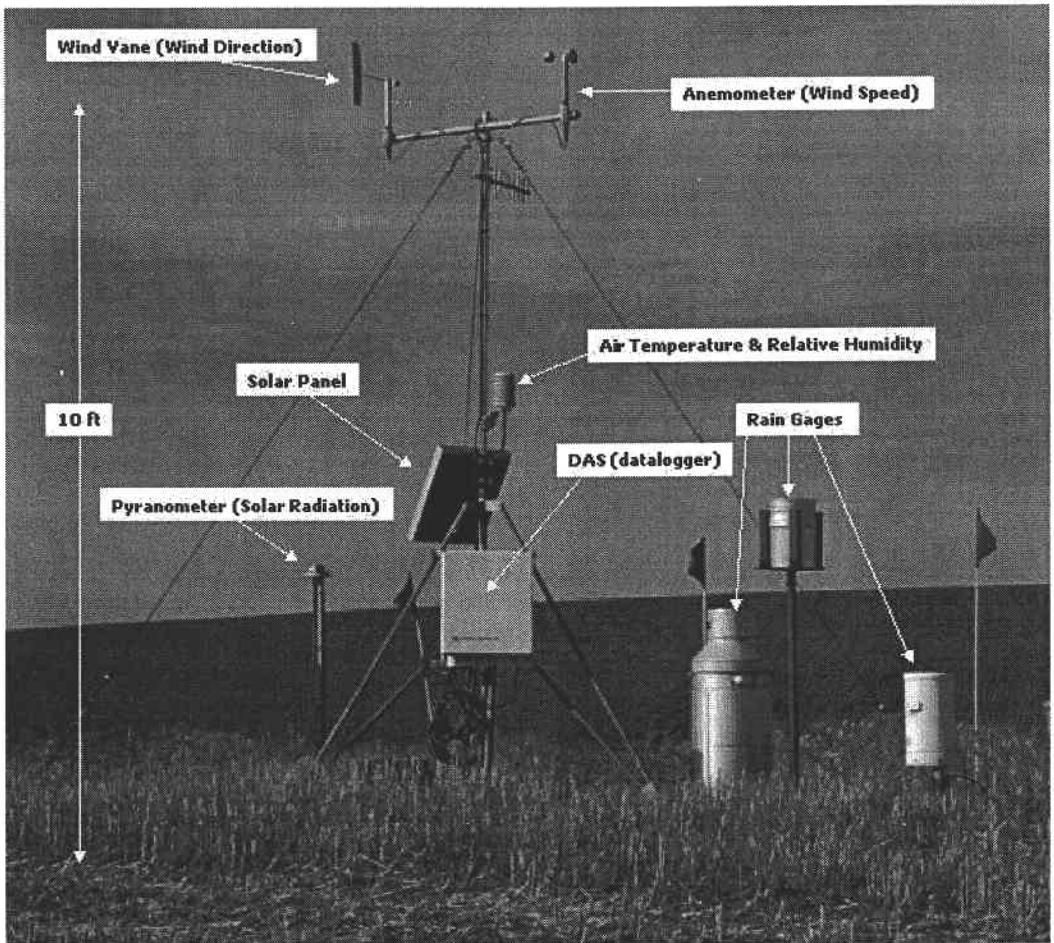

Figure 2. Typical ARS meteorological monitoring installation

Site Selection, Calibration, and Operations

Site Selection

Following is an overview of the tasks required to set-up, implement, install, and operate a station configured with the aforementioned instrumentation. Generalizations have been made in order to provide the reader with a "representative" scheme on the operation of a research-oriented meteorological monitoring station, similar to the ones used at the ARS sites.

Initially, an acceptable location must be selected to conduct the monitoring and collect the measurements. The primary objective is to place the instrument in a location where it can make precise measurements that are representative of the general state of the atmosphere in that area, consistent with the objectives of the data collection program (United States Environmental Protection Agency [EPA] 1989). Issues such as site access, minimization of disruption of local agricultural practices, and site security are also important criteria used for site selection.

The World Meteorological Organization (WMO 1971), National Oceanic and Atmospheric Administration (NOAA 1995), and the U.S. Environmental Protection Agency (EPA 1989), have produced several useful documents and guidelines for the site selection and operation of meteorological systems similar to the ARS systems. The site selection and installation criteria for each of the sensors used are reviewed according to the WMO, NOAA, and EPA guidelines during the system implementation process.

Although ARS does not operate under regulatory guidelines delineated by EPA, the stations in the Umatilla County network are sited, installed, and operated following recommended practices outlined by EPA and other agencies. One major exception is the measurement height of the wind speed and direction sensors. EPA and NOAA recommend a measurement height of 10 m above ground level. The rationale is due to the following: 10 m is the measurement height employed at airports for general aviation. This height is equivalent to the last height that a pilot can take corrective actions on landing and take off. Additionally, EPA requires this measurement height since the data is readily available from most U.S. airports and can be readily used (and scaled up) in air quality dispersion models. The ARS sites measure the wind speed and wind direction at 3 m. This height is used in order to provide measurements more representative of the research activities in the canopy and at ground level.

The ARS network data can be considered of high quality and accuracy, meeting recommended quality assurance guidelines for presentation and acceptance for use in long-term climatological and agronomic studies (Nunes, et.al. 2001).

Once a suitable monitoring site has been identified, documented, and validated, the meteorological station is installed following recommended manufacturer procedures, while meeting the siting and measurement guidelines for meteorological monitoring (NCAR 1984).

The initial phase of system installation consists of wiring and configuration, including the documentation of detailed information regarding sensor type and planned application. The wiring and configuration documentation is vital in the preparation of the site-specific data acquisition software program. The programming effort is driven by the following items: (1) number and type of sensors, (2) power requirements of individual sensors, (3) type of measurement required to achieve final output, and (4) desired data format.

The continuous meteorological data are collected and stored using the programmed Campbell Scientific, Inc. CR23X data acquisition system (DAS). The DAS is equipped with four megabytes of extended memory for on-site data backup (up to 30 days of unattended operation). The data logger contains a nickel cadmium (NiCad) battery backup that provides power for the DAS memory to store date, time, DAS program, and meteorological data, should system power be disconnected, or power outages occur.

Main power for the CR23X is provided by a 12-volt marine battery (80 amp-hour, or equivalent). The battery is continuously charged via a regulated 20-watt solar panel. The CR23X is interfaced to all meteorological sensors by individual shielded signal cables. The on-site cellular telephone and voice modem are also integrated into the system. The data logger and cell phone are housed in a weatherproof NEMA enclosure constructed of heavy-duty fiberglass. The enclosure is mounted on the meteorological tower near the base for easy user access.

Calibration

Initially, operational assessment of individual instruments and sensors is determined at installation/start up and subsequently checked on a semi-annual basis by system and individual sensor calibrations. Additionally, calibrations are performed if sensor maintenance or replacement occurs. The accuracy and reliability of the measurements are determined as the sensors are calibrated against known standards and references. The calibration criteria of the meteorological sensors are defined in Table 2.

Table 2. ARS meteorological calibration methods and tolerance limits

Parameter	Calibration method	Tolerance limit
DAS	Voltage input/output	± 2%
Wind speed	Synchronous motor	≤ 0.1 m/sec
Wind direction	Orientation with respect to true north	± 5°
	Linearity	≤ 3°
Temperature	NIST [1] thermometer collocation comparison	≤ 0.5°C
Relative humidity	NIST psychrometer collocation comparison	± 10%
1 in and 4 in soil temperature	NIST thermometer collocation comparison	≤ 0.5°C
Solar radiation	Certified pyranometer collocation comparison	± 5%
Precipitation	Volumetric addition	± 5%

[1] NIST – National Institute of Standards and Testing .

All calibration equipment is certified by the manufacturer, or by using an NIST equivalent transfer standard (Lockhart 1985). DAS systems are calibrated by applying known voltages or signals with a NIST-traceable voltage generator and verifying DAS output. Wind speed sensors (anemometers) are calibrated by applying a "synthetic" wind speed through the system and verifying that the system output corresponds to the input value. Wind direction sensors are calibrated by sighting along the wind crossarm with a certified precision compass to assure proper orientation with respect to true north. Wind direction potentiometer linearity values are verified by checking the sensor output at 25 different angular positions (12 clockwise, 13 counterclockwise) at 30° increments throughout the entire range of sensor output (0° to 360°). Air and soil temperature sensors are calibrated by direct comparison of the system output to a certified NIST reference standard thermometer accurate to 0.05°C. A multi-point comparison (ice bath, hot water, cool water, and ambient air) is taken with the precision NIST mercury-in-glass thermometer to verify proper temperature response in all ranges. Relative humidity sensors are calibrated by direct comparison of the system output to a certified NIST reference standard psychrometer equipped with thermometers accurate to 0.05°C. Solar radiation sensors (pyranometers) are calibrated and verified by collocating a certified pyranometer with the site pyranometer for a period of 24 hours and comparing data values. Precipitation gauges are calibrated by adding known volumes of water to the gage and verifying sensor response.

Operations

Primary data downloading is accomplished using a personal computer (PC) located at the ARS-CPCRC office. A telephone modem in the ARS PC is used to connect to the DAS, activate the DAS software, and transfer the data.

As a part of routine station operations, an ARS technician visits the monitoring site approximately once every 2 weeks to evaluate the performance and physical condition of the meteorological system and instrumentation. Extreme weather conditions and wildlife can damage the sensors, so each sensor is carefully examined to see that it is functioning properly and in good working order. All individual site maintenance activities, measurement abnormalities, malfunctions, and repairs are entered and documented on a site-specific checklist. The site checklists provide a historical journal of site visit dates, times, operations, maintenance, adjustments, calibrations, and other technician observations.

Any time data are downloaded, either via cell modem retrieval or during the on-site checks, the data are intensively screened to determine their validity. The general purpose of this screening and validation routine is to generate data for the monitoring program that are valid with respect to being: (1) complete, (2) representative, (3) accurate, and (4) comparable with other stations and historical climatic trends. It is necessary to develop and define criteria for determining valid data for meteorological measurements. ARS has developed a screening spreadsheet to review the data for these criteria. Additionally, an ARS staff member, with an extensive data analysis and verification background, reviews each data set as it is retrieved from the station to further ensure data validity and accuracy. Control limits established for individual parameters are used in the data validation process. Measurements that found to be "out-of-tolerance" are identified during instrument inspection (site checks), and during data screening.

Meteorological parameters are monitored on a continuous basis and averaged and recorded digitally in hourly and daily values. The primary means of data processing is via the digital record and output from the validation and averaging spreadsheet used for generation of the data report. A raw data record is archived. Once the raw data is processed for a specific time period, the visual screening checks are performed. These procedures include:

- Verifying data exist and are properly identified;
- Verifying data are in proper format;
- Verifying data identifiers conform to monitoring time periods;
- Identifying missing or anomalous data.

The initial method of editing the digital data involves the comparison with the upper and lower limits of the allowed range. This screening is conducted using the validation spreadsheet. If values outside the allowed range limit are discovered, they are flagged accordingly and documented for future reference.

The data files are also checked for reasonableness based on expected minimum/maximum ranges for the eastern Umatilla County region (using Pendleton airport NWS site, as well as records from other stations in the network). The data reduction screening spreadsheet is used to properly format and reduce the data file.

In addition to the general screening procedures outlined above, the screening criteria in Table 3 have been incorporated into the ARS data reduction program to assist in the validation portion of the data review.

Once the data sets have been validated and anomalies removed, the data is sorted chronologically. Site specific data required by the various research projects are evaluated by the lead researcher(s). All data are archived on a monthly basis for future reference. Only complete, verified, and validated data are incorporated into the final archived database. These data sets are available for use by the general public or other research agencies.

Table 3. ARS meteorological data screening criteria

Variable	Screening criteria (flag data for review if:)
Wind speed	1. Is threshold <0.5 m/sec; or >35 m/sec 2. Does not vary by >0.2 m/sec for 3 consecutive hours 3. Does not vary by >0.5 m/sec for 12 consecutive hours
Wind direction	1. Is <0° or >360° 2. Does not vary by >1° for >3 consecutive hours 3. Does not vary by >10° for 18 consecutive hours
Temperature	1. Is > record high (monthly) for E. Umatilla County Region 2. Is < record low (monthly) for E. Umatilla County Region 3. Is >5°C change from the previous hour 4. Does not vary by more than 0.5°C for 12 consecutive hours
Relative humidity	1. Is >100% or less 0% 2. Is >25% change from the previous hour 3. Does not vary >5% for 12 consecutive hours
1 in and 4 in soil temperature	1. Is value > or < air temperature 2. Does not vary by>0.5°C for 4 consecutive hours
Solar radiation	1. Is value <0, or > than average daily value (month) 2. Does not vary diurnally
Solar Radiation	1. Is value < 0, or > than average daily value (month) 2. Does not vary diurnally
Precipitation	1. Is hourly or daily value <0, or >10 mm 2. Is Daily value >25 mm 3. Daily value exceeds max value for daily accumulation in E. Oregon

Cost

Table 4 provides a brief description of the equipment used at each station, with an associated cost. This information is provided in order to give the reader a general idea of the capital requirements necessary to implement and conduct meteorological monitoring. The total estimated system cost of $10,000 would provide an end-user with a system capable of collecting weather data in user-specified time intervals. Additionally, the quoted system will allow for real-time data access and remote downloading through the cellular telephone voice modem and dedicated PC. The estimate does not include labor for installation, land lease charges, site access, or easement. The equipment costs presented are for equipment that is identical to that used in the ARS monitoring network. A user could design his or her system (to meet budgetary and measurement requirements) by adding/removing, or replacing components with different instrumentation, which could raise or lower the overall system cost.

Table 4. ARS meteorological system equipment costs.

Variable	Manufacturer	Cost
Digital data acquisition	Campbell Scientific, Inc. [1] Model 23X (incl. Telemetry)	$5,500
Wind Speed	Met One, Inc. Model 014A (incl. Cable)	$400
Wind direction	Met One, Inc. Model 024A (incl. Cable)	$520
Air temperature	Vaisala, Inc. Model HMP45C (incl. cable)	$750
Relative humidity	Vaisala, Inc. Model HMP45C (incl. Cable)	Cost included w/ air temp
1 in soil temperature	Campbell Scientific, Inc. Model 107 (incl. Cable)	$90
4 in soil temperature	Campbell Scientific, Inc. Model 107 (incl. Cable)	$90
Solar radiation	Eppley Model 8-48 LiCor Model 200X	$400
Precipitation	Texas Electronics Model TE525	$400
Equipment tripod	Campbell Scientific, Inc. CM10	$400
Battery and 20 watt solar panel	Campbell Scientific, Inc. Model MSX20R	$650
Data logger Software	Campbell Scientific, Inc. Model PC208W	$400
EQUIPMENT TOTALS		**$10,000** [2]

1 The reference to products, vendors, or manufacturers is for specific information only and (ARS) does not endorse or recommend that product(s) or company to the exclusion of others that may be suitable.

2 This is a total estimated cost based upon purchases made by ARS during 2001 and does not necessarily reflect what an agency or individual would be required to pay if purchasing the equivalent in 2002.

Summary

A monitoring system was designed by the ARS-CPCRC staff in Pendleton, Oregon to provide for the collection of site-specific agricultural research-oriented meteorological data that are accurate and complete at remote locations. The systems employ a variety of accurate and reliable instrumentation linked to user-friendly data acquisition systems that can be easily accessed by the researchers. The information can be accessed and retrieved in a real-time platform, which facilitates efficient research analysis and planning.

Extensive programmatic and manual validation is conducted on the collected data sets to ensure that all archived data are accurate.

Currently the ARS-CPCRC meteorological monitoring network is operating at four remote stations. In the future, additional research sites may be established at different locations and additional stations will probably need to be installed. Future stations will be implemented with similar instrumentation and software in order to provide consistency and continuity throughout the network.

Additionally, there are plans, dependent upon funding, to provide access to the data via an internet-based platform (web page or ftp site), to members of the general public, growers, or other agencies interested in meteorological data. At this time, interested parties are welcome to contact the authors to access or obtain data from any stations in the monitoring network. It is important to note that the network has been installed, implemented and brought into operational status between June 1, 2000, and September 1, 2000.

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References

Brock, F.V. 1984. Instructor's handbook on meteorological instrumentation. National Center for Atmospheric Research (NCAR) Technical Note, NCAR/ATN-237+1A, Boulder, CO.

Lockhart, T.J. 1985. Quality assurance of meteorological measurements. Page 253-259 *in* J.K. Taylor and T.W. Stanley (eds). Quality Assurance for Environmental Measurements, ASTM STP 867. American Society for Testing and Materials, Philadelphia, PA.

Nunes, L.F., R.A.C. Carvahlo, and V.M.S. Prior. 2001. Surface automatic meteorological observations: Portuguese experience and future perspectives. Pages 267-272. *in* Proceedings from the 11th Symposium on Meteorological Observations and Instrumentation, 14-18 Jan. 2001, American Meteorological Society, Albuquerque, NM.

U.S. Department of Commerce, NOAA. 1995. Federal meteorological handbook (FMH) Number 1. Surface weather observations and reports. Government Printing Office, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1982. Guidelines for siting and exposure of meteorological instruments for environmental purposes. Research Triangle Park, NC

U.S. EPA. 1989. Quality assurance handbook for air pollution measurement systems: Volume IV. Meteorological measurements. Research Triangle Park, NC.

World Meteorological Organization (WMO). 1971. Guide to meteorological instrument and observing practices. Fourth edition. Secretariat of the WMO, Geneva, Switzerland.

NITROGEN MANAGEMENT FOR WINTER MALTING BARLEY

Steve Petrie, Pat Hayes, Jennifer Kling, Karl Rhinhart, and Ann Corey

Abstract

Winter malting barley is a potential alternative crop for dryland producers in eastern Oregon. Excessively high or low grain protein levels will result in unacceptable malt quality. The objective of this research was to evaluate the effects of different nitrogen (N) management schemes on grain yield and protein and various malting quality characteristics. We seeded three winter barley varieties and six winter barley lines in mid-October. Pre-plant fall N was applied at 0, 50, 100, or 150 lbs per acre and spring N was applied at either 0 or 50 lbs per acre when the barley was in the four-leaf stage of development. Increasing fall N application rates increased grain yield and protein. Applying 50 lbs of N in the spring further increased grain protein but had little effect on grain yield. Spring N application had mixed effects on malting quality.

Key Words
Malting barley, nitrogen management, barley yield, malting barley quality

Introduction

The development of a superior quality, well-adapted winter malting variety will offer growers in eastern Oregon a potential alternative crop. Winter malting barley lines suitable for production in eastern Oregon are being developed at Oregon State University (OSU); the most promising of these lines are currently undergoing evaluation for malting and brewing quality. We are evaluating the response of these lines to various agronomic variables in this research program. This report will discuss only the nitrogen (N) management component of the program.

Grain protein is a key "gateway" characteristic for malting quality. Excessively high or low protein levels result in unacceptable malt quality. Six-row malting barley should have from 11.5 to 13.5% protein. In many other production areas, the major grain quality issue is excessively *high* protein levels and growers are challenged to produce grain with protein levels less than 13.5%. This presents real difficulties since there are only limited crop management options to minimize grain protein under these conditions. Fortunately, we in the dryland Pacific Northwest (PNW) are in the enviable position of having to manage our barley crops to increase the grain protein levels. There are more management options available to growers to raise protein levels.

New barley varieties are being developed and their yield and grain protein response to N fertilizer has not been evaluated. Determining the effect of N management on grain protein levels in advanced barley lines will permit us to make informed decisions about these lines prior to public release.

There are questions regarding the optimum N fertilization practices that are needed to consistently produce malting barley with acceptable protein levels. There has been only limited research on N management for malting barley in the PNW so we must turn to N management research on wheat for some general guidelines. Preplant N applications to hard red winter wheat tend to increase grain protein only after the yield potential is achieved. Further increasing the N application rate beyond that needed for maximum yield will then lead to increased grain protein. High rates of preplant N fertilization can be used to increase grain yield and protein but there are significant disadvantages to this practice. This practice increases the potential for N losses and the higher N rates used increase grower cost and often lead to lodging that can reduce yield and greatly increase harvest difficulty.

The objectives of this research were to evaluate the effects of increasing N application rates and split N applications on the plant height, grain yield, grain protein, and plumpness of three winter barley varieties and six winter barley lines. In this article we will report on the first year of the study.

Materials and Methods

Three winter barley feed varieties and six winter malting barley lines were seeded on October 16, 2000 using a nine-row Hege cone seeder with disk openers on 6-in row spacing. Soil samples collected prior to seeding were analyzed and the results are shown in Table 1.

Table 1. Soil test results.

Sample depth	NO_3-N	NH_4-N	P	SO_4-S
--- ft ---	----------	---------- ppm	----------	----------
0 – 1	8.3	4.0	21	7
1 – 2	6.5			8
2 – 3	7.3			
3 – 4	4.5			
4 – 5	5.3			
Total	31.9	4.0		

Preplant nitrogen was applied at 0, 50, 100, or 150 lbs of N/acre as anhydrous ammonia. The entire trial area received 100 lbs K_2SO_4/acre to supply K and S and 80 lbs of P_2O_5/acre as triple superphosphate (0-45-0). Individual treatments received an additional 50 lbs of N as urea broadcast applied on March 5, 2001 when the plants were in the four-leaf stage of development. The trial was arranged as a split-split plot design with preplant fall N rates as main plots, spring N rates as sub-plots and malting barley lines as sub-sub-plots. Plant height was measured and the plots were harvested using a Hege plot combine. The grain from the plots was weighed and subsamples collected for determination of test weight, grain protein, and plumpness.

Results and Discussion

Averaged across all N rates, the plant height of the three varieties and six lines in this study varied from 35.8 in for Stab 113 to 39.2 in for 88Ab536 and Stab 47 (Table 2). It is important to note, however, that none of the varieties or lines lodged, even at the highest N rates.

There were significant differences in the yield potential of the three varieties and six lines averaged across all N rates (Table 2); Strider had the greatest grain yield with 5735 lbs/acre while Kold produced the least grain with only 4840 lbs/acre.

Table 2. Plant height, yield, and protein for three winter barley varieties and six winter barley lines averaged across all N rates.

Selection	Plant ht	Yield	Grain protein
	-- inches --	lbs/acre	-- % --
Strider	36.9	5735	10.7
Scio	35.6	5300	11.0
Kold	36.3	4840	11.3
88Ab536	39.2	5015	11.2
Stab 7	37.1	5075	11.2
Stab 47	39.2	5015	11.6
Stab 113	35.8	5035	10.8
Stab 171	38.1	5230	11.4
Kab 68	38.0	5320	10.7
$LSD_{0.05}$	0.81	245	0.24

The yields in this trial were substantially less than the yields in a separate variety trial seeded about 2 weeks earlier in the same field. For example, Strider produced about 7,500 lbs of grain/acre in the adjacent trial that was seeded on October 4, 2000. We speculate that the earlier seeding date increased the yield potential of this variety.

Grain protein also varied significantly among varieties and lines; Strider and Kab 68 had the lowest average protein at 10.7% while Stab 47 had 11% protein. The grain protein of the other varieties and lines was intermediate between Strider and Kab 68 and Stab 47. These data are the mean of all the N rates used in the study.

Nitrogen fertilizer applications markedly increased the plant height, grain yield, and grain protein (Fig. 1). The mean plant height was increased from 33 in with no N fertilizer to about 39 in when 100 lbs of N/acre or more was applied (Fig. 1A). Spring N increased the plant height when 0 or 50 lbs of N/acre was applied in the fall but did not increase plant height when 100 or 150 lbs of N was applied in the fall.

Application of N markedly increased the grain yield; mean grain yield was increased from 4200 to 5330 lbs/acre by the application of only 50 lbs of N/acre in the fall (Fig. 1B). Spring N applications increased the grain yield only when no N fertilizer was

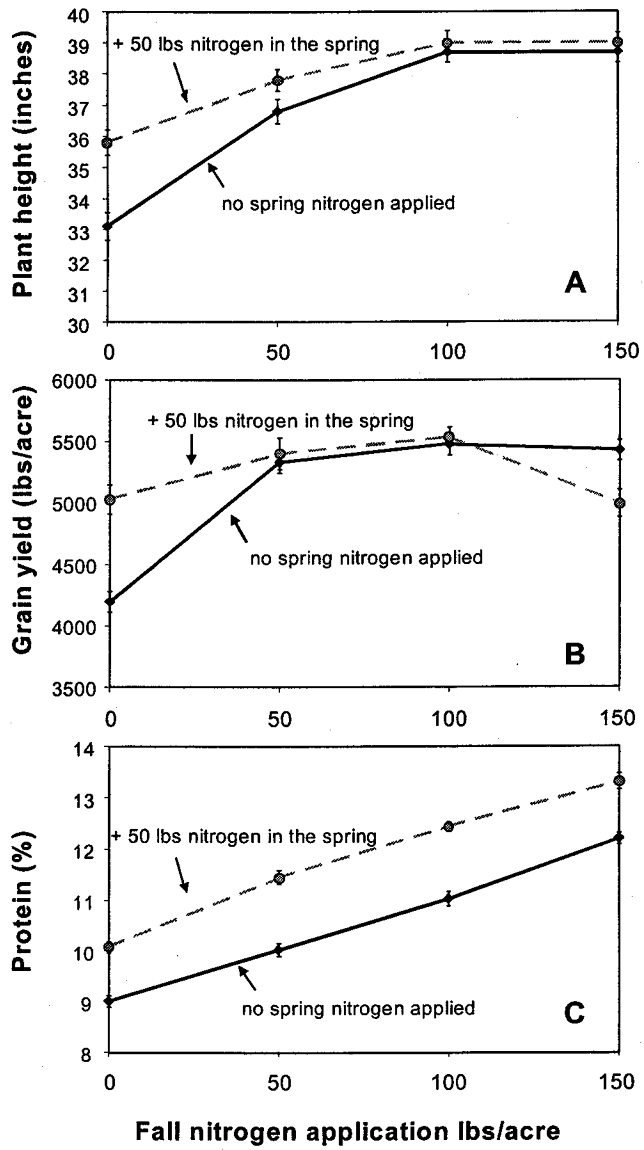

Figure 1. Average plant height (A), grain yield (B), and grain protein (C) of winter barley varieties and lines grown with different combinations of fall- and spring-applied N fertilizer. Error bars represent standard errors for each N treatment.

applied in the fall and actually decreased the yield when 150 lbs of N was applied in the fall. The possible reasons for this yield reduction are not clear; this yield reduction was not due to lodging as no lodging occurred in this trial.

Increasing the rate of fall N from 0 to 150 lbs of N/acre increased the mean grain protein from 9 to 12.2% (Fig. 1C). Applying 50 lbs of N in the spring resulted in about a 1% protein increase regardless of the fall N rate.

Malting quality data was obtained for five lines from one replication. Results are therefore preliminary, and will need to be verified in future trials.

Averaged across all varieties and lines, grain plumpness decreased with additions of fall and spring N fertilizer (Fig. 2A). On the average, adding 50 lbs N/acre in the spring decreased plumpness from 59 to 49%. One likely explanation for these results is that tillering increased with increased N levels, resulting in higher yields, but smaller kernels per tiller.

Important malting barley quality parameters include malt extract percentage, alpha-amylase activity, diastatic power, and plumpness. Malt extract percentage decreased slightly with increasing levels of fall N (Fig. 2). Spring N application also caused a slight reduction in malt extract percentage. Despite these effects, increased N levels had a generally positive effect on alpha-amylase content and diastatic power. Fall fertilizer treatments had little effect on levels of alpha-amylase, but spring N applications increased alpha-amylase activity by 6.7 units (data not shown). Diastatic power increased in response to fall and spring N application (Fig. 2C). A maximum diastatic activity of 135 was obtained in plots that received 100 lbs N/acre in the fall and 50 lbs N/acre in the spring.

In general, ranks of genotypes for malting quality characteristics were fairly consistent across N levels, so only the averages across N levels are presented (Table 3). Stab 171 had the greatest plumpness, malt extract, and alpha-amylase content, and had

Table 3. Average malting quality of five winter barley lines across all nitrogen fertilizer treatments in Pendleton, Oregon, 2000-2001.

Lines	Plumpness (%)	Malt extract (%)	Alpha amylase (20°DU)	Diastatic power %(DSB)
Stab 7	43.4	79.4	56.3	120
Stab 47	52.8	77.7	54.6	111
Stab 113	64.9	79.0	51.1	102
Stab 171	66.5	80.7	57.0	74
88Ab536	42.7	78.5	51.0	125
Mean	54.1	79.0	54.0	107

relatively low turbidity. Unfortunately, this genotype had low diastatic power, and will probably not have acceptable quality for malting and brewing. Among the new lines, Stab 7 had the highest level of diastatic power (120), which was comparable to that of the standard check variety, 88Ab536.

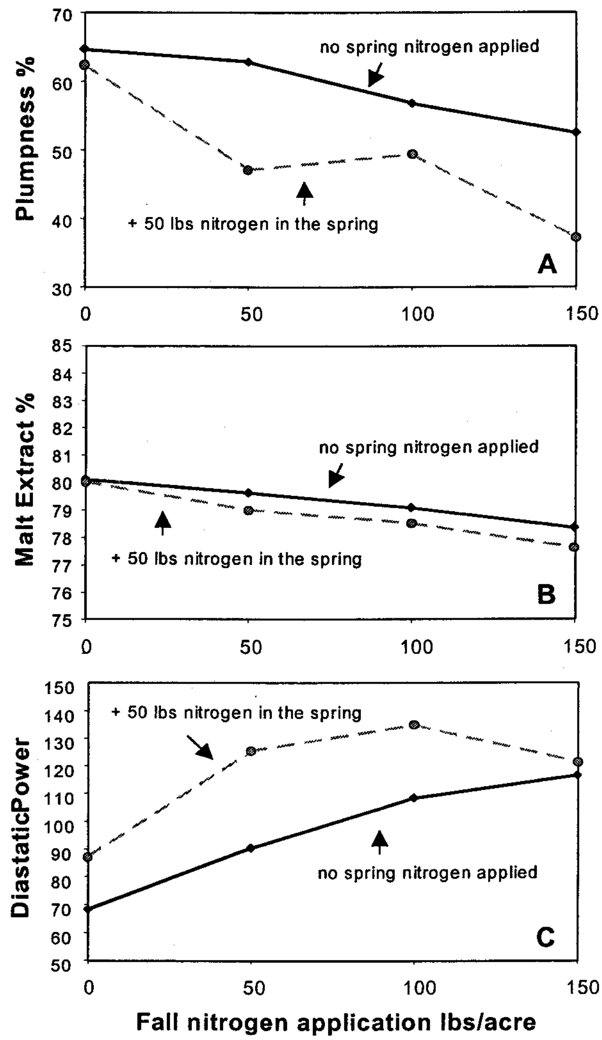

Figure 2. Average estimates of plumpness (A), malt extract (B), and diastatic power (C) of winter barley varieties and lines grown with different combinations of fall- and spring-applied N fertilizer. Data were obtained from a single replicate.

Summary

These three varieties and six lines of winter malting barley exhibited marked differences in plant height, grain yield, and grain protein and there were also significant differences in malting quality parameters between the malting lines. The application of N fertilizer increased the plant height, grain yield, and protein and had mixed effects on malting quality. These are preliminary results based on only 1 year of field trials but these results indicate that winter malting barley can be produced in the Pendleton area with acceptable yields and quality.

Acknowledgements

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EFFECTS OF HEADER MODIFICATIONS ON GARBANZO BEAN HARVESTING LOSSES

Mark C. Siemens, Mary K. Corp, and Robert F. Correa

Abstract

Due to the lack of specialized equipment, harvesting losses of garbanzo beans (*Cicer arietinum* L.) can be excessive as compared to other major crops like wheat, corn, and soybeans. This study was conducted to determine if recently developed header technologies would reduce harvesting losses. Six different combine header configurations were investigated on a field site that yielded approximately 1,000 lb/acre during the 2001 crop year. Equipment evaluated in the study included two types of knife guards, two guard attachments, a stripper header, and two types of pickup reels. Depending on the header configuration used, harvesting losses ranged from a low of 11 percent to a high of nearly 26 percent. Double density guards were found to reduce losses by 45 percent (116 lb/acre) as compared to single density guards. Short and long plastic fingers, which attach to specially made double density knife guards, did not affect combine header losses, total loss, or yield when compared to the standard knife guard without the attachments. The experimental air reel tested reduced header losses by 30 percent (45 lb/acre), but this difference was not statistically significant ($P = 0.05$). The stripper header had the highest losses (290 lb/acre) and least combine yield (693 lb/acre), but due to the improper header height used, the results found in this study may not accurately reflect stripper header performance. Header losses were nearly identical to total combine losses for all experiments, indicating that header loss is the dominant factor in harvesting losses for garbanzo beans and that threshing, separating, and cleaning losses are minimal. The losses reported in this study may be higher than conventional field losses due to the late harvest date and the improper header height used. They do, however, suggest that garbanzo bean harvesting losses can be economically significant and that header configuration can dramatically affect harvesting losses.

Key Words
Harvest loss, combine performance, harvesting technology, chickpea, garbanzo

Introduction

One of the problems associated with the economic viability of garbanzo beans (*Cicer arietinum* L.) and other specialty crops is the lack of specialized equipment needed to seed, harvest, and process the crop in a cost effective manner. Harvesting losses for major crops like wheat, corn, and soybeans are typically less than 7 percent (Hunt 1977, Doane Information Services 1981); however, when conventional equipment is used to harvest garbanzo beans, harvesting losses can be as high as 25 percent (M.C. Siemens, unpublished data, 2001). Primary Sales of Australia[1] manufactures plastic fingers (Fig. 1) that attach to specially made double density knife guards and have been used to significantly reduce header losses for lupin, a legume crop with short stature similar to that of garbanzo beans (G. Riethmuller, personal communication,

[1] Reference to a product or company is for specific information only and does not endorse or recommend that product or company to the exclusion of others that may be suitable.

2001). These devices come in a variety of shapes and sizes and are designed to support plants from below and prevent them from falling off the front of the header. Riethmuller (1995) reported additional technologies that were shown to reduce header loss for legume crops. These devices include double density knife guards and air reels. Double density guards reduce the distance the plant is moved prior to being cut, since they have twice as many cutting surfaces per unit length compared to single density guards. This limits plant shaking and therefore cutter bar harvesting losses. Air reels reduce shatter loss by delivering the crop to the header with a blast of air rather than mechanically with bats or fingers. It is expected that these devices will reduce garbanzo bean harvesting losses, but they have not been thoroughly evaluated in the Pacific Northwest. To address this, a research study was initiated to investigate the effectiveness of these devices relative to a conventional header equipped with a bat reel and single density guards.

Objectives

The objectives of this study were to:

1. determine garbanzo bean header loss from various header configurations, and

2. evaluate the economic implications of header modifications for the garbanzo bean grower.

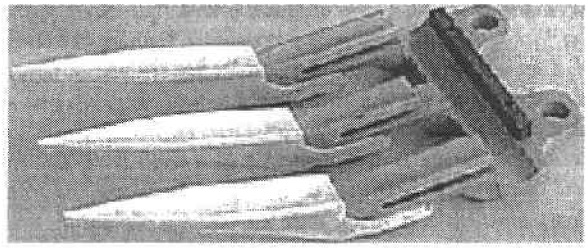

Figure 1. Double density guard with plastic finger attachment.

Methods

The effect of various types of header configurations on garbanzo bean harvesting losses was investigated during the 2001 crop year. Two types of knife guards, two guard attachments, a stripper header, and two types of pickup reels were examined in the study. This resulted in six unique treatments (Table 1). The two types of knife guards tested included single density guards with individual guards spaced 3 in apart and double density guards with 1.5 in guard spacing. Single density knife guards were mounted on a John Deere 7700 combine equipped with a 22-ft platform and a bat reel header. The double density guards were tested on a Wintersteiger plot combine with a 5.5-ft-wide draper type platform. This platform was also used to test two types of the previously mentioned plastic finger guard attachments that mount on specially designed double density knife guards.

The two guard attachments evaluated included short and long finger attachments that measure 5 in long by 0.75 in wide and 15.75 in long x 2 in wide respectively (Fig. 2). The short plastic finger attachments

Table 1. Description of equipment configurations and treatments examined for garbanzo bean harvesting loss study, Adams, Oregon, 2001.

Treatment number	Combine make	Header width	Header/reel type	Guard density	Guard attachment
		ft			
1	John Deere 7700	22	Bat reel	Single	None
2	Wintersteiger	51/2	Bat reel	Double	None
3	Wintersteiger	51/2	Air reel	Double	None
4	Wintersteiger	51/2	Air reel	Double	Short fingers
5	Wintersteiger	51/2	Air reel	Double	Long fingers
6	Gleaner F-Series	12	Stripper	None	None

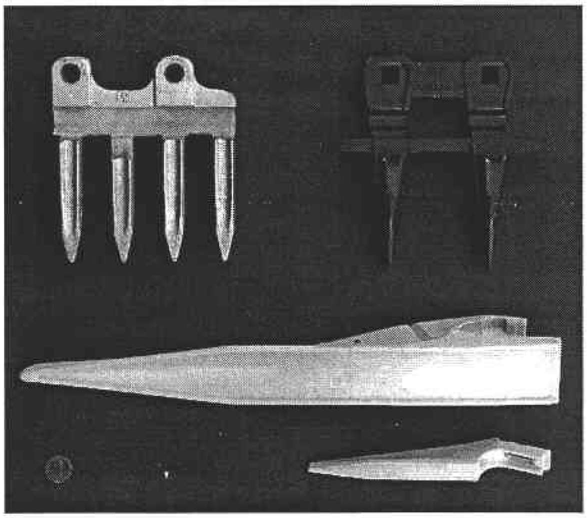

Figure 2. Single and double density knife guards and short and long plastic finger guard attachments.

were mounted on each double density knife guard according to the manufacturer's instructions. Each long finger guard attachment fits over two double density knife guards and were mounted on the header with one knife guard between each plastic guard attachment.

Three types of crop gathering devices were tested including a bat reel, an air reel, and a stripper header. Conventional bat reels were evaluated on the previously mentioned John Deere 7700 combine with a 22-ft-wide platform and on the Wintersteiger plot combine with a 5.5-ft-wide platform. The air reel is an experimental unit designed and developed by the USDA-ARS in Pendleton, Oregon for use on a Wintersteiger plot combine. The device was patterned after commercially available air reels and is principally comprised of a 5-in-diameter aluminum tube that serves as the main plenum, a Gandy impeller blower, flexible tubing, and a 5.5-HP Honda engine (Fig. 3). Extending from the main plenum are 1-in inner diameter tubes spaced 10 in apart, which direct streams of air towards the header during operation. The stripper header evaluated was a 12-ft-wide,

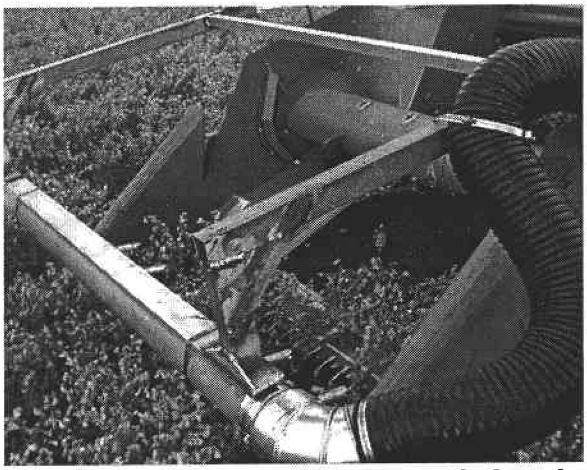

Figure 3. Experimental air reel attached to the header of a plot combine.

Shelbourne Reynolds model mounted on an F-series Gleaner combine.

The study was conducted at the Columbia Basin Agricultural Research Center near Adams, Oregon on a field that was planted to 'Sinaloa' garbanzo beans on April 24, 2001. A John Deere 9400 deep furrow drill with 10-in row spacing was used to plant the crop at a rate of 150 lb/acre. Inoculum and 75 lb/acre of starter fertilizer (16-20-0-14) were mixed with the seed at planting. Weed control consisted of a preplant application of glyphosate (24 oz/acre) and trifluralin (1.5 pt/acre) incorporated to a depth of 3 in with a cultivator.

Test plots, 100 ft in length, were laid out in a completely randomized block design with 5 replications and 5 treatments in each block. The sixth treatment, the JD 7700 combine with single density guards and a bat reel, was tested on an area immediately adjacent to the blocked plot area due to limitations in available plot area. Prior to conducting the combine harvest loss portion of the study, plants were manually collected from each plot from a sample area measuring 3.28 ft long by 3.33 ft wide (4 rows). The plants were later threshed by hand to determine harvestable yield. Also, two harvest loss sample areas were established in each plot

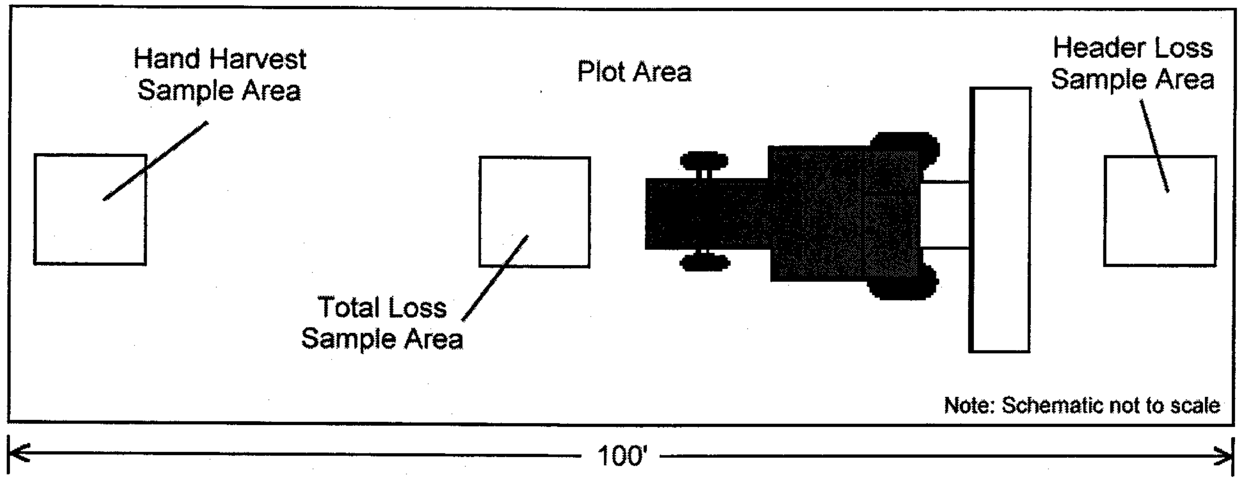

Figure 4. Sample area locations for hand harvest, combine header loss, and combine total loss for harvesting loss study.

and marked with paint, one near the middle of the plot and the other close to the end of the plot (Fig. 4). Sample areas measured 3.28 ft long by 3.33 ft wide (4 rows). Pods and seeds from each of these areas were collected, threshed, and weighed to determine preharvest loss. The first sample area near the middle of the plot was used to determine total harvesting losses, which includes header losses and machine losses due to threshing, separating, and cleaning. The second area near the end of the plot area was used to determine header losses. Header losses were determined by running the combine at operating speed to the end of the plot and then stopping abruptly. With the combine stopped, the residue remaining in the combine discharged out of the rear of the combine into an area behind and outside of the sample area. After harvesting the plot areas, pods and seeds in the sample areas were collected manually, threshed and weighed to determine header and total harvest loss. Combine grain samples were collected to determine combine yield.

Results

During the experiment, two problems were encountered that may have impacted the study's results. First, while harvesting with the Wintersteiger combine, it was observed that cut plant material lodged on the outside edges of the header and would not feed properly into the machine. The plot combine's header is designed and works well for wheat, but for short stature crops like garbanzo beans, the belt feeding mechanism is too narrow and the baffling too steep to properly feed the cut crop. As a result, using this header probably caused excessive loss as compared to using one with a different geometry. The other major problem encountered was the tall ridges of soil between crop rows that were formed by the deep furrow drill used to seed the crop. These soil ridges prevented the combine operator from being able to lower the header to the proper operating height and therefore also caused atypical harvest losses.

Table 2. **Average[1] combine yield, combine losses, and hand harvest yield of garbanzo beans in 2001, Adams, Oregon.**

Yield source	Yield
	lb/acre
Combine grain	826
Combine losses	169
Total harvestable grain	995
Hand harvest grain	1,010

[1] Sample size n = 30.

Due to the late harvest date of September 5, 2001, preharvest losses were high and averaged nearly 350 lb/acre. Over all treatments, the average combine yield was 826 lb/acre, while the average total combine loss was 169 lb/acre. The sum of these two, 995 lb/acre, reflects the total harvestable grain yield and compares favorably to the hand harvested grain yield of 1,010 lb/acre (Table 2). This result suggests that plot and sample size were sufficiently large to obtain accurate results.

The effect of guard type, guard attachment, and header type on garbanzo bean header loss, total combine loss, combine yield, value of lost crop, and cost of modification are shown in Table 3. Compared to single density guards, the double density guards reduced total combine harvesting losses from 255 lb/acre to 139 lb/acre, or 45 percent. This difference of 116 lb/acre was statistically significant at the 95 percent confidence level. According to Ferrel (2002), garbanzo bean prices typically average between $0.18/lb and $0.23/lb and have fluctuated from a low of $0.14/lb to a high of $0.47/lb over the last 15 years. Assuming a historically low, but current price of $0.15/lb (G.D. Ferrel, personal communication, 2002), reducing losses by 116 lb/acre would represent a savings of $17.40/acre. Depending on the manufacturer, double density guards cost between $30/ft and $70/ft of header width. The higher cost of $70/ft is for the special double density guards that accommodate the plastic finger attachments, while the lower cost of $30/ft is for standard double density

Table 3. Effect of header configuration on combine header loss, total loss, combine yield, lost crop value, and modification cost for garbanzo beans in 2001, Adams, Oregon.

Treatment	Header loss	Total loss	Combine yield	Value of crop loss[1]	Modification cost[2]
	lb/acre	lb/acre	lb/acre	$/acre	$/ft
Guard type					
Double density	---	139 a	807	21	30-70
Single density	---	255 b	---	38	---
Guard attachment					
None	107 a[3]	102 a	873 a	16	---
Long	125 a	116 a	868 a	18	41
Short	236 a	126 a	890 a	19	9-18
Header/reel type					
Air reel	107 a	102 a	873 a	16	8,900
Bat reel	160 a	139 a	807 a	22	---
Stripper	290 b	281 b	693 b	43	30,000[4]

[1] Value is average of header loss and total combine loss multiplied by $0.15/lb.
[2] Modification cost for replacing single density knife guards and bat reel with alternative indicated (a 30-ft header width is assumed).
[3] Within columns and treatment category, means followed by the same letter are not significantly different by Duncan's new multiple range test (P = 0.05).
[4] Trade in value of 30-ft bat reel header not accounted for in this estimate.

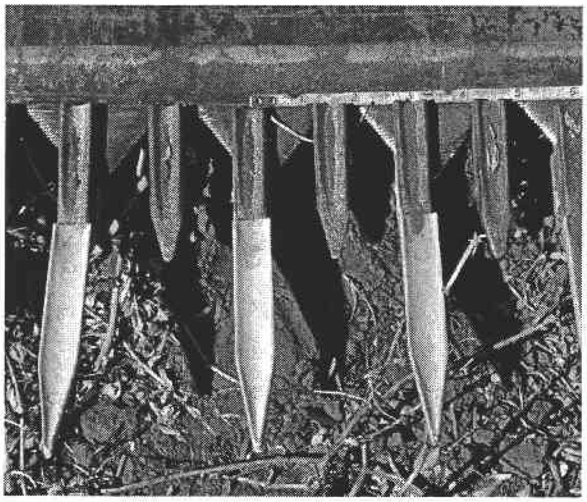

Figure 5. Short plastic finger attachment mounted on every other double density knife guard.

guards. Assuming this reduction in losses of 116 lb/acre would carry over to a commercial field, the $30/ft double density guards mounted on a 30-ft header would pay for themselves on as few as 50 acres.

Compared to the treatment where no guard attachments were used, the long plastic finger attachments had little effect on header loss, total loss, or combine yield and no statistically significant differences were found. Within treatments, total combine losses were similar (within 9 lb/acre), but lower than header losses, indicating that combine threshing, separating, and cleaning losses were insignificant when compared to header losses.

The header loss data were consistent and reasonable with the exception of one trial where the short finger attachments were used. In this trial, header losses of 236 lb/acre were found and were nearly twice as high as the total combine harvest losses of 126 lb/acre. This unexpected result can be explained by the fact that as the combine moved across the field, the density of plastic fingers was such that the crop was pushed towards the end of the plot, rather than fed into the combine. After harvesting two replications with this configuration, the plastic finger density was halved by removing every other plastic finger (Fig. 5). In subsequent trials, crop feeding improved substantially and header losses were reduced to values that were comparable to total combine losses. Consequently, header loss sampling error over all replications was high and no statistically significant differences in header losses were found between trials with different guard attachments. A separate analysis was conducted comparing just the long finger attachment header losses with the no finger attachment header losses because of this high header loss sampling error. Again, no statistically significant differences between treatments were found. Although measured header losses were higher when the short plastic fingers were used, total harvesting losses of 126 lb/acre and combine yields of 890 lb/acre were similar to and not statistically different from the total loss and combine yield values found in trials where the long fingers or no attachments were used.

Despite finding no significant reduction in harvesting loss, it is the author's opinion that the short finger attachments have the potential to reduce losses in certain garbanzo bean harvesting conditions. They may also be economically feasible given their relatively low cost ($9/ft if used on every other guard). The long plastic fingers were considered to be oversized and too expensive ($41/ft) to show much promise of improving garbanzo bean harvesting efficiency, either mechanically or economically.

Compared to the conventional bat reel header and stripper header, the air reel had the lowest header loss (107 lb/acre), the lowest total combine loss (102 lb/acre), and the highest combine yield (873 lb/acre). Although this represents approximately 30 percent less loss than the bat reel header, these differences were not statistically significant. Use of the stripper header resulted in significantly higher losses (300 lb/acre) and lower combine yields (700 lb/acre). A large percentage of these losses was probably due to operating the header too high rather than at the recommended setting. Therefore, these results may not accurately reflect stripper header harvesting performance.

Conclusions

Garbanzo bean harvesting losses can be high and of significant economic importance to growers. Depending on the header configuration used, harvesting losses ranged from a low of 11 percent to a high of nearly 26 percent. Double density guards reduced losses by 45 percent (116 lb/acre) compared to single density guards. Double density guards are commercially available for $30/ft and would pay for themselves in less than 50 acres, assuming a loss reduction of 116 lb/acre, a 30-ft header, and garbanzo beans priced at $0.15/lb. Short and long plastic fingers, which attach to specially made double density knife guards, did not affect combine header loss, total loss, or yield compared to the standard double density knife guard without any attachments. It is the author's opinion that the short plastic fingers may be beneficial in certain harvesting conditions, while the long plastic fingers are oversized for garbanzos and hold little promise for improving garbanzo bean harvesting efficiency. The experimental air reel reduced header losses by 30 percent (45 lb/acre) compared to a bat reel, but this difference was not statistically significant. The stripper header had the highest losses (290 lb/acre) and least combine yield (693 lb/acre) of any header tested, but due to the improper header height used, the results found in this study may not accurately reflect stripper header performance. The losses reported in this study may be higher than conventional field losses due to the late harvest date and the improper header height used. The results should therefore be interpreted with some caution. They do, however, suggest that garbanzo bean harvesting losses can be economically significant and that header configuration can dramatically affect harvesting losses. Further testing of these devices is planned for 2002.

Acknowledgment

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References

Doane Information Services. 1981. Facts and figures for farmers. Doan Information Services, St. Louis, MO.

Ferrel, G.D. 2002. Garbanzo bean production guide. Blue Mountain Seed, Inc., Walla Walla, WA.

Hunt, D.R. 1977. Farm power and machinery management. The Iowa State University Press, Ames, IA.

Riethmuller, G. 1995. Lupin harvesting modifications. Farmnote No. 19/95. Chief Executive Officer, Department of Agriculture, Western Australia, Bentely, Western Australia, Australia.

ECONOMIC IMPACT OF HESSIAN FLY ON SPRING WHEAT

Richard Smiley, Ruth Whittaker, Jennifer Gourlie, Karl Rhinhart, Erling Jacobsen, Sandra Easley, and Kimberlee Kidwell

Abstract

Economic damage caused by Hessian fly was quantified on three spring wheat experiments near Pendleton, Oregon during 2001. Genetic resistance or an insecticide each led to a doubling of grain yields for susceptible varieties, and improved grain market grades by up to two grades; e.g., test weight was increased as much as 2.8 lb/bu. Hessian fly therefore caused damage in excess of $70 per acre (20 bu/acre x $3.50/bu) without considering price discounts for reduced market quality. Genetic resistance is available at no additional input cost to the grower, compared to costs incurred through the use of chemical insecticides. The biology and control of Hessian fly are also summarized.

Key Words
Hessian fly, wheat, genetic resistance, root lesion nematode, insecticide.

Introduction

Hessian fly (*Mayetiola destructor*) is one of the most intractable insect pests of wheat in the United States (Morrill 1995). This insect causes economic damage to susceptible wheat varieties in Oregon during 1 of every 2 or 3 years. Spring wheat is much more heavily damaged than winter wheat, and both are subject to especially heavy damage in high-residue and annual cropping systems (Fisher et al. 1981, Pike and Antonelli 1981, Pike et al. 1993). Hessian fly adults are small mosquito-like flies with a life span of approximately 2 days. During that brief time they mate and the female lays about 200 eggs in the grooves on the upper side of wheat leaves. Eggs hatch and small larvae move along the groove to the leaf sheath and then to comparative safety between the leaf sheath and stem. Larvae suck sap from the stem above the leaf base and inject a toxin that stunts tillers and weakens the stem at the node where feeding occurred. The over-wintering and over-summering stage is a puparium that looks like a flax seed, located under the leaf sheath and just above a stem node. Damaged tillers often lodge at maturity. Even without lodging, Hessian fly-damaged plants produce less grain with reduced test weight compared to healthy wheat plants.

The Hessian fly is a cool-season insect with a life cycle that is heavily influenced by weather. Outbreaks occur sporadically and very rapidly. Flights of adults occur in the Pacific Northwest (PNW) at least three times annually, once during the autumn and twice during the spring. The flight during the autumn typically occurs before mid-October; however, if late summer rain occurs there may be two flights during the autumn instead of the usual one flight. The first spring flight occurs after the mean temperature reaches 45-50°F. A second flight occurs during late May or June. Four to eight biotypes (races) of the Hessian fly occur in the PNW (Ratcliffe and Hatchett 1997; Ratcliffe et al. 2000; Dr. Steve Clement, USDA-ARS, Pullman, WA, personal communication 2001).

Experiments in the Oregon State University (OSU) plant pathology program at Pendleton provided opportunities to quantify economic damage caused by Hessian fly on spring wheat during crop year 2001. None of the experiments were designed for this purpose. Portions of two experiments are summarized to illustrate the impact of Hessian fly on spring wheat production.

Methods

Genetic Resistance

An experiment was designed to examine spring wheat cultivars and advanced breeding lines for differences in genetic resistance to Fusarium crown rot (Fusarium foot rot; *F. pseudograminearum*). The experiment was planted onto summer fallow following a winter wheat crop harvested during 1999 at the OSU Columbia Basin Agricultural Research Center (CBARC) at Pendleton. Dr. Kimberlee Kidwell (Washington State University [WSU]), who emphasizes selection for resistance to Hessian fly in her spring wheatbreeding program, provided 22 wheat entries for this experiment. Precipitation for the crop year (September 2000 through August 2001) was 16.5 inch at this site.

Wheat was planted into 5- by 20-ft plots with a John Deere HZ deep-furrow drill equipped with a cone-seeder and four openers spaced at 14 in. Each wheat entry was planted with and without supplemental inoculum consisting of five isolates of *F. pseudograminearum* collected from infected wheat crowns in Oregon and Washington. Procedures used for preparing and dispensing the fungal inoculum are not described since responses to Hessian fly damage are only reported for non-inoculated plots. Wheat seed was treated with benomyl (Benlate 50W; 0.72 oz/cwt) in accordance with accepted procedures to examine varietal responses to Fusarium crown rot. On March 20, wheat was planted at 25 seeds/ft^2 and 2.75-in depth into moist soil. Temperature in the seed zone at planting time was 52°F. The experimental design (as adjusted to exclude inoculated plots) was a randomized complete block with four replicates. Hessian fly damage was noted during June. Samples were collected and plants were scored positive if at least one puparium was detected. Prematurely ripening (whiteheads) and total heads per row were counted in July and grain was harvested during August.

Variety x Insecticide Interaction

An experiment was designed to determine if root lesion nematodes cause economic damage. Spring wheat was planted into annually cropped fields at three locations, two in Umatilla County and one in Sherman County. The Sherman County experiment is not included in this report because drought confounded experimental variables and Hessian fly infestations were lower (30 percent of plants contained puparia) than at the other two locations. Experimental sites for this report include the CBARC, 8 miles northeast of Pendleton, and a commercial field (Mary Ann [Hill] Davis), 8 miles southeast of Pendleton. Each site is planted annually without tillage. Spring wheat followed 2 years of winter wheat at CBARC, and followed 1 year of canola that followed winter wheat at the Hill Farm. Precipitation for the crop year (September 2000 through August 2001) was approximately 16 inch at these sites.

Three spring wheat varieties in this experiment were selected because they are either resistant ('Krichauff' and 'Sunvale') or susceptible ('Machete') to root lesion nematodes in Australia. One PNW variety ('Westbred 926', Western Plant Breeders) and one from Mexico ('Opata 85'; International Maize and Wheat Improvement Center [CIMMYT]) were included for comparison. 'Westbred 926' is known for having resistance to Hessian fly (Wash. State Crop Improvement Assoc. 2001 Certified Seed Buying Guide). Each variety was planted with or without Temik® 15G (Rhône-Poulenc) to assist in interpreting potential damage by nematodes. Aldicarb (Temik 15G) is an insecticide/nematicide that is not registered for use on wheat; all grain was therefore destroyed after harvest data were collected. Wheat was planted on March 20 into 5- by 20-ft plots with a John Deere HZ deep-furrow drill equipped with a cone-seeder and four openers spaced at 14 in. Temperature in the seed zone was 54°F at the time of planting. Temik was dispensed with the seed and applied at a rate of 25 lb/acre. Seed was treated with RTU Raxil-Thiram (Gustafson LLC). Starter fertilizer (mixture of 16-20-0-14) was metered from a Gandy box (at 10 lb N/acre) and was banded 1 inch below the seed. The experimental design was a split plot with wheat cultivar as the main plot and Temik treatments (plus or minus) as subplots in blocks replicated three times. Plants were evaluated for diseases during June, at which time it was noted that many plants were infested with Hessian fly. Plants were scored positive if they contained one or more puparia per plant. Grain was harvested during August.

Results and Discussion

Genetic Resistance

Wheat entries in this test had highly divergent levels of resistance to Hessian fly, ranging from none to 100 percent. Entomologists score this insect more precisely on the basis of numbers of puparia per infested tillers, rather than presence or absence of one or more puparia per whole plant. That precise procedure was beyond the scope of work in our pathology program. Plant growth and grain yield were strongly reduced by Hessian fly (Table 1).

Table 1. Influence of Hessian fly on development of whiteheads, grain yield, and grain quality in spring wheat varieties and breeding lines at Pendleton, Columbia Basin Agricultural Research Center, during 2001.

Wheat entry	Plants with one or more puparia	White-heads	Grain yield	Test weight	Market grade
	percent	*percent*	*bu/acre*	*lb/bu*	*US No.*
Macon	0	3	50	58.3	1
WA 7894	0	2	43	59.1	1
WA 7877	3	1	57	58.7	1
Zak	5	2	58	57.5	2
WA 7892	20	1	42	57.9	2
WA 7906	23	1	51	58.3	1
WA 7893	23	1	49	58.9	1
Tara	23	1	43	58.6	1
WA 7905	35	1	54	58.9	1
WA 7887	35	1	52	58.9	1
WA 7890	48	2	56	57.4	2
WA 7904	73	3	42	56.7	3
WA 7902	85	7	18	59.4	1
WA 7910	90	5	39	58.8	1
WA 7886	90	3	31	56.0	3
Calorwa	90	8	19	52.7	5
Scarlet	93	3	34	58.3	1
WA 7900	95	5	19	57.1	2
WA 7883	98	6	31	56.3	3
WA 7901	100	5	36	54.8	3
WA 7907	100	3	33	57.4	2
WA 7914	100	4	26	58.3	1
LSD (p = 0.05)	37	4	9	2.7	-
CV (%)	47	93	16	3	-
P (>F)	<0.001	0.003	<0.001	0.001	-

Grain yield was highly correlated (Fig. 1A) with percentages of plants infested by Hessian fly ($p < 0.001$, $R^2 = 0.62$). The plot of data in Figure 1A suggested that there may be a critical level of infestation above which yield is depressed. This possibility was assessed by bracketing the data into quadrants and then moving the vertical and horizontal dividing lines to approximate the percentage at which yield declined rapidly (Fig. 1B). The bracketed data suggest that for this experiment, damage became particularly acute when at least one puparium was present in more than 80 percent of the plants.

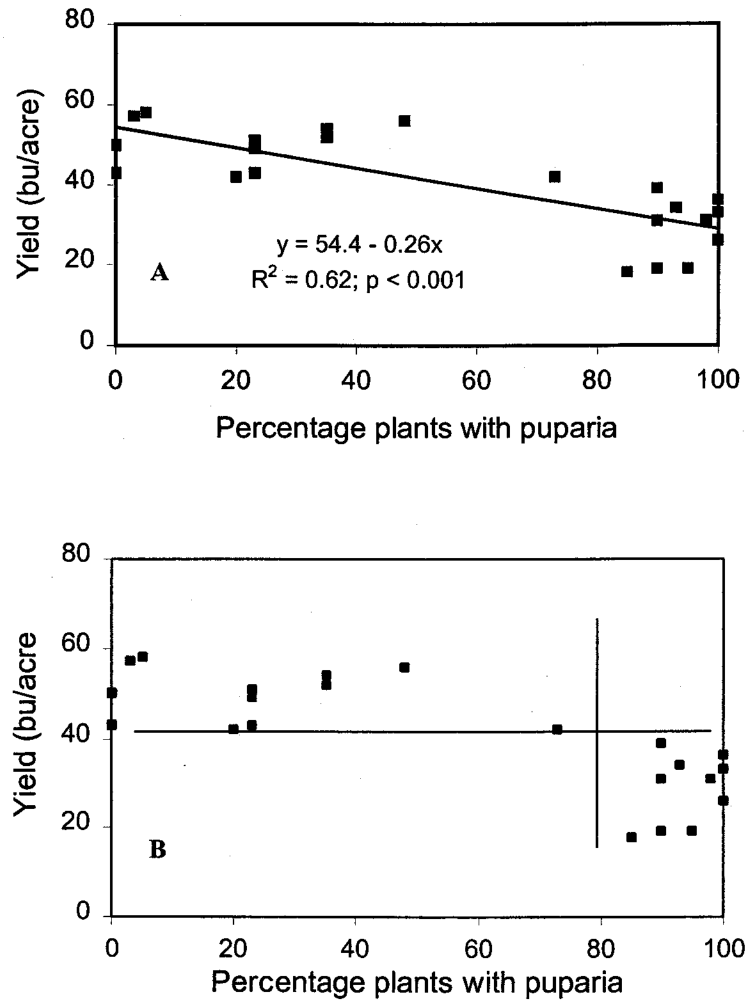


Figure 1. Effects of Hessian fly infestation on yield of 22 spring wheat varieties and lines at the Columbia Basin Agricultural Research Center, 2001; (A) linear regression of yield and level of infestation, (B) data bracketed to illustrate the infestation rate at which yield potential was strongly suppressed.

Test weight was also correlated with percentages of plants infested by Hessian fly (Fig. 2A). Bracketed data also indicated that test weights for some wheat entries became unstable and declined when more than 80 percent of plants were infested (Fig. 2B).

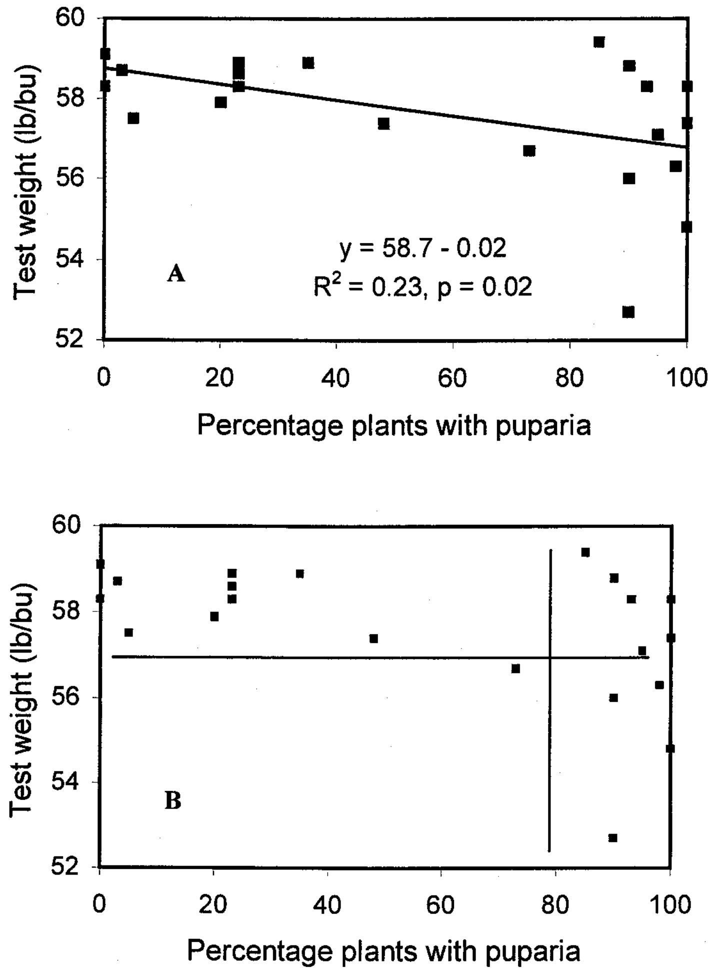
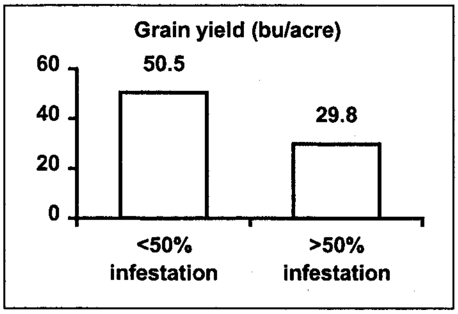


Figure 2. Effects of Hessian fly infestation on test weight of 22 spring wheat varieties and lines at the Columbia Basin Agricultural Research Center, 2001; (A) linear regression of test weight and level of infestation, (B) data bracketed to illustrate the infestation rate at which test weight became unstable and, for some entries, became strongly suppressed.

Another way to evaluate damage by Hessian fly is to compare average yields and test weights for entries having either more or less than 50 percent infested plants. Eleven entries with less than 50 percent infested plants yielded 69 percent more grain than eleven entries with more than 50 percent infested plants: 50.5 vs. 29.8 bu/acre (Fig. 3). Those same groups of plants had average test weights of 58.4 and 56.9 lb/bu, respectively, suggesting that Hessian fly had a strong limiting influence on grain quality



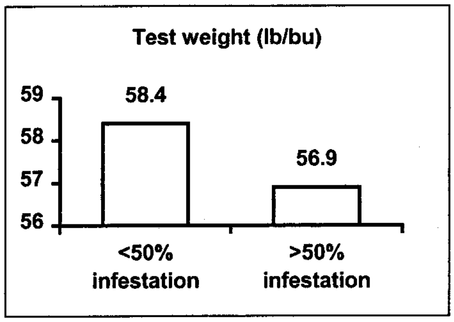


Figure 3. Comparison of grain yield and test weight for two groups of 11 spring wheat entries that had one or more Hessian fly puparia in less than or more than 50 percent of the plants, Columbia Basin Agricultural Research Center, 2001.

by reducing the wheat marketing grade from No. 1 to No. 3.

Whiteheads occurred on many tillers infested by Hessian fly. The regression equation and significance of this relationship were: yield = 50.02 bu/acre – 0.23 (percent infested plants); $r^2 = 0.41$; $p < 0.001$; $n = 120$. Although the regression includes wheat entries that differ in yield potential, the equation indicates that yield is reduced by nearly one-quarter bushel for each percentage of plants infested by the fly.

Variety x Insecticide Interaction

High levels of Hessian fly were recorded at both sites. A maximum of 12 puparia per tiller were observed at CBARC, where the fly caused extensive lodging. About 90 percent of the susceptible varieties contained at least one puparium under the leaf sheath of one or more tillers when plants approached maturity at both locations (Table 2). In contrast, 'Westbred 926' had no puparia in plants at the Hill Farm and only 10 percent of plants at CBARC had puparia. Percentages of plants with Hessian fly puparia were significantly different among varieties at both locations, with the primary difference being that 'Westbred 926' was resistant and the other four varieties were susceptible. Temik strongly improved foliar growth and tiller density throughout the season at CBARC, and reduced lodging at both locations at the end of the season. However, the insecticide/nematicide did not reduce final fly infestation rates, as assessed by puparia present on plants late in the growing season. This indicates that the insecticide did not greatly reduce over-summering or over-wintering populations capable of emerging for the autumn or spring flight.

'Westbred 926' had higher grain yields than the four other varieties. The other varieties were therefore grouped for this report. Yield improved 4 to 7 percent when Temik was applied to 'Westbred 926' (Table 2). Yields for the group of susceptible varieties were improved 44 percent and 105 percent by applying Temik at the Hill Farm and at CBARC, respectively. The yield benefit from genetic resistance was far less when Temik was applied (26 to 22 percent) than when not applied (45 to 60 percent).

The small positive yield response to Temik in 'Westbred 926' may have been from reduction in damage by nematodes, wireworm, other insect pests, or from incomplete resistance to Hessian fly biotypes present at these locations. However, Temik induces hormonal effects

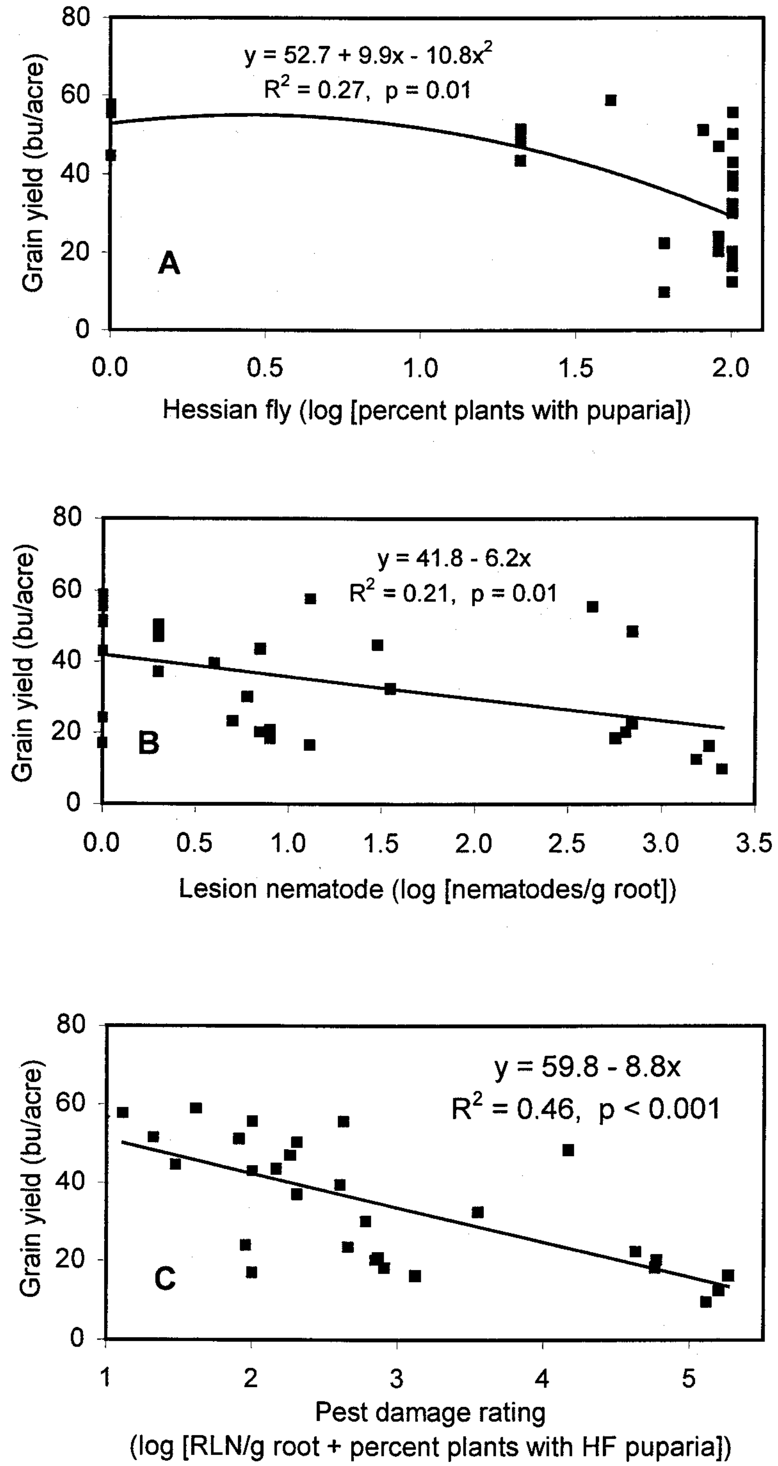


Figure 4. Relationship of spring wheat yield to Hessian fly infestation (A), root lesion nematode (B), and combined effects of damage from Hessian fly and lesion nematode (C), in a factorial that are capable of imparting small growth-enhancing effects in the absence of pests, which could confound interpretation of results. Nevertheless, it was very clear that the principal yield-promoting influence of Temik in this experiment was through pesticidal effects because differences in yield were far greater on the group of Hessian fly-susceptible varieties (44 to 105 percent) than the Hessian fly-resistant variety (4 to 7 percent).

Yield data in this factorial experiment with five varieties treated or not treated with Temik could be explained more fully by regressing yield against a combined damage rating function for Hessian fly plus lesion nematodes (Fig. 4C: 46 percent of yield explained) than for individual functions for Hessian fly (Fig. 4A: 27 percent of yield) or lesion nematode (Fig. 4B: 21 percent of yield). The combined function was improved to 50 percent when data were plotted on a log-log axis rather than the log-linear axis shown in Figure 4. We conclude that both pests were important constraints to grain yield in this experiment.experiment including five varieties planted with or without aldicarb insecticide at the Columbia Basin Agricultural Research Center, 2001.

Test weight also improved 2 to 3 lb/bu when Temik was applied to 'Westbred 926' (Table 2). U.S. grain marketing requirements are strongly influenced by test weight. Minimum standards for hard red spring wheat and white club are 58 lb/bu for No. 1, 57 lb/bu for No, 2, 55 lb/bu for No. 3, 53 lb/bu for No. 4, and 50 lb/bu for No. 5 (Subpart M, United States Standards for Wheat;

Table 2. Influence of Temik®, applied with seed at the time of planting, on numbers of Hessian fly puparia, grain yield, and test weight for resistant ('Westbred 926') and four susceptible (all others) varieties of spring wheat.

Location and varieties	Mature plants with one or more puparia		Grain yield			Grain test weight		
	Control	Temik	Control	Temik	benefit	Control	Temik	benefit
	percent	*percent*	*bu/acre*	*bu/acre*	*percent*	*lb/bu*	*lb/bu*	*lb/bu*
Hill Farm								
Westbred 926	0	0	29	31	7	55.5	58.3	2.8
Other 4 varieties	99	88	16	23	44	55.3	57.4	2.1
Krichauff	*100*	*80*	*21*	*34*	*62*	*55.1*	*58.2*	*3.1*
Machete	*97*	*90*	*10*	*13*	*30*	*53.6*	*54.8*	*1.2*
Opata 85	*100*	*90*	*20*	*25*	*25*	*56.6*	*57.6*	*1.0*
Sunvale	*97*	*93*	*14*	*19*	*36*	*55.8*	*58.8*	*3.0*
Reduced yield and test weight			45%	26%	-	0.2	0.9	-
CBARC								
Westbred 926	7	13	48	50	4	57.0	58.9	1.9
Other 4 varieties	91	92	19	39	105	54.7	56.1	1.4
Krichauff	100	73	26	51	96	57.0	55.7	-1.3
Machete	87	23	13	22	69	52.4	54.5	2.1
Opata 85	83	97	18	40	122	54.1	55.1	1.0
Sunvale	93	97	18	41	128	55.4	59.1	3.7
Reduced yield and test weight			60%	22%	-	2.3	2.8	-

http://usgmrl.ksu.edu/gqu/HWWQL/wheat_stds.htm). For all varieties except 'Machete', the market grade was improved at both locations by one or two grades through application of Temik. The benefit of genetic resistance was also clear. 'Westbred 926' ranked two to three market grades higher than all other varieties except 'Krichauff' (without Temik) and 'Sunvale' (with Temik) at CBARC. Benefits of resistance were less clear at the Hill Farm, where 'Westbred 926' and all other varieties graded U.S. No. 3 or lower in the absence of Temik, and all except 'Machete' were improved one or two grades by application of Temik.

Summary

Data from experiments near Pendleton indicated that spring wheat yields and test weights could have been improved by employing strategies for controlling damage from the Hessian fly during 2001. Overall yields were improved by about 20 bu/acre where either genetic resistance or chemical control strategies were employed. There did not seem to be a strong benefit from applying both genetic and chemical controls, although that was useful where nematodes as well as Hessian flies caused damage. The combination of genetic resistance and insecticide could also be important for protecting varieties with incomplete resistance to the biotypes of Hessian fly present. Likewise, test weights were improved by up to 2.8 lb/bu where damage from the Hessian fly was limited by genetic resistance or chemical control. The gross economic benefit attained by reducing Hessian fly damage equated to as much as $70 per acre ($3.50/bu x 20 bu/acre). There is an inherent advantage to using genetic resistance for insect control in that it comes at no additional input cost to the grower compared to costs incurred through the use of chemical control measures. Improved test weight attained by controlling fly damage would further influence income; test weights in damaged wheat were moved downward by as many as two marketing grades in our experiments.

Acknowledgements

We wish to thank Mary Ann (Hill) Davis for hosting an experiment reported in this paper. We also thank Drs. Steve Clement (USDA-ARS, Pullman) and Dave Bragg (WSU, Pomeroy) for providing helpful suggestions and editorial oversight. This research was funded through a Specific Cooperative Agreement between Oregon State University and USDA-Agricultural Research Service: CSA 58-5348-9-100 *"Control of Root Diseases of Wheat and Barley"*.

Precaution

Application of Temik® to small grain cereals is inconsistent with the product label, and therefore illegal for commercial wheat production. Application of Temik to wheat in this experiment was for research purposes only. All grain produced in the study was destroyed.

References

Pike, K., R. Veseth, B. Miller, R. Schirman, L. Smith, and H. Homan. 1993. Hessian fly management in conservation tillage systems for the inland Pacific Northwest. PNW. Conservation Tillage Handbook Series, Chapter 8, No. 15. 5 pages.

Fisher, G., K. Pike, R. Rickman, and D. Maxwell. 1981. The Hessian fly in Oregon. Oregon State University Extension Circ. 1093. 4 pages.

Morrill, W.L. 1995. Insect pests of small grains. APS Press, St. Paul, MN. 140 pages.

Pike, K.S., and A.L. Antonelli. 1981. Hessian fly in Washington. Washington State University Research Center, Pullman. 12 pages.

Ratcliffe, R.H., and J.H. Hatchett. 1997. Biology and genetics of the Hessian fly and resistance in wheat. Pages 47-56 *in* K. Bondari (ed.). New Developments in Entomology. Research Signpost, Scientific Information Guild, Trivandrum, India.

Ratcliffe, R.H., S.E. Cambron, K.L. Flanders, N.A. Bosque-Perez, S.L. Clement, and H.W. Ohm. 2000. Biotype composition of Hessian fly populations from the southeastern, Midwestern, and northwestern United States and virulence to resistance genes in wheat. Journal of Economic Entomology 93:1319-1328.

Management Strategies for Hessian Fly

Spring Wheat

Management practices for spring wheat include: (1) planting a fly-resistant variety, (2) controlling volunteer wheat and grass weeds from the time they germinate in the fall until the new crop is planted in the spring, (3) planting as early as possible, (4) rotating wheat with non-host crops such as legumes or canola, and/or (5) applying an insecticide at planting, either through a seed treatment or using a registered product in-furrow with the seed. Adapted resistant varieties currently available or in the certified seed increase process include the soft white spring varieties 'Wakanz', 'Wawawai', and 'Zak', as well as the hard red spring varieties 'Westbred 926', 'Hank', and 'Tara'. Washington State University's first hard white spring wheat variety release, 'Macon' (WA 7899) also is resistant to the Hessian fly. Insecticides currently registered for seed treatment include Cruiser® and Gaucho®. Insecticides registered for application in-furrow below or with the seed include Di-Syston®, Phorate®, and Thimet®. Damage to spring wheat is greater in high-residue or no-till seedbeds particularly if preceded by another susceptible crop. Hessian fly is less damaging to winter wheat, spring barley, and triticale than to spring wheat.

Winter Wheat

Although winter wheat is generally less affected than spring wheat, specific management practices for winter wheat may become required in some areas. Damage to winter wheat can be reduced by (1) planting after October 15, (2) controlling volunteer wheat and grass weeds through the summer, (3) reducing the level of surface residues from previous susceptible crops, (4) rotating with non-host crops such as legumes or canola, (5) planting a fly-resistant variety; and/or (6) applying an insecticide at planting either by treating seed or placing a registered product in the furrow with the seed. Winter barley and triticale are less susceptible than winter wheat.

All Wheat

Growers and crop advisors also must scout fields to evaluate the performance of varieties that are currently resistant to the Hessian fly. This fly occurs as a mixture of biotypes ("races"), which are either virulent or avirulent to individual genes for resistance in wheat. Deployment of new resistance genes is required to maintain levels of genetic resistance currently available. Four to eight biotypes are currently present in the PNW (Dr. Steve Clement, USDA-ARS, Pullman; personal communication, 2001). Several biotypes that are not present in high proportions of the total population are virulent to resistance genes currently deployed in resistant spring wheat varieties. A shift in dominance of biotypes, or the entry into the region by new biotypes could defeat the genetic resistance currently available. Wheat breeders and entomologists are well aware of this possibility and are working hard to identify biotypes and employ genes with resistance to current and newly emerging threats to the wheat industry.

ISOLATION AND IDENTIFICATION OF BACTERIA IN EASTERN OREGON AGRICULTURAL SOILS

Stephanie A. Boyle and Stephan L. Albrecht

Abstract

Because of their high occurrence and large diversity in the soil, the types of bacteria living in particular crop fields may have a significant impact on the quality of that soil and on the productivity of a crop. Isolating and identify soil bacteria is therefore important, but not always easy. Visual observations, under a microscope, of individual bacteria or their colony profiles are not always accurate or reliable. However, bacteria can be readily identified by their metabolic activity. A system, used in conjunction with a differential staining technique (Gram stain[1]), has been developed by BIOLOG® Inc. that tests a bacterium's ability to use different carbon compounds and identifies them based on utilization patterns. This method was used on 42 strains isolated from the CBARC long-term plots in Pendleton, OR. Sixteen strains were positively identified. Many of the strains were Gram-positive bacteria suggesting this type of bacteria makes up the majority of the culturable populations residing in the plots investigated. This observation is in contrast to many agricultural soils that are inhabited by predominately Gram-negative bacteria. The bacterium *Bacillus subtillis* was one of the species identified. This microorganism is reported to suppress disease-causing organisms in wheat crops.

Key Words
Long-term experiments, wheat, bacteria, gram stain, carbon substrate utilization

Introduction

Microbiologists currently estimate that only one percent of soil microorganisms have been observed (Sylvia et al. 1998). This small fraction points to the substantial diversity present in terrestrial habitats and the difficulties associated with identifying microorganisms, such as bacteria. Garland and Mills (1991) cite two major obstacles in the characterization of bacteria: small individual size and morphological similarity. Unlike plant and animal species that can typically be identified through careful visual observation, bacteria are not so easily distinguished. For example, two bacterial cells may look identical under a microscope, while further testing reveals the first capable of transforming nitrogen and the second of excreting a hormone that stimulates plant growth. Therefore, researchers must look beyond morphology to accurately differentiate bacterial species from one another.

Microbiologists have developed a variety of strategies to accurately identify bacterial species. Traditional identification requires extensive testing that includes staining and the inoculation of selective and determinant media (Benson 1998). Recently, a variety of

[1] Gram staining refers to bacterial smears treated with a series of solutions: crystal violet, Gram's iodine, isopropyl alcohol, and safranin. Because of the difference in cell wall compositions, these solutions react to stain the cells blue in the case of Gram-positive (GP) strains and red when the unknown is Gram-negative (GN). Gram staining allows bacteria to be quickly separated into groups, thus aiding in the identification (Benson 1998).

molecular identification procedures have been developed. These methods include the amplification of genetic material and—in some cases—the use of probes to detect targeted sequences. Whether traditional or cutting-edge, all of these techniques have unique problems associated with them. Some require large investments of time, while others depend on expensive tools. An alternative to these identification techniques, developed by BIOLOG® Inc. (Hayward, CA), uses microtiter plates[2] filled with a variety of sugars, each of which maybe a source of energy for microorganisms. When the added bacteria are able to use a particular carbon source, an oxidation-reduction dye changes the well from clear to purple. A reacted microtiter plate will contain a variety of clear and purple wells, and this pattern can then be compared against a known database. The BIOLOG® system was chosen for its relatively inexpensive cost and its ability to accurately identify organisms with minimal laboratory testing.

Testing an unknown strain in this system may yield several results. First, the bacterium can be positively identified if the utilization pattern matches a species included in the BIOLOG® software. If a resulting pattern does not match, a list of 10 similar patterns may indicate a species closely related to the unknown strain. At the very least, information on the metabolic potential of an unknown strain may limit the number of additional determinative tests that will be needed. The role of one bacterium in the soil community can sometimes be revealed without a species identification, simply by examining those carbon sources that the strain is able to use.

[2] Microtiter plate: 12.5 x 8.5 x 1.7 cm clear plastic tray containing 96 cylindrical wells. Each well is 1 cm in diameter, and wells are labeled 1-12 along the length of the tray and A-H along the width.

Biodiversity and microbial community structure are central to any agroecosystem. As management systems continue to evolve, they undoubtedly affect biodiversity, microbial community structure, and the important processes they control, such as soil quality and nutrient cycling. These processes in the dryland farming areas of the Pacific Northwest (PNW) are critical for agricultural stability and productivity. Because agroecosystems comprise a substantial amount of all ecosystems in the PNW, agriculture may be the most important ecosystem in preserving and maintaining biodiversity. Yet it is unclear how agricultural management practices affect biodiversity and ecosystem structure.

The goal of this research was to isolate several bacterial strains from soil collected in the Columbia Basin Agricultural Research Center (CBARC) long-term plots, identify these strains, and develop a database of bacteria present in eastern Oregon agricultural soils. After bacteria were successfully identified, further literature searches were conducted to uncover their possible functions. The identification of local bacteria could provide important insights into the transformation of carbon, nitrogen, sulfur, and other nutrients. Additional long-term benefits of this research could include, discovering a biological control for soil-borne pathogens or detecting a beneficial strain that encourages plant growth.

Material and Methods

Soil was collected during summer 2000 and 2001, from the CBARC long-term plots (Rasmussen and Smiley 1994). Five long-term plots were sampled, including a grass pasture (GP), conventionally-tilled annual winter wheat (AWCT), no-till winter wheat (NT), wheat/pea (WP), and two treatments in a residue management experiment (CR). Both residue management treatments were in a wheat-fallow rotation, one with manure (CRM) and the other with no fertilizer and burned in September (CRFB). Using sterile collection techniques, cylindrical cores 2 cm in diameter were collected to a depth of 10 cm from four random locations.

Using dilution/plating methods, bacterial colonies were grown from composite soil samples. According to the procedure outlined in Holt (1984), sterile water was used to make dilutions of 1:10,000, 1:100,000 and 1:1,000,000. These dilutions were spread on nutrient agar plates and incubated at 30° C for 48 hours. Bacteria from well-defined colonies were then transferred to fresh plates using a sterile needle. An isolate was considered to be a pure strain after three consecutive transfers without evidence of other microorganisms, and purity was verified by Gram staining and examination of cells at 1000x magnification. Cellular morphology was also examined at this time; most isolates could be characterized as either rod or coccus. The term rod denotes cells appearing as ovals either individually or in chains of five to ten. Coccus shape cells appear round and usually occur unconnected. If an isolate was Gram positive, then an additional stain, performed after 72 hours, tested for the presence of endospores (Benson 1998).

After collection of preliminary data, each isolate was tested in the BIOLOG® system. Isolates were streaked on Biolog Universal Growth (BUG™) agar (57 g/L) and grown for 24 hours at 30° C. A cell suspension was then created by transferring growth from the plates into tubes of inoculating fluid. To ensure an even distribution of cells throughout the suspension, tubes were gently shaken. Prior to the addition of cells, 100 microliters of 7 percent sodium thioglycolate solution was added to inoculating fluid, decreasing clumping. In some cases, clumping occurred in spite of thioglycolate addition. These problematic strains were grown on 25 percent BUG agar (13 g/ L), before creating a cell suspension. Microtiter plates were inoculated with uniform suspensions.

The pattern of carbon substrate utilization was observed at 4 to 6 hours and 24 hours. Any reading from the top left well (A-1) was subtracted from values on the other 95 wells, because it did not contain a substrate. Individual wells were characterized as positive, negative, or borderline, and patterns were compared against those of known bacteria. Statistical tests, built into the software, established the validity of any identification. A microtiter plate inoculated and incubated for 24 hours is pictured (Fig. 1).

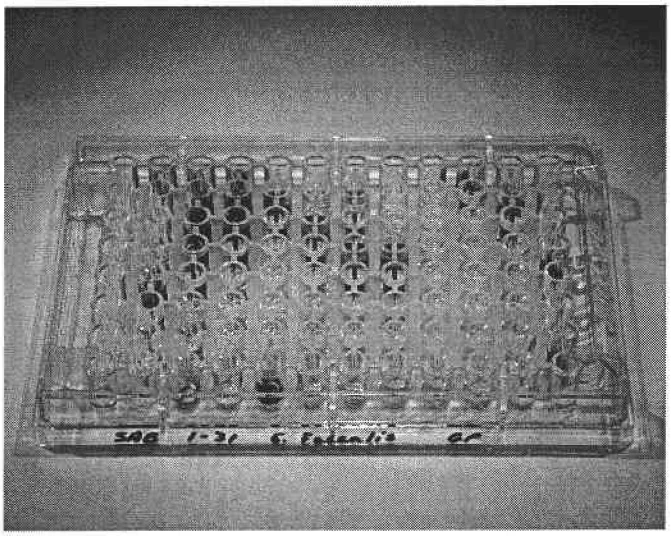


Figure 1. BIOLOG® microtiter plate inoculated with a bacterial strain and incubated to produce a carbon substrate utilization pattern, Columbia Basin Agricultural Research Center, 2000, 2001.

Results

A total of 42 strains were isolated, purified, and assigned lab identifications. Nine of these isolates were GN and the remaining 33 were GP. Seven GN and nine GP strains were positively identified (Table 1).

Most of the GP strains were characterized as rods, including 17 strains capable of forming endospores. Taxonomically, only three genera contain GP spore-forming rods: *Bacillus*, *Clostridium*, and *Sporolactobacillus*. The possible identity of unknown strains could be further narrowed to only *Bacillus* strains, given that members of the genus *Clostridium* are anaerobic and the genus *Sporolactobacillus* contains only one species. The six positively identified isolates are listed in Table 1.

Table 1. Bacteria identified using BIOLOG® system, Columbia Basin Agricultural Research Center, 2000, 2001.

Bacterial type[1]	**Sample location**[2]	**Genus**	**Species**
GP, SF	AWCT	*Bacillus*†	*amyloliquefaciens*
GP, SF	CRFB	*Bacillus*†	*halodurans*
GP, SF	CRFB	*Bacillus*	*subtilis*
GP, SF	CRFB	*Bacillus*	*circulans*
GP, SF	CRM	*Bacillus*	*maroccanius*
GP, SF	WPA	*Bacillus*	*subtilis*
GP	GP	*Aureobacterium*	*testaceum*
GP	CRM	*Staphylococcus*	*lentus*
GP	WP	*Arthrobacter*	*ilicis*
GN	GP	*Acinetobacter*	*genospecies 13*
GN	GP	*Chryseobacterium*	*scophthalmum*
GN	NT	*Alcaligenes*	*denitrificans*
GN	AWCT	*Pseudomonas*	*fluorescens biotype G*
GN	AWCT	*Listonella*	*pelagia*
GN	CRFB	*Burkholderia*	*glumae*
GN	CRM	*Stentrophomonas*	*maltophilia*

[1]Identifications were made using standard techniques, except if marked (†). Bacterial types include Gram positive spore-formers (GP, SF), Gram positive non-spore-formers (GP), and Gram negative (GN). [2]Sample locations are as follows: conventional-till annual wheat (AWCT), crop residue fall burned (CRFB), crop residue manure (CRM), wheat/pea (WP), grass pasture (GP), and no-tilled wheat (NT).

Two of the remaining GP strains were cocci and 14 were rods that did not form spores. One coccus was identified as *Curtobacterium*; however, the species could not be determined at this time. The other coccus produced a clear utilization pattern, but did not match any known organism. Because of clumping and false positives in the control wells, only three rods were positively identified (Table 1). Four of the non-spore-forming GP rods were particularly difficult to evaluate. They formed long chains of cells, and when observed at 1000x magnification, these chains appeared intertwined. These strains also had a tendency to be Gram-variable in cultures older than 48 hours. All clumped when added to inoculating fluid, never yielding a uniform suspension or positive identification.

Nine isolates were determined to be GN. All of these isolates were grown on BUG agar with added maltose (2.5 g/L); when added to inoculating fluid, they all formed uniform cell suspensions. Additionally, these isolates yielded clear patterns of utilization after 24 hours. Table 1 lists seven strains that produced patterns closely matching those of known species.

Discussion

The majority of bacteria isolated from CBARC long-term plots were GP, and approximately half of the GP strains had spore-forming capabilities. If these results are representative, it may mean that local soils are composed primarily of GP bacteria, some of which form endospores. Strains capable of forming spores may remain inactive in the soil during stressful times of year, including periods of drought or cold weather, and return to an active state during periods with more favorable conditions. The isolation techniques employed in this particular study may have inadvertently selected for spore-forming organisms, however, meaning that the ratio of GP to GN bacteria in the soil is still unknown. The isolated spore-formers may be culturable, while other types of bacteria, perhaps present in larger numbers, do not grow on nutrient agar. These spore-forming strains may also overwhelm other culturable strains when placed on nutrient-rich media.

Although this study did not conclusively determine the relative population size of *Bacillus* species, the identified strains indicated the presence of potentially beneficial bacteria in eastern Oregon soils. *Bacillus subtilis*, a relatively common soil bacterium, was isolated and identified from two different long-term treatments. One greenhouse study suggested a decrease in the wheat pathogen, take-all, and an increase in seedling growth when *B. subtilis* was added to soil (Ryder et al. 1999). *B. subtilis* is present in local soils, although the population size and contribution is not known. The confirmed presence of *Bacillus circulans* may also be of interest, because some strains are capable of weakly degrading cellulose (Holt 1984) and may play a role in the breakdown of residue.

Those GP strains that proved hard to culture may be actinomycetes. The order *Actinomycetales*, composed of bacteria capable of producing long branching hyphea similar to fungi, has been previously studied in soils and is known to be Gram variable. Some laboratory strains resembled actinomycetes in cellular configuration and even relatively young cultures were Gram variable. It may be possible to identify these strains in a future study by using a microtiter plate designed specifically for actinomycetes and filamentous fungi.

The identification of *Arthrobacter ilicis* demonstrated both the wide variety of genera that could be present in eastern Oregon soils and problems associated with accurately identifying bacterial strains. Members of the genus *Arthrobacter* have previously been found in soils and may compose a significant fraction of the aerobic bacterial population, but *A. ilicis* is described as a blight-causing organism in American holly (Holt 1984). Although the unknown strain had a utilization pattern similar to this known species and registered a positive identification, it is possible that the unknown strain was not *A. ilicis*. The unknown strain may resemble *A. ilicis*, but was not included in the current BIOLOG® database. Further testing is required to confirm identification.

Gram-negative strains proved easier to identify than the GP isolates, and results showed a potentially diverse soil population. Most of the GN strains could be identified because of low levels of clumping and clear utilization patterns. All genus level identifications were unequivocal, given current information on the habitats and morphological characteristics of known species. Various members of the genera *Acinetobacter*, *Chryseobacterium*, *Alcaligenes*, *Pseudomonas*, *Listonella*, *Burkholderia*, and *Stentrophomonas* have previously been found and studied in agricultural soils. *A. denitrificans* has previously been identified as a soil bacteria capable of reducing nitrate and nitrite in terrestrial ecosystems (Holt 1984).

The initial soil bacteria database suggested eastern Oregon agricultural soils support a diverse population of bacteria. It remains to be discovered, however, if Pacific Northwest cropping systems encourage the growth of certain bacterial populations. Given the abundance of bacteria in agricultural soils and their vital functions, it is important to determine what impact particular crops and cropping systems have on the structure of local communities. Identifying a small fraction of these bacteria proved to be a useful starting point, but more extensive research should be conducted before a clear bacteriological profile of our local soils emerges.

Summary

The isolation and identification of isolates indicated a wide variety of soil bacteria present in the CBARC long-term experiments. The BIOLOG® system proved useful in the identification of Gram-negative isolates, but less successful in the determination of Gram-positive strains. Some minor modifications to the identification procedure yielded limited success, but did not positively identify strains that continually clumped in suspension. Thirty-three of the 42 isolated strains were Gram-positive, suggesting the possible dominance of Gram-positive bacteria in local soils. Sixteen of the 42 were positively identified, including *Bacillus subtilis*, a common soil bacterium with potential benefits to Pacific Northwest wheat.

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References

Alexander, D.B. 1998. Bacteria and archea. Pages 44-71 *in* D.M. Sylvia, J.J. Fuhrmann, P.G. Hartel, and D.A. Zuberer (editors). Principles and Applications of Soil Microbiology. Prentice-Hall, Upper Saddle River, NJ.

Benson, H.J. 1998. Microbiological Applications: Laboratory Manual in General Microbiology. WCB McGraw-Hill, Boston.

Garland, J.L., and A. Mills. 1991. Classification and characterization of heterotrophic microbial communities on the basis of patterns of community-level sole carbon-source utilization. Applied and Environmental Microbiology 57:2351-2359.

Holt, J.G, editor. 1984. Bergey's Manual of Systematic Bacteriology. Vol. 1. Williams and Wilkins, Baltimore.

Rasmussen, P.E., and R.W. Smiley. 1994. Long-term experiments at the Pendleton Agricultural Research Center. 1994 Columbia Basin Agricultural Research Annual Report 933:14-20.

Ryder, M.H., Z. Yan, T. Terrace, A. Rovira, W. Tang, and R. Correll. 1999. Use of strains of *Bacillus* isolated in China to suppress take-all and rhizoctonia root rot, and promote seedling growth of glasshouse-grown wheat in Australian soils. Soil Biology and Biochemistry 31:19-29.

Sylvia, D.M., J.J. Fuhrmann, P.G. Hartel, and D.A. Zuberer (editors). Principles and Applications of Soil Microbiology. Prentice-Hall, Upper Saddle River, NJ.

STATEWIDE CEREAL VARIETY TESTING PROGRAM

Nathan Blake, John P. Bassinette, Russell S. Karow, Karl Rhinhart, and Steve Petrie

Abstract

Cereal grain was grown on more than 1 million acres in Oregon for the 2001 crop year. Cereal growers need timely wheat and feed grain performance data so that informed variety selection decisions can be made. Trials with wheat, barley, oat, rye, and triticale were located at 11 different locations representing major cereal production regions. Trial results are summarized and posted on the OSU Cereals Extension web site, published in extension newsletters, annual reports, and shared at field days and grower meetings.

Key Words
Triticum aestuvum, Hordeum vulgare, Avena sativa, Secale cereale, Triticum secale.

Introduction

The statewide cereal variety testing program as initiated in 1992. The objective of this program is to provide wheat and feed grain performance data, in a timely manner, to growers in all of Oregon's major cereal-producing regions so that informed variety selection decisions can be made.

In the 2000-2001 growing season, over 50 winter grain varieties were evaluated at 8 locations, and over 70 spring grains were evaluated at 11 locations across Oregon. The proportion of wheat and feed grain varieties tested was approximately two-thirds wheat and one-third feed grains. Varieties tested varied by location, but included a core set of varieties: those commonly used in the local area and advanced experimental lines. Russ Karow and John Bassinette coordinate the program. Nathan Blake manages the five Columbia Basin sites.

These five sites encompass dryland (Pendleton, Moro, Lexington) and irrigated (Hermiston, LaGrande) environments. Each site in the Columbia Basin was planted, managed, and harvested by the trial manager with cooperation from growers at off-station locations (Table 1).

Combine-harvested grain is transferred to the central team (Bassinette and Karow) who process the grain, analyze data, and provide results to extension agents, seed dealers, agricultural field representatives, and growers.

This article reports yield data, collected in 2001 and a compilation from 1999 to 2001, for the Columbia Basin sites. More complete data, including test weights, heading dates, and protein information, can be found on the Internet (www.css.orst.edu/cereals/) and in various extension publications.

Materials and Methods

All experiments were designed as a randomized complete block with three replications. Grain was sown at a rate of 20 viable seeds/ft^2 for dryland and 30 viable seeds/ft^2 for irrigated sites into plots at least 20 ft long by 5 ft wide. Seed weight (kernels/lb) and germination percentage were determined for each variety and used to determine the amount of seed to be sown. Among varieties, seeding rates ranged from

60 to 150 lb/acre to attain the desired plant population. Small plot equipment (drills, tractors, combines) was used to sow and harvest plots. Plots were managed using best management practices for each location.

Harvested grain from each plot was run through a Pelz rub-bar® seed cleaner. After cleaning, plot yield, test weight, protein, and moisture were determined on grain samples. Yields are reported on a 10 percent moisture basis and in 60 lb/bu for wheat and triticale and in lb/acre for barley. Test weight was based on a 1-quart sub-sample.

In addition to small-plot variety trials, large-scale winter wheat drill-strip trials have been conducted across the state for the past 7 years. Cooperators were provided with seed and with the assistance of local county agents, established side-by-side, non-replicated drill-strip plots in their fields. Strips were managed and harvested by the cooperator using commercial equipment and best management strategies for their area. Weigh wagons or weigh pads were used to obtain yield data. When possible, a 2-quart sub-sample was collected and used for test weight and protein determination. Results are reported in Bassinette et al. (2002a, b).

Results and Discussion

Tables at the end of this report contain yield information from 2001 trials as well as compilations of data from 1999 to 2001. Because year-to-year variability is often high, conclusions should not be made from a single year's data. Three-year averages are a better indication of how well a variety is suited to a location. For newer lines that have not been tested over multiple years, the 2001 data may help identify lines to watch in the future.

***Soft White and Club Winter Wheat** (Tables 2 and 3)*

'Rod' and 'Stephens' continue to be among the highest yielding varieties tested for the last 3 years at all locations in the Columbia Basin. Experimental line, OR939526 also continues to perform well. Grain yield of this line has been greater than or equal to all current varieties over the past 3 years. Overall quality is similar to 'Stephens' but test weight has been slightly lower. Jim Peterson, Oregon State University wheat breeder, has initiated a breeder seed increase of OR939526, which will be released in the next few years if it continues to perform well.

There was little difference between the newer club lines 'Coda', 'Hiller', and 'Temple'. However, across Basin locations, 'Coda' had the highest average yield over the past 3 years. 'Rohde' has performed well, but the newer club lines have the advantage of both stripe rust and foot rot resistance. WA7855 was included in the trials for the first time in 2001 and led all club yields. WA7855 is resistant to foot rot and stripe rust, but heads 2 days later than Madsen. WA7855 was released in September of 2001 under the name 'Chukar'.

***Winter Barley** (Tables 4 and 5)*

'Strider' and 'Kold' were the highest yielding winter barley cultivars for the 2000-2001 growing season. They also have the highest average yield among winter barleys over the last 3 years. While Scio has had above average yields at many sites, it tends to have lower test weight and is susceptible to stripe rust.

***Soft White and Club Spring Wheat** (Tables 6 and 8)*

'Wawawai' and 'Zak' were the highest yielding spring soft white entries averaged across all sites in 2001. 'Zak' is Hessian fly tolerant, has better end use quality than 'Wawawai', and is intended as a 'Wawawai' replacement. Over the past 3 years, (Table 8) 'Wawawai' and 'Alpowa' have been the highest yielding spring soft white lines in the Columbia Basin.

Among experimental lines, WA7902, (club type) was among the highest yielding lines across locations even when compared to other common soft white wheat. WA7902 was approved for pre-release in February 2001 with registered seed available by spring of 2003.

***Hard White and Hard Red Spring Wheat** (Tables 7 and 8)*

In 2001, across locations, WA7899 ('Macon') and ID533 ('Lolo') were the highest yielding hard white spring lines. Overall, grain yields of the spring hard whites were similar to those of the best soft white spring lines. 'Winsome' and ID377S have been the highest yielding hard whites averaged over the last 3 years. These lines have had similar grain yield, test weight and protein over this time. The Wheat Marketing Center in Portland has identified Winsome as a superior cultivar for Asian noodle production and should be considered for identity preserved sales.

Hard red varieties, 'Jefferson' and 'Hank' continued to perform well in 2001. Across market classes, 3-year averages show 'Jefferson' to be the top yielding variety at three of five Columbia Basin locations (Table 8). Across locations and market classes, 'Hank' was the top yielding line. 'Hank' is tolerant to Hessian fly and has performed well, especially in irrigated or high-rainfall environments.

***Spring Barley** (Tables 9 and 10)*

Across locations, 'Chinook' had the highest yield in 2001 and the highest average yield over the last 3 years. 'Chinook' has stripe rust resistance, while 'Steptoe' and 'Baronesse' (not included in 2001 trials) do not. 'Valier' continued to perform well in 2001 and has 3-year-average grain yield similar to 'Chinook'.

Conclusions

While any variety may excel in a single location and year, data over multiple years should be examined when selecting a variety. Growers should also consider disease resistance, winter hardiness, or other factors pertinent to their location. See Bassinette et al,. (2002a,b) for more information on disease resistance, winter hardiness, etc. When switching to a new variety, small acreages should be grown for more than a year before making a larger commitment.

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References

Bassinette, J.P., R. Karow, E. Marx, S. McDonald, R. Bafus, M. Bohle, E. Eldredge, P. Hayes, J. Peterson, K. Rykbost, C. Shock, and D. Smiley. 2001. Winter grain varieties for 2001. Special Report 775. Oregon State University Extension Service, Corvallis, OR.

Bassinette, J.P., R. Karow, N. Blake, R. Bafus, M. Boyle, D. Clark, E. Eldredge, P. Hayes, E. Jacobsen, J. Peterson, S. Petrie, K. Rhinhart, K. Rykbost, C. Shock, and J. Smith. 2002a. Spring grain varieties for 2002. Special Report 986. Oregon State University Extension Service, Corvallis, OR.

Bassinette, J.P., R. Karow, N. Blake, R. Bafus, M. Boyle, E. Eldredge, P. Hayes, J. Peterson, S. Petrie, K. Rykbost, and C. Shock. 2002b. Winter grain varieties for 2002. Special Report 775. Oregon State University Extension Service, Corvallis, OR.

Bassinette, J.P., R. Karow, S. McDonald, K. Rhinhart, R. Bafus, M. Bohle, D. Clark, E. Eldredge, P. Hayes, J. Peterson, S. Petrie, K. Rykbost, C. Shock, and D. Smiley. 2001. Spring grain varieties for 2001. Special Report 986. Oregon State University Extension Service, Corvallis, OR.

Bassinette, J.P., R. Karow, S. McDonald, K. Rhinhart, and D. Smiley. 2001. Statewide cereal variety testing program. Columbia Basin Agricultural Research Center Special Report. 1026. Oregon State University, Corvallis, OR.

Table1. 2001 statewide variety testing program trial type, location, manager, and cooperator.

Trial name	Trial type[1]	Location	Manager[2]	Grower cooperator
Corvallis	W,S-dryland	Hyslop Exp. Stn.	Bassinette/Karow	
Scio	S-dryland	Haugerud Farm	Bassinette/Karow	Carl Haugerud
Moro	W,S- dryland	Sherman Exp. Stn.	Blake/Petrie	
Lexington	W,S-dryland	Starvation Farms	Blake/Petrie	Chris Rauch
Hermiston	W-irrigated	Madison Farm	Blake/Petrie	Kent Madison
Hermiston	S-irrigated	Carroll Farm	Blake/Petrie	Larry Carroll
Pendleton	W,S-dryland	CBARC	Blake/Petrie	
LaGrande	W,S-irrigated	Cuthbert Farm	Blake/Petrie	John Cuthbert
Ontario	W,S-irrigated	Malheur Exp. Stn.	Eldredge/Shock	
Madras	W,S-irrigated	Central OR Exp. Stn.	Bafus/Bohle	
Klamath Falls Organic	S-dryland	Henzel Farms	Clark/Rykbost	Sam and Thurston Henzel
Klamath Falls Mineral	S-dryland	Klamath Exp. Sta.	Clark/Rykbost	

[1]W and S are used to designate winter and spring trials respectively.

[2]Statewide trials are coordinated through Cereals Extension, Oregon State University, Corvallis, Oregon.

Table 2. 2001 statewide variety testing program winter wheat, oat, rye, and triticale yield for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Moro[3]	Pendleton	Across site average	Across site % of average
		Yield (60lb.bu/acre @ 10% moisture)					
Bruehl	Club	99	26	25	81	58	86
Brundage	SW	119	32	25	102	70	104
Coda	Club	103	62	25	80	68	101
Edwin	Club	83	48	23	67	55	82
Foote	SW	101	17	25	98	60	90
Hubbard	SW	103	61	28	107	75	112
ID 11713A	SW	119	64	22	89	74	110
ID-52814A	SW	111	53	25	89	70	104
ID-B-96	SW	112	63	20	97	73	109
Kolding Oat	Oat	59	35	26	40	40	60
Madsen	SW	108	67	25	85	71	106
Madsen/Stephens	SW	114	45	23	96	70	104
OR 939526	SW	118	54	23	91	72	107
OR 939528	SW	115	28	26	99	67	100
OR 941044	SW	109	29	25	100	66	98
OR 941904	HW	115	49	24	95	71	106
OR 943560	SW	117	45	24	94	70	104
Rely	Club	81	42	23	95	60	90
Stephens	SW	128	25	23	100	69	103
Temple	Club	128	16	23	93	65	97
WA 7853 (Finch)	SW	94	59	27	97	69	103
WA 7855 (Chucker)	Club	108	69	21	101	75	112
Weatherford	SW	114	58	25	92	72	108
Yamhill	SW	113	63	28	83	72	107
Alzo	Triticale	101	—	—	85	—	—
Bogo	Triticale	88	—	31	86	—	—
Boundary	HR	112	—	25	87	—	—
Connie	Durum	85	—	21	65	—	—
Gene	SW	—	31	22	84	—	—
Hiller	Club	111	17	—	102	—	—
ID517	HR	116	21	—	103	—	—
ID 550	HW	77	46	—	83	—	—
Kansas FT31	Triticale	113	—	—	93	—	—
MacVicar	SW	—	45	—	—	—	—
Malcolm	SW	122	—	—	—	—	—
OR 850513-19	HW	122	—	24	93	—	—
OR 850513-8	HW	104	—	27	89	—	—
OR 941899	SW	96	49	—	87	—	—
Rhode	Club	95	42	—	100	—	—
Rifle	Rye	130	—	—	88	—	—
Rod	SW	136	59	—	96	—	—
Trial Mean		107	45	24	95	67	—
CV		16	31		10	avg	
PLSD (0.05)		27	23		14		
PLSD (0.10)		23	19		12		
Pr > F		0.00	0.00		0.00		

[1] All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 30 seeds/ft^2. for all locations except Moro and Pendleton where seeding rate was 20 seeds/ft^2.

[2] SW-soft white, HW-hard white, HR-hard red.

[3] Only one replication harvested due to planting error.

Table 3. 1999-2001 statewide variety testing program winter wheat yield data for Columbia Basin locations.

Variety or Line [1]	Market class [2]	Hermiston	LaGrande [3]	Lexington [4]	Moro	Pendleton	Across site average
		Site Location					
		-------------Yield (60 lb, bu/acre @ 10% moisture)-------------					
1999							
Boundary	HR	73	47	—	62	87	67
Coda	Club	80	67	—	69	96	78
Foote	SW	25	28	—	52	74	45
Hiller	Club	70	38	—	64	91	66
Madsen	SW	70	63	—	66	96	74
Madsen+Stephens mix	SW	79	53	—	59	80	68
OR 939526	SW	84	64	—	65	92	76
Rely	Club	75	26	—	61	87	62
Rod	SW	96	61	—	64	92	78
Rohde	Club	64	41	—	66	78	62
Stephens	SW	72	47	—	63	85	67
Temple	Club	61	33	—	64	92	63
Weatherford	SW	92	58	—	60	85	74
Trial average (bu/acre)		72	48	—	63	87	68
							0
2000							0
Boundary	HR	97	109	34	52	115	81
Coda	Club	112	118	37	51	110	86
Foote	SW	86	124	27	35	104	75
Hiller	Club	114	126	34	56	132	92
Madsen	SW	131	98	36	58	116	88
Madsen + Stephens mix	SW	138	114	36	57	117	92
OR 939526	SW	133	140	42	57	132	101
Rely	Club	99	126	38	47	116	85
Rhode	Club	93	131	42	57	118	88
Rod	SW	117	145	36	55	132	97
Stephens	SW	128	133	39	72	113	97
Temple	Club	104	132	43	43	116	88
Weatherford	SW	135	108	37	53	111	89
Trial average (bu/acre)		114	123	37	53	118	89
2001							
Boundary	HR	112	—	—	25	87	—
Coda	Club	103	62	—	25	80	68
Foote	SW	101	17	—	25	98	60
Hiller	Club	111	17	—	—	102	—
Madsen	SW	108	67	—	25	85	71
Madsen+Stephens mix	SW	114	45	—	23	96	70
OR 939526	SW	118	54	—	23	91	72
Rely	Club	81	42	—	23	95	60
Rod	SW	136	59	—	—	96	—
Rohde	Club	95	42	—	—	100	—
Stephens	SW	128	25	—	23	100	69
Temple	Club	128	16	—	23	93	65
Weatherford	SW	114	58	—	25	92	72
Trial average (bu/acre)		111	42		24	93	68

Table 3 (continued). 1999-2001 Winter wheat yields for varieties tested at Columbia Basin locations.

Variety or lin	Market class	Hermiston	LaGrande[3]	Lexington[4]	Moro	Pendleton	Across site average
		Yield (bu/acre @ 10% moisture)					
1999-2001							
Boundary	HR	94	—	34	46	96	—
Coda	Club	98	82	37	48	95	72
Foote	SW	71	56	27	37	92	57
Hiller	Club	98	60	34	—	108	—
Madsen	SW	103	76	36	50	99	73
Madsen+Step	SW	110	71	36	46	98	72
OR939526	SW	112	86	42	48	105	79
Rely	Club	85	65	38	44	99	66
Rod	SW	116	88	36	—	107	—
Rohde	Club	85	71	42	—	99	—
Stephens	SW	109	68	39	53	105	75
Temple	Club	98	60	43	43	100	69
Weatherford	SW	114	75	37	46	93	73
1999-2001 average (bu/acr		99	71	37	46	100	71
1999-2001		Yield expressed as percent of trial average					
Boundary	HR	95	—	92	100	96	96
Coda	Club	99	115	101	104	95	103
Foote	SW	72	79	72	80	92	79
Hiller	Club	99	85	93	—	108	96
Madsen	SW	104	107	96	109	99	103
Madsen+Step	SW	111	100	98	100	98	101
OR939526	SW	113	121	114	105	105	112
Rely	Club	86	92	103	96	99	95
Rod	SW	117	124	97	—	107	111
Rohde	Club	86	100	113	—	99	99
Stephens	SW	110	96	106	115	105	106
Temple	Club	99	85	115	93	100	98
Weatherford	SW	115	106	100	100	93	103

[1] All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 20 seeds/ft^2

[2] SW-soft white, HW-hard white, HR-hard red.

[3] LaGrande trials were damaged by hail storms on June 24, 1999.

Table 4. 2001 winter barley yields for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Site location: Hermiston	LaGrande	Lexington	Pendleton	Across site average	Across site % of average
		Yield (lbs/acre @ 10% moisture)					
88Ab536	6RM	4804	2587	1709	3963	2836	83
Kab-37	6RF/M	4069	2554	1153	5047	3100	91
Kold	6RF	4266	2664	1667	5661	3664	107
Scio	6RF	4327	2780	1201	5615	3408	100
Stab-113	6RF/M	3948	2176	1687	5400	3544	104
Stab-47	6RF/M	4556	2283	1396	4528	2962	87
Stab-7	6RF/M	4718	2734	1555	4783	3169	93
Strider	6RF	4527	2410	2690	5774	4232	124
Trial Mean		4402	2523	1632	5096	3413	
CV		22	22	25	7		
PLSD (0.05)		ns[3]	ns	726	633		
PLSD (0.10)		ns	ns	596	520		
Pr > F		0.95	0.86	0.01	0.00		

[1] All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 20 seeds/ft^2 for all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] 6RF-six-row feed; 6RF/M-six-row being assessed for feed and malting use.

[3] ns-not significant

Table 5. 1999-2001 winter barley yields for varieties tested at Columbia Basin locations.

Variety[1]	Market class[2]	Site location: Hermiston	LaGrande[3]	Lexington[4]	Moro	Pendleton	Across site average
		Yield (lbs/acre @ 10% moisture)					
1999							
Kold	6RF	4220	—	—	2346	4672	4783
Scio	6RF	3940	—	—	3430	5628	5355
Strider	6RF	3793	—	—	2687	5564	4221
Trial average (lb/acre)		3985	—	—	2821	5288	4598
2000							
Kold	6RF	4421	5739	2192	2411	5456	4044
Scio	6RF	5491	6584	2138	2875	4929	4403
Strider	6RF	5683	5874	2544	3192	5831	4625
Trial average (lb/acre)		5198	6065	2291	2826	5405	4357
2001							
Kold	6RF	4266	2664	1667	—	5661	3565
Scio	6RF	4327	2780	1201	—	5615	3481
Strider	6RF	4527	2410	2690	—	5774	3850
Trial average (lb/acre)		4373	2618	1853	—	5683	3632
1999-2001 average							
Kold	6RF	4302	4202	1929	2378	5263	3615
Scio	6RF	4586	4682	1669	3152	5391	3896
Strider	6RF	4668	4142	2617	2940	5723	4018
1999-2001 average (lb/acre)		4519	4342	2072	2823	5459	3843

[1] All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 20 seeds/ft^2 for all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] 6RF-six-row feed; 6RF/M-six-row being assessed for feed and malting use.

[3] LaGrande site was damaged by hail in 1999.

[4] Lexington site data were too variable to report in 1999. Site data were lost to equipment problem in 2001.

Table 6. 2001 spring soft wheat and spring oat yields for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Lexington	Moro	Pendleton[3]	Across site average	Across site % of average
		Yield (60 lb, bu/acre @ 10% moisture)						
Alpowa	SW	78	66	16	31	33	45	102
Alpowa (no Gaucho)	SW	97	57	18	25	21	44	99
Alpowa (untreated)	SW	99	64	20	30	21	47	106
Chalis	SW	73	58	19	27	18	39	89
IDO 526	SW	74	61	18	29	24	41	94
Jefferson	HR	88	72	25	38	50	55	124
Jubilee (IDO 525)	SW	91	55	22	31	13	42	96
Penawawa	SW	92	52	21	36	19	44	100
Treasure	SW	80	56	22	31	24	43	97
WA 7884	SW	91	63	17	37	35	49	110
WA 7902	Club	89	65	13	38	23	46	104
Wawawai	SW	85	64	18	35	50	50	115
Zak (WA 7850)	SW	87	57	18	32	57	50	114
Cayuse	Oat	61	53	21	31	51	43	99
Lamont	N Oat	67	30	13	22	35	33	76
Provena	N Oat	74	30	9	24	33	34	77
Whitebird	SW	97	47	18	35	—	—	—
Winsome	HW	97	60	21	28	—	—	—
IDO 556	Club	—	—	19	31	25	—	—
Trial Mean		84	56	18	31	31	44	—
CV		21	11	16	15	9		
PLSD (0.05)		ns[4]	10	5	8	5		
PLSD (0.10)		ns	9	4	7	4		
Pr > F		0.33	0.00	0.00	0.00	0.00		

[1] All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 20 seeds/ft^2 for all locations except Hermiston and LaGrande where seeding rate was 30 seeds/ft^2.

[2] SW-soft white, HW-hard white, HR-hard red, N Oat-naked oat. HR and HW entries included as checks.

[3] Yields reflect damage done by Hessian fly.

[4] ns-not-significant.

Table 7. 2001 hard spring wheat yields for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Lexington	Moro	Pendleton[3]	Across site average	Across site % of average
		Site Location						
		Yield (60 lb, bu/acre @ 10% moisture)						
Alpowa	SW	100	63	19	32	34	50	110
Hank	HR	107	66	16	35	46	54	120
IDO 377S	HW	78	54	15	33	17	39	88
IDO 545	HR	71	49	14	30	42	41	92
IDO 557	HR	86	68	19	37	21	46	103
Iona	HR	79	53	16	34	21	41	90
Jefferson	HR	91	61	20	34	48	51	113
Lolo (IDO 533)	HW	86	67	18	35	29	47	104
OR 4910028	HR	71	65	16	34	43	46	102
Penawawa	SW	84	48	18	37	23	42	93
Scarlet	HR	90	58	17	35	24	45	100
Sunco	HW	78	58	18	31	20	41	91
Tara (WA 7824)	HR	72	61	12	30	33	42	92
WA 7839	HR	75	69	19	36	37	47	105
WA 7899 (Macon)	HW	94	53	18	34	42	48	107
WA 7901	HW	76	58	15	31	25	41	91
Winsome	HW	77	65	20	35	25	44	99
WPB 936	HR	93	65	12	31	18	44	97
Yecora Rojo	HR	88	67	19	35	30	48	106
IDO 560	HW	99	60	—	—	—	—	—
OR 4920002	HR	—	57	—	—	34	—	—
WA 7900	HW	84	63	20	33	—	—	—
Winsome (high rate)	HW	84	52	21	37	—	—	—
Winsome (low rate)	HW	56	60	15	27	—	—	—
Trial Mean		83	60	17	33	31	45	—
CV		17	11	14	15	22		
PLSD (0.05)		23	11	4	ns[4]	11		
PLSD (0.10)		19	9	3	ns	9		
Pr > F		0.02	0.00	0.00	0.39	0.00		

[1] Fertilized for desired hard wheat protein levels. All seed was treated with fungicide and insecticidal seed treatment unless otherwise noted. Seeding rate was 20 seeds/ft^2 for all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] SW-soft white, HW-hard white, HR-hard red. SW entries included as checks.

[3] Yields reflect damage done by Hessian fly.

[4] ns-not-significant.

Table 8. 1999-2001 spring wheat yields for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Lexington	Moro	Pendleton	Across site average
		--------------	---------Yield bu/acre @ 10% moisture-			--------------	----------------
1999							
Alpowa	SW	74	41	18	44	34	42
Alpowa (fungicide only)	SW	76	34	16	49	36	42
IDO377S	HW	87	58	19	45	36	49
Jefferson	HR	84	44	20	45	36	46
Penawawa	SW	80	48	17	43	36	45
Scarlet	HR	65	31	20	43	37	39
Wawawai	SW	77	26	21	39	35	40
Whitebird	SW	80	48	19	40	35	44
Winsome	HW	74	49	17	41	35	43
WPB936	HR	60	34	19	45	32	38
Yecora Rojo	HR	45	27	17	40	37	33
Trial average (bu/acre)		77	45	19	44	35	44
2000							
Alpowa	SW	52	118	28	52	41	58
Alpowa (fungicide only)	SW	57	113	30	52	38	58
IDO 377S	HW	43	107	34	50	49	57
Jefferson	HR	42	102	34	54	51	57
Penawawa	SW	48	106	23	52	25	51
Scarlet	HR	42	107	25	38	48	52
Wawawai	SW	47	104	24	44	55	55
Whitebird	SW	48	91	24	48	44	51
Winsome	HW	50	103	31	51	48	57
WPB 936	HR	44	102	21	51	33	50
Yecora Rojo	HR	51	104	25	50	32	52
Trial average (bu/acre)		46	102	26	46	43	53
2001							
Alpowa	SW	78	66	16	31	33	45
Alpowa (fungicide only)	SW	97	57	18	25	—	39
IDO 377S	HW	78	54	15	33	17	39
Jefferson	HR	88	61	20	34	48	50
Penawawa	SW	92	52	21	36	19	44
Scarlet	HR	90	58	17	35	24	45
Wawawai	SW	85	64	18	35	50	50
Whitebird	SW	97	47	18	—	—	32
Winsome	HW	56	60	20	35	25	39
WPB 936	HR	93	65	12	31	18	44
Yecora Rojo	HR	88	67	19	35	30	48
Trial average (bu/acre)		86	59	18	33	29	45

Table 8 continued. 1999-2001 spring wheat yields for varieties tested at Columbia Basin

1999-2001 average							
Alpowa	SW	68	75	21	42	36	48
Alpowa (fungicide only)	SW	77	68	21	42	37	49
IDO 377S	HW	69	73	23	43	34	48
Jefferson	HR	71	69	25	44	45	51
Penawawa	SW	73	69	20	44	27	47
Scarlet	HR	66	65	21	39	36	45
Wawawai	SW	70	65	21	39	47	48
Whitebird	SW	75	62	20	44	39	48
Winsome	HW	60	71	23	42	36	46
WPB 936	HR	65	67	17	42	28	44
Yecora Rojo	HR	61	66	20	42	33	44
1999-2001 average (bu/acre)		69	68	21	42	36	47

1999-2001 average		---------------------- Yield expressed as a percent of trial average----------------------------					
Alpowa	SW	99	110	98	101	101	102
Alpowa (fungicide only)	SW	111	100	102	100	97	102
IDO 377S	HW	101	108	108	102	89	101
Jefferson	HR	103	102	117	106	119	109
Penawawa	SW	106	101	97	104	71	96
Scarlet	HR	95	96	98	92	96	95
Wawawai	SW	101	95	100	94	123	103
Whitebird	SW	109	91	97	105	103	101
Winsome	HW	87	104	108	101	95	99
WPB 936	HR	95	98	83	101	73	90
Yecora Rojo	HR	89	97	97	99	87	94

[1] All seed was treated with fungicide and insecticidal seed treament unless otherwise noted. Seeding rate was 20 seeds/ft^2 for all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] SW-soft white, HW-hard white, HR-hard red.

Table 9. 2001spring barley yields for varieties tested at Columbia Basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Lexington	Moro	Pendleton	Across site average	Across site % of average
		----------------	----------Yield (bu/acre @ 10% moisture)-------------				----------------	
Bancroft	2RM	3780	2596	1259	2103	2572	2462	93
Othello (BCD 47)	2RF/M	4249	3438	1343	1970	2100	2620	99
Chinook	2RM	4402	4469	1603	1931	2710	3023	114
Farmington (Wa 9504-04)	2RF	3944	3753	1016	1988	2730	2686	101
Garnet	2RM	3891	3840	1281	2133	2668	2763	104
H3860224	2RF/M	4433	3405	1377	1809	2742	2753	104
Harrington	2RM	4300	3850	1170	1629	2805	2751	104
Morex	6RM	3115	3843	1365	1817	2020	2432	92
Orca	2RF	3499	4328	1587	1430	2187	2606	98
Stab-7	6RF/M	3766	3758	566	1173	1956	2244	85
Steptoe	6RF	4502	3812	1402	1624	2258	2720	103
Tango	6RF	3893	2411	1235	1481	1632	2130	80
Valier	2RF	5011	3701	1323	2071	2722	2966	112
WA 8682-96	6RF/M	4910	2875	1607	2335	2997	2945	111
Stab-113	6RF/M	3403	—	614	1524	1687		
Stab-47	6RF/M	4951	3824	837	1135	—		
Xena	2RF	4646	—	—	2212	2321		
Trial Mean		4158	3594	1224	1786	2381	2650	
CV		19	19	12	15	8		
PLSD (0.05)		1307	1122	241	452	303		
PLSD (0.10)		1087	933	200	376	252		
Pr>F		0.00	0.04	0.00	0.00	0.00		

[1] All seed was treated with fungicide and insecticide prior to planting unless otherwise noted. Seeding rate was 20 seeds/ft^2 at all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] 2R-two row, 6R-six row, F-feed, M-malt, F/M-may be considered for feed or malt

Table 10. 1999-2001 spring barley yields for varities tested at Columbia basin locations.

Variety or line[1]	Market class[2]	Hermiston	LaGrande	Lexington	Moro	Pendleton	Across site average
		---Yield (lbs/acre @ 10% moisture)-----					
1999							
Bancroft	2RM	3796	1989	1176	3093	2943	2599
Chinook	2RM	3610	2754	1374	3322	2817	2775
Orca	2RF	2994	3281	1314	3071	2801	2692
Steptoe	6RF	3290	1650	1421	3641	3068	2614
Tango	6RF	3425	1770	1341	3617	2858	2602
Valier	2RF	4346	2318	1525	3284	3010	2897
Trial average (lb/acre)		3577	2294	1359	3338	2916	2697
2000							
Bancroft	2RM	3991	4951	1474	3241	2505	3232
Chinook	2RM	3827	6474	1569	3043	1843	3351
Orca	2RF	4097	5389	2101	2875	2126	3318
Steptoe	6RF	3995	6791	2297	3177	1940	3640
Tango	6RF	4187	4695	2288	3893	1852	3383
Valier	2RF	3216	4199	2111	3263	2496	3057
Trial average (lb/acre)		3886	5416	1973	3249	2127	3330
2001							
Bancroft	2RM	3780	2596	1259	2103	2572	2462
Chinook	2RM	4402	4469	1603	1931	2710	3023
Orca	2RF	3499	4328	1587	1430	2187	2606
Steptoe	6RF	4502	3812	1402	1624	2258	2720
Tango	6RF	3893	2411	1235	1481	1632	2130
Valier	2RF	5011	3701	1323	2071	2722	2966
Trial average (lb/acre)		4181	3553	1402	1773	2374	2657
1999-2001 average							
Bancroft	2RM	3856	3179	1303	2812	2673	2765
Chinook	2RM	3946	4566	1515	2765	2457	3050
Orca	2RF	3530	4333	1667	2459	2371	2872
Steptoe	6RF	3929	4084	1707	2814	2422	2991
Tango	6RF	3835	2959	1621	2997	2114	2705
Valier	2RF	4191	3406	1653	2873	2743	2973
Average yield 1999-2001 (lb/acre)		3881	3754	1578	2787	2463	2893
1999-2001 average		---------Yield expressed as percent of trial average---------					
Bancroft	2RM	99	85	83	101	109	95
Chinook	2RM	102	122	96	99	100	104
Orca	2RF	91	115	106	88	96	99
Steptoe	6RF	101	109	108	101	98	103
Tango	6RF	99	79	103	108	86	95
Valier	2RF	108	91	105	103	111	104

[1] All seed was treated with fungicide and insecticide prior to planting unless otherwise noted. Seeding rate was 20 seeds/ft^2 at all locations except Hermiston and LaGrande, where seeding rate was 30 seeds/ft^2.

[2] 2R-two row, 6R-six row, F-feed, M-malt.

FERTILIZER PLACEMENT IN ANNUAL CROP DIRECT-SEEDED CANOLA

Dale Wilkins, Don Wysocki, Mark Siemens, Sandy Ott, Bob Correa, and Tami Johlke

Abstract

The effect of fertilizer amount and placement on stand establishment, plant growth, and yield in direct-seeded fall canola following spring wheat was evaluated in a field near Pendleton, Oregon. 'Ericka' canola was seeded on September 25. Comparisons were made among starter fertilizer (100 lb/acre of 16-20-0-14) placed with the seed, below and to the side of seed, no starter applied at seeding, and placing the full complement of fertilizer (100 lb/acre of 16-20-0-14 plus 160 lb/acre of 46-0-0) below and to the side of seed. These factors had a significant impact on yield with nearly a two-fold difference between the best and worst treatments. Placing the full complement of fertilizer to the side and below the seed provided the best stand establishment, winter survival, accumulated dry matter, and yield. The worst canola yield resulted from applying all the fertilizer in the spring, rather than at the time of seeding.

Key Words
Canola, no-till, direct-seed, stand establishment, seeding, fertilizer

Introduction

Annual crop direct-seed systems in the inland Pacific Northwest (PNW) region, where wheat/fallow and wheat/pea are the traditional production systems, would benefit if a broadleaf crop such as canola (*Brassica napus* L.) could be rotated with cereal crops (Brown et al. 2001). Conventionally tilled canola can be grown, but these systems are not sustainable and therefore conservation systems such as direct seed are needed. Although winter canola yields two times spring canola (Wysocki et al. 1992), adequate soil water is not always present at the optimum seeding time and therefore stand establishment is difficult, especially in a direct-seed or minimum tillage system. This research was conducted to address this issue and determine the influence of fertilizer amount and placement on canola stand establishment, plant growth, and yield in a PNW annual crop direct-seed system.

Materials and Methods

'Ericka' canola was seeded on the Pendleton Agricultural Research Center at the rate of 8.2 lb/acre on September 25, 2000 into flailed spring wheat stubble using a direct-seed hoe-type plot drill. Four treatments were sown in 12-ft by 50-ft plots in a randomized complete block experiment with four replications. All treatments received equal amounts of N (nitrogen), P_2O_5 (phosphorous pentoxide), and S (sulfur), but varied in fertilizer form, placement, timing, and method of application. The four treatments investigated included the following:

1. Starter fertilizer (100 lb/acre of 16-20-0-14) placed with the seed plus 74 lb of N per acre (solution 32 formulation) applied on March 20, 2001 with a spoke-wheel applicator.
2. Starter fertilizer (100 lb/acre of 16-20-0-14) placed below and beside the seed plus 74 lb of N per acre (solution 32 formulation) applied on March 20, 2001 with a spoke-wheel applicator.

3. No starter fertilizer applied at seeding. Spoke-wheel application of 90, 20, and 14 lb/acre of N, P_2O_5, and S, respectively, on March 20, 2001.
4. Starter fertilizer plus urea (100 lb/acre of 16-20-0-14 and 160 lb/acre of 46-0-0) placed below and beside the seed.

Seed and fertilizer placement were determined from 2- by 2- by 4-in-deep soil cores sectioned into 0.4-in increments. Stand observations were taken on October 20, 2000 and March 7, 2001. Above-ground dry matter production was measured on April 4, 2001 and seed yield was determined at harvest with a plot combine.

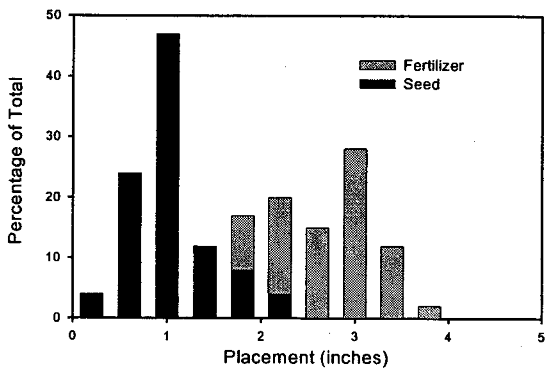


Figure 1. Vertical distribution of seed and fertilizer in canola plots near Pendleton, Oregon in 2000.

Results

Figure 1 shows the distribution of seed and fertilizer where the full complement of fertilizer (starter plus urea) was placed below the seed. Although the mean seed depth was 1.1 in, seed depth ranged from 0.2 to 2.8 in. Mean fertilizer depth (2.4 in) was over 1.25 in deeper than mean seed depth; however, fertilizer was found at depths ranging from 1.75 in to 3.75 in.

Table 1 shows stand observations on October 20 and March 7, winter survival, above-ground dry matter accumulation on April 4 prior to bolting, and seed yield. Stand establishment, winter survival fraction (stand on March 7 divided by stand on October 20), plant growth, and yield were superior with the full complement of fertilizer (starter plus urea) compared to no fertilizer applied at seeding. Starter fertilizer applied at seeding improved winter survival and seed yield compared to no fertilizer applied at seeding. There were no statistically significant differences in stand establishment, winter survival, accumulated dry matter, or seed yield for starter fertilizer placed with the seed, or beside and below the seed.

Table 1. Effect of fertilizer amount and placement on stand establishment and dry matter production of Canola in April, 2001, Agricultural Research Center, Pendleton, Oregon.

Treatment	Plant stand Oct. 20	Plant stand Mar. 7	Winter survival[1]	Above-ground dry matter on April 4	Above-ground dry matter on April 4	Seed yield
	plants/ft^2	plants/ft^2	fraction	g/plant	lb/acre	lb/acre
1. Starter[2] with seed	3.8 b[3]	3.2 bc	0.86 a	0.38 ab	92 b	852 ab
2. Starter below seed	5.0 b	4.9 b	1.01 a	0.29 b	78 b	783 b
3. No starter	5.6 b	2.1 c	0.37 b	0.10 b	14 b	517 c
4. Starter plus urea[4] below seed	8.0 a	8.4 a	1.10 a	0.49 a	406 a	900 a

[1] Winter survival = plant stand on Mar. 7 divided by stand on Oct. 20.
[2] Starter (16-20-0) applied at the rate of 100 lb/acre.
[3] Numbers within a column followed by the same letter are not statistically different by LSD test (P = 0.05).
[4] Urea (46-0-0) applied at the rate of 160 lb/acre.

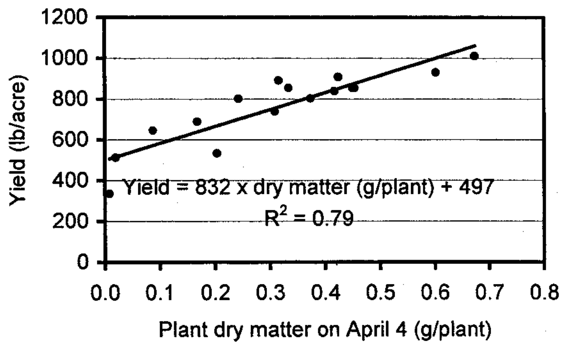


Figure 2. Canola yield at Pendleton, Oregon in 2001 as influenced by above-ground canola plant dry matter on April 4, 2001.

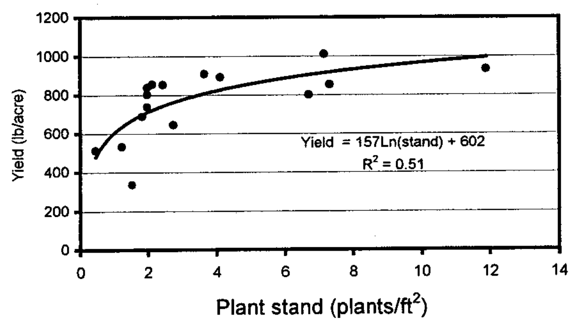


Figure 3. Effect of canola plant stand on yield at Pendleton, Oregon in 2001.

Data plotted in Figure 2 show the importance of early plant size on yield. Treatments that had large plants in April produced the highest yields. A linear regression fit to the early plant growth and yield data had an R^2 (coefficient of determination) value of 0.79. This indicates that 79 percent of the variation in yield was accounted for in early plant growth. Plant stand also influenced yield (Fig. 3). Yield increased from 450 lb/acre to 800 lb/acre as stand increased from 1 plant/ft^2 to approximately 4 plants/ft^2. Plant densities of more than 4 plants/ft^2 did not increase yield significantly. The logarithmic equation that best fit these data was determined to be:

Yield = 157 (Ln(stand)) + 602

where stand is in units of plants/ft^2 and yield is expressed in lb/acre.

The coefficient of determination (R^2) was 0.51.

Accumulated dry matter per acre is a function of stand and plant size. Increases in stand and/or plant size increase accumulated above-ground dry matter. Figure 4 shows the logarithmic relationship found between accumulated dry matter and seed yield per acre. At dry matter levels below 75 lb/acre, yield decreased dramatically as dry matter decreased. At dry matter levels above 100 lb/acre, increased levels of dry matter increased yield slightly.

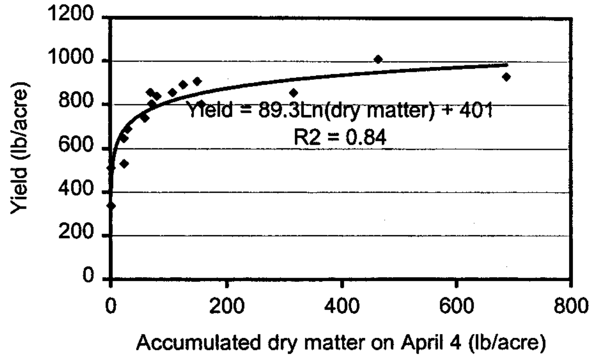


Figure 4. Influence of accumulated dry matter on canola yield at Pendleton, Oregon in 2001.

The logarithmic equation that best fit these data was determined to be:

$$\text{Yield} = 89.3(\text{Ln}(\text{dry matter})) + 401$$

where dry matter is the above-ground oven-dried plant material in lb/acre and yield is expressed in lb/acre.

The coefficient of determination (R^2) for this regression equation was 0.84, indicating that 84 percent of the variation in yield can be accounted for by the early above-ground dry matter production.

Observations in this experiment are supported by canola growth and nutrient uptake data taken in past growing seasons at the Agricultural Research Center near Pendleton, Oregon (Table 2). Of the total amount of nutrients in the above-ground plant material, over one-half of the nitrogen and roughly one-third of the sulfur and phosphorus are in the plant by the spring rosette stage of growth. It therefore is essential to have these nutrients available to the plant early in its development.

Summary

Placement and timing of fertilizer in annual crop direct-seed canola following wheat near Pendleton, Oregon greatly impacted stand establishment and plant size. These factors had a significant impact on yield with nearly a two-fold difference between the best and worst treatments. Placing the full complement of fertilizer to the side and below the seed provided the best stand establishment, winter survival, accumulated dry matter, and yield. The worst canola yield resulted from applying all the fertilizer in the spring, rather than at the time of seeding. Future research is planned to determine optimum vertical and horizontal separation of canola seed and fertilizer for direct-seeded winter canola.

Table 2. Winter canola dry matter and nutrient uptake, Pendleton, Oregon in 1998-1999 growing season.

Date	Stage	DM[1]	N[2]	N	S[3]	S	P[4]	P	B[5]	B
		lb/ac	%	lb/ac	%	lb/ac	%	lb/ac	ppm	lb/ac
9/11/98	Sowing		0	0	0	0	0	0	0	0
11/25/98	Winter rosette	2,407	4.86	121	0.36	9	0.57	14	27	0.07
2/26/99	Spring rosette	2,719	4.39	124	0.53	15	0.51	14	38	0.11
3/26/99	Bolting	4,534	4.01	189	0.45	22	0.49	23	44	0.21
4/8/99	First bloom	6,954	2.55	187	0.36	27	0.41	30	41	0.29
4/22/99	Early bloom	9,470	2.38	236	0.33	33	0.40	39	44	0.43
5/12/99	Full bloom	12,212	1.56	197	0.32	41	0.35	44	31	0.39
6/10/99	Pod filling	15,376	1.10	175	0.29	47	0.28	44	31	0.50
7/9/99	Harvest	12,620	1.21	153	0.32	40	0.32	41	28	0.35
	Straw at harvest	9,219	0.56	51	0.30	28	0.09	8	33	0.30
	Seed at harvest	3,401	3.00	102	0.37	13	0.96	33	13	0.04

[1]DM = dry matter in lb/acre.
[2] N = nitrogen.
[3] S = sulfur.
[4] P = phosphorous.
[5] B = boron.

References

Brown, J., D. Wysocki, and J.B. Davis. 2001. Developing *Brassica* crops and management strategies for direct-seeding systems. Pages 165-171 *in* Roger Veseth (ed.). Proc. Northwest Direct Seed Cropping Systems Conference. January 16-18, 2001, Spokane, WA. Northwest Direct Seed Conference, Pasco, WA.

Wysocki, D., S. Ott, M. Stoltz, and T. Chastain. 1992. Variety and planting date effects on dryland Canola. Pages 32-37 *in* T. Chastain (ed.). 1992 Columbia Basin Agricultural Research Annual Report. Special Report No. 894. Agricultural Experiment Station, Oregon State University and USDA-Agricultural Research Service, Pendleton, OR.

ENUMERATING SOIL BACTERIAL POPULATIONS IN THE CBARC LONG-TERM PLOTS

Stephanie A. Boyle and Stephan L. Albrecht

Abstract

Diverse soil bacterial populations contribute to the breakdown of crop residues, nutrient cycling, and nitrogen fixation. In addition, the size and activity of bacterial population may also be indicative of overall soil quality. In this study, dilution-spread-plating methods were used to enumerate the bacterial populations from several Columbia Basin Agricultural Research Center long-term plots, in Pendleton, OR. By diluting soil samples, plating a portion of these dilutions on nutrient agar, and incubating the plates for 24 and 48 hours, the number of bacteria per unit of dry weight soil was determined. Bacterial populations, in a no-till experiment, were found to be greater in a 120 lbs/acre N treatment than in a 0 N treatment. In contrast, bacterial populations in conventionally tilled 0 N and 120 lbs/acre N treatments were similar, demonstrating that the no-till residue management, at higher N levels, will support greater bacterial populations. This study also examined seasonal changes in populations. A general decrease in bacterial numbers was observed in the fall. This general decline may have been due to colder temperatures or the depletion in available nutrients. The addition of supplementary organic material, such as manure, increased bacterial numbers, even in conventionally tilled systems.

Key Words
Bacteria, Long-term experiments, Soil Management, No-till, Seasonal change

Introduction

Bacteria compose the largest portion of soil microorganisms. They are a useful indicator of the overall diversity and health of soil communities. Even soils planted in wheat monocultures support highly diverse bacterial populations that are responsible for carbon cycling and, to some extent, the breakdown of crop residue and nitrogen fixation. Additionally, the presence of certain bacteria have been linked to increased plant growth and disease suppression.

Because of their high variability, small size, and large numbers even in the poorest of soils, recognizing the importance of bacteria in any soil community is easier than accurately enumerating them or quantifying their activity. Some techniques, like soil respiration or fluorescein diacetate hydrolysis (Smith and Albrecht 2001), attempt to determine the total microbial activity. Other methods are used to quantify the bacteria present. For instance, direct counting methods using epifluorescence microscopy allow microbiologists to count individual cells in soil sub-samples (De Fede and Sexstone 2000). Counting can also be accomplished using pour or spread plating techniques, where a dilute soil suspension is either added to warm, liquid agar and then poured into a petri dish or spread across the top of a pre-poured plate. After an appropriate incubation to allow bacteria time to multiply, colonies are counted (Alexander 1998).

In this study, spread plating was chosen for a number of reasons. Unlike direct counting that does not distinguish between living and dead cells, in spread plating viable cells grow and are counted. Pour plating, a similar technique, distributes cells throughout the agar, making counting large numbers of colonies difficult and inaccurate. One disadvantage to spread plating is that only culturable (able to grow on laboratory media) bacteria are counted.

The goals of this study were to determine the relative populations of soil bacteria residing in several Columbia Basin Agricultural Research Center (CBARC) long-term plots and evaluate any correlations between farming practices and bacterial population size. Samples were collected during summer and fall, to examine seasonal-shifts in bacterial numbers. Determining the size of bacterial populations can be an important part of assessing overall soil quality. Similarly, studying population variability may help us understand the relationship between tillage management and bacterial communities. Differences in bacterial populations may also show agriculture's long-term effects on soil quality and composition.

Materials and Methods

Soil was collected from eleven treatments in the CBARC long-term plots (Rasmussen and Smiley 1994) during summer 2000, summer 2001, and fall 2001. In summer 2000, soil was collected from three different No-Till experiments: no-till wheat/fallow rotation for eighteen years, NT-A; no-till wheat/fallow rotation for three years, NT-B; and conventionally tilled wheat/fallow rotation for eighteen years, CT. The NT-A and NT-B experiments have five fertilizer treatments ranging from 0 to 180 lbs. of nitrogen/acre, but samples from NT-A and NT-B were taken from the 0-N and 120-N only. CT 0-N and 120-N were also included. Summer and fall 2001 samples were taken from the fall burn (CRFB) and manure (CRM) treatments in the long-term Crop Residue experiment. Samples were also taken in summer and fall 2001 from the Grass Pasture (GP), Annual Wheat No-Till (AWNT), and Annual Wheat Conventional Till (AWCT). Samples came from fallow ground in NT-A, NT-B, CT, CRM, and CRFB, but for GP, AWNT, and AWCT, samples were taken from cropped or recently harvested areas. In order to reduce spatial variability, four soil cores were taken from each plot and combined to form a composite sample. Each cylindrical core was 4 in. deep with a diameter of approximately 1 in.. Sterile collection technique was used to exclude lab-based contaminants.

Soil from each sample was used to determine soil moisture and to perform a dilution series (Alexander 1998). A sub sample was diluted according to procedures outlined by Alexander (1998). Three nutrient agar plates were spread at each of three dilution levels--1:10,000; 1: 100,000; and 1:1,000,000.

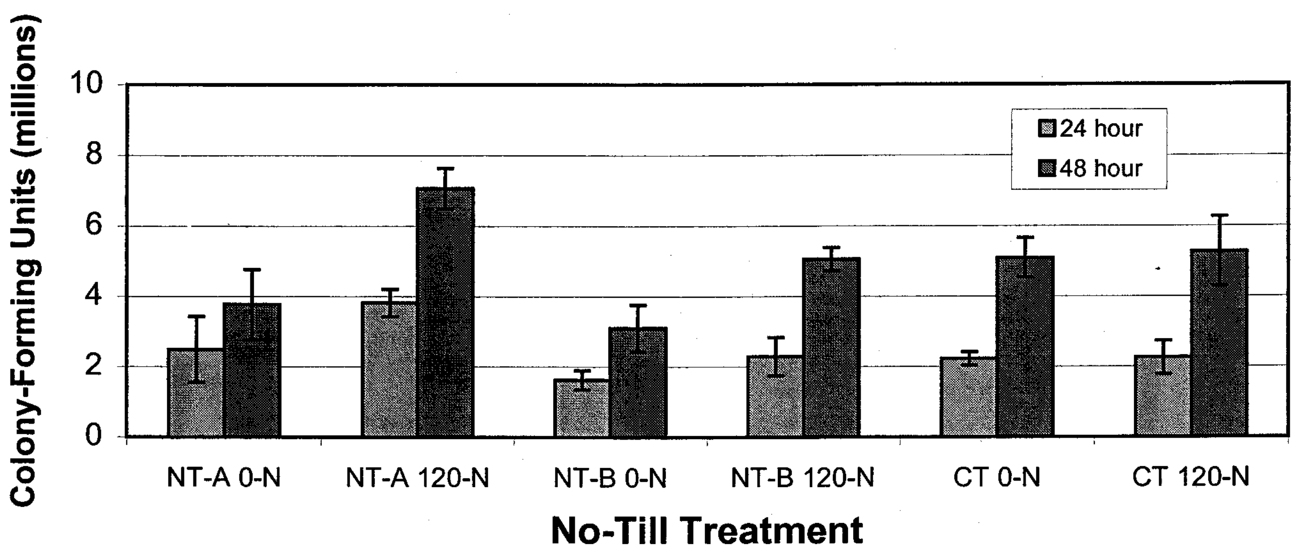
During incubation, humidity and temperature approximated soil conditions (Germida 1993). After incubation at 30°C for both 24 and 48 hours, each colony on the plate was counted. When plates were counted at 24 hours, they were kept closed to prevent any contamination that would influence the 48 hour count. The 48 hour incubation allowed slow growing bacteria time to form colonies, but prevented the growth of fungi that begin to overgrow plates after 2 days.

Plates with 30 and 300 colony-forming units (CFUs) were selected for counting. Colony forming units ranged in size from pinpoints (diameter less than .04 in) to dime size (diameter of approximately half an in) colonies that were visible to the naked eye. Plates containing more than 300 colonies were not counted to avoid inaccuracies (Bailey and Scott 1966). CFUs were corrected for dilution level and moisture content before the final counts were expressed as the number of 100 culturable bacterial cells per .035 oz. (1g) of dry soil.

Results

The plate counts for six different tillage/fertilizer treatments in the No-Till experiment are summarized in Figure 1. The numbers of CFUs are the mean of four field replications and two lab replications. Error bars were calculated using the standard error of the mean (SEM).

Figure 1. Mean colony-forming units (CFUs) for three No-Till tillage treatments and two fertilizer treatments in the long-term plots at CBARC, Pendleton, OR, summer 2000.



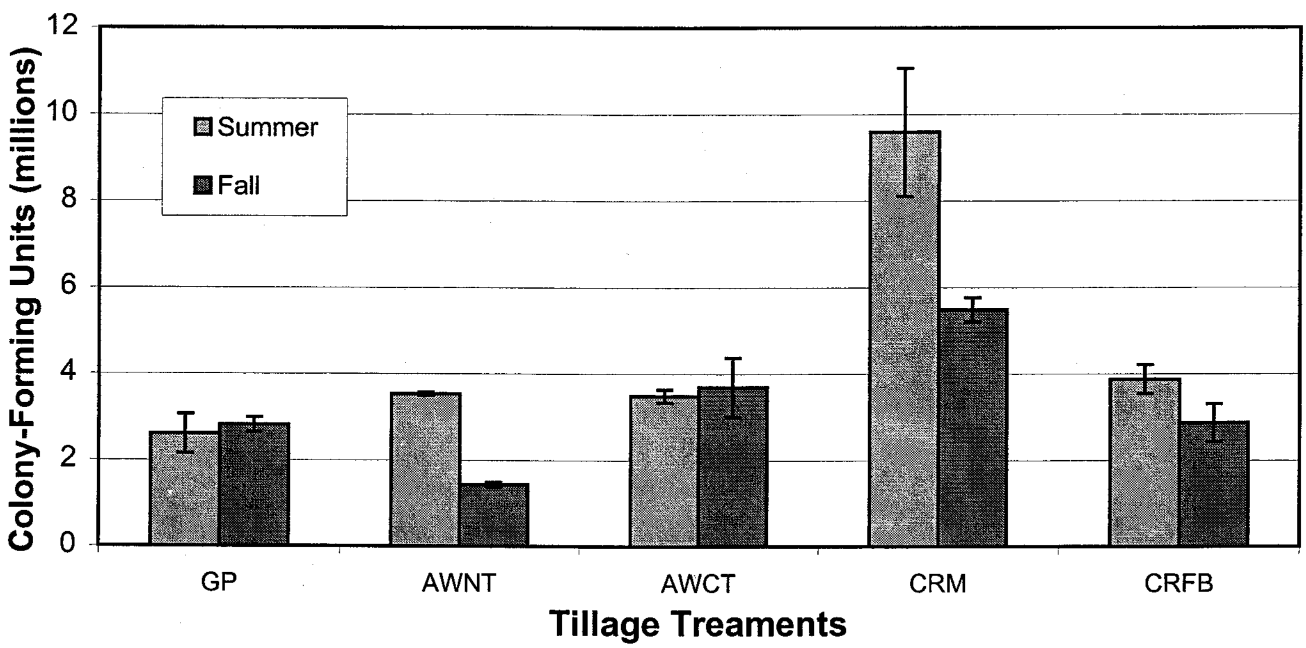
Plots include NT-A no-tilled for eighteen years, NT-B no-tilled for three years, and CT conventionally tilled. Fertilizer treatments include O-N (no nitrogen added) and 120-N (lbs/acre). Errors were calculated fron the standard error of the mean between four field replications and two lab replications.

Twenty-four hour CFUs for the No-Till plots ranged from a low of 1.6 million in the NT-B 0-N to a high of 3.8 million in the NT-A 120-N. All six No-Till treatments showed increasing bacterial numbers between 24 and 48 hours, although the rate of increase varied among treatments (rate calculations are not shown). At the end of 48 hours, CFUs ranged from 3.1 million in NT-B 0-N to 7.1 million in the NT-A 120-N. The NT-A treatments had the greatest variability with an increase of approximately 47 percent from no nitrogen to 120 lbs/acre. In contrast, the CT were similar with 5.1 million for 0-N and 5.3 million for 120-N.

Five CBARC long-term experiments were sampled during the summer and fall of 2001, to study possible seasonal changes and differences among farming systems (Figure 2).

Summer samples ranged from 2.6 million in the GP to 9.6 million in the CRM. The fall range was lower, between 1.43 million for AWNT to 5.5 million in CRM. A decline in the number of bacteria from summer to fall was observed in the CRM, CRFB, and AWNT which decreased by almost 60 percent. The CRM also showed a substantial decline of approximately 43 percent. The results from the GP and AWCT registered a slight increase from the summer to fall sample.

Figure 2. Mean colony-forming units (CFUs), during summer and fall 2001, inside five long experiments at the Pendleton, OR experiment station.



Soil was collected from the Grass pasture (GP), Annual wheat no-till (AWNT), Annual wheat conventional till (AWCT), Crop residue manure (CRM), and Crop residue fall burn (CRFB). Error bars were calculated using the standard error of the mean between three lab replications.

Discussion

An increase in the number of CFUs were observed in NT-A, NT-B, and CT from 24 to 48 hours. CT 0-N and 120-N both had increases of approximately 56 percent between 24 and 48 hours, but the NT-A 0-N only increased 25 percent. The different rates of increase may be due to differences in the bacterial compositions between soil samples. For example, the NT-A 0-N soil may have included bacteria that were dormant at the time of sampling and required a longer incubation before sufficient growth could occur.

A possible relationship between management and the number of culturable bacteria was observed in summer 2000. The largest differences in 48 hour 0-N and 120-N were in the NT-A, showing that bacteria were present in greater numbers when fertilizer was added. The length of time that plots were no-tilled rather than conventional-tilled could have also contributed to NT-A numbers, because it had been no-tilled fifteen years longer than NT-B. The number of organisms may have increased in relation to nitrogen fertilization levels because the fertilization may provide more available nitrogen for bacterial populations or because higher nitrogen levels promote crop growth, which in turn generates more residue, hence, providing more material to support bacterial growth and developmnet.

The application of other fertilizers, such as manure, may similarly increase bacterial populations, as in CRM. A difference of almost 60 percent was observed in 2001 between the CRM and the CRFB. This increase may be a result of an added nutrient base, which encouraged the growth of bacteria already in the soil. Another possibility is that application of manure introduced more bacteria. The lower numbers in CRFB may reflect a lack of usable carbon.

A combination of factors may have contributed to the population decreases from summer to fall in both the CRM and CRFB. One possible reason for the large decline in the CRM could be the time between addition of the manure and collection of the sample. Manure was added 47 days before the summer sample; in contrast, the fall sample was taken over 150 days after manure addition. Regardless of the reason for this initial increase in bacteria immediately following manure addition, at least some of these bacteria may not survive to reproduce (Albrecht et al. 1983). At least two other environmental changes may have contributed to the CRM and CRFB decreases. The bacteria may have had a limited carbon source in November or may have been killed by low temperatures.

With the exception of CRM, the remaining results were similar. Although the CRFB showed a slight elevation over AWCT, there was no substantial difference. A comparison of AWCT and CRFB showed that the size of bacterial populations was the same for fallow and continuous wheat. Numbers from treatments where crops were present may be low for the same reason that the CRFB numbers were low. Growing plants may tie up nutrients, thereby decreasing the number of bacteria.

The decrease in bacterial populations between summer and fall from AWNT may have been due to an unidentified environmental stress. One of the largest obstacles to accurately enumerating bacterial populations is spatial variability, even in a small geographic area. Although a composite sample was taken from each treatment, pockets containing unusually composite sample was taken from each treatment, pockets containing unusually large or small populations of bacteria could have biased results. Also, interactions of bacteria with other microorganism have not been considered. For example, the AWNT decline may have been the result of competition from more successful fungi, rather than a lack of carbon source.

Plate count results illustrated possible correlations between farming practices and bacterial numbers. For example, long-term no-till farming may have contributed to higher bacterial populations. Established populations of bacteria may be able to use increased nitrogen levels for growth, or nitrogen fertilizer, resulting in increased plant productivity, provides an energy source for larger soil bacterial populations. Similarly, the plate count data showed a distinct increase in the bacterial populations, when manure is added. Given the decline in the CFUs as the time between manure addition and sampling increased, further tests could determine if populations eventually stabilize and if this level is above or below other treatments. Collecting data in winter and spring could further our understanding of bacterial responses to environmental stresses. Given the variability among plots at any one time, future studies should rely on a greater number of samples per area. Increased sampling cannot guarantee, however, that the great diversity and uneven distribution of bacterial populations will be adequately represented.

Summary

Bacterial populations in the soil of various CBARC long-term plots were determined using traditional dilution, spread plating methods. By diluting soil samples, plating on nutrient agar, and growing for 24 to 48 hours the number of bacteria per unit of soil could be determined. Comparison of the 0-N and 120-N data collected from the No-Till experiments in 2000 showed a possible link between no-till farming and an increase in bacterial populations. Comparison of bacterial numbers between the summer and fall of 2001 for five different long-term experiments showed a general decrease in populations in the fall. A bacterial population increase was observed in the Crop Residue treatment with periodic manure additions, when compared to the Crop Residue treatment with a fall burn and no addition of fertilizer.

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References

Albrecht, S. L., M.H. Gaskins, J.R. Milam, S.C. Schank, and R.L. Smith. 1983. Ecological factors affecting survival and activity of Azospirillum in the rhizosphere. Experientia 48:138-148.

Alexander, D. B.. 1998. Bacteria and archea. Pages 44-71 *in* D.M. Sylvia, J. J. Fuhrmann, P. G. Hartel, and D. A. Zuberer (editors). Principles and Applications of Soil Microbiology. Prentice-Hall, Upper Saddle River, NJ.

Bailey, R.W., and E. G. Scott. 1966. Methods for obtaining pure cultures. Pages 22-30 *in* Diagnostic Microbiology 2nd edition. Mosby Company, Saint Louis.

De Fede, K. L., and A. J. Sexstone. 2000. Differential response of size-fractionated soil bacteria in BIOLOG® microtiter plates. Soil Biology and Biochemistry 33:1547-1554.

Germida, J. J.. 1993. Culture methods for soil microorganisms. Pages 263-275 *in* M. R. Carter (editor) Soil Sampling and Methods of Analysis. Lewis Publishers, Boca Raton, FL.

Rasmussen, P.E. and R.W. Smiley. 1994. Long-term experiments at the Pendleton Agricultural Research Center. Columbia Basin Agricultural Research Annual Report 933:14-20.

Smith, D. M., and S. L. Albrecht. 2001. Fluorescein diacetate hydrolysis as a method of determining soil microbial activity in Columbia Basin silty loam soils. Columbia Basin Agricultural Research Center Annual Report 1026:111-117.

FROM WINTER BARLEY TO COLD BEER

Pat Hayes, Ann Corey, Tanya Filichkin, Luis Marquez-Cedillo, Steve Petrie, Karl Rhinhart, and Jari VonZitzewitz

Summary

Winter malting barley is a new crop opportunity for Pacific Northwest growers, based on new varieties of the world's oldest crop. In this report, we summarize a number of issues pertinent to winter malting barley variety development, including a brief review of the genetics of malting quality and winter hardiness, our breeding strategy, management issues, and economic issues.

Background

Winter malting barley offers the U.S. barley industry a new source of supply and Pacific Northwest (PNW) growers an alternative crop. Winter malting barley is an option to the weather- and disease-related risks of spring barley in the upper Midwest, weather-related risks and variable quality in western dryland spring barley, and the cost of western irrigated spring barley. In the PNW, we have a range of highly productive farming systems, ranging from dryland to irrigated. The winter rainfall pattern means that yields of winter barley on dryland can be as good, or better, than yields of spring barley under irrigation.

Water is a key resource in much of the West, and as a result optimum dryland production is an economically attractive option. Where winter cereals can be irrigated, as in parts of the Columbia Basin and the Snake River Plain, yields are phenomenal. Agronomic data on winter barley varieties and selections under dryland (Pendleton, Oregon and Pullman, Washington) and irrigation (Aberdeen, Idaho) are shown in Table 1. In the PNW, there are existing storage and transportation networks for malting barley, and these could be used for winter malting barley, which is harvested by mid-July, well before most of the U.S. spring barley crop.

Table 1. Agronomic and malting quality data for winter barley selections and check varieties; 1989-2001; average of data from Pendleton, OR, Pullman, WA, and Aberdeen, ID.

Variety/selection	Grain yield (lbs/ac)	Test weight (lbs/bu)	Grain protein (%)	Malt extract (%)	Diastatic power	Alpha amylase
88Ab536	5278	52	11.3	79.2	160	52.4
STAB 7	5920	52	10.9	79.9	140	56.5
STAB 47	5187	52	11.9	78.1	140	57.9
STAB 113	6419	53	10.0	80.1	130	51.1
KAB47	5532	52	11.0	79.8	120	62.3
KAB 51	5686	53	10.9	79.4	120	53.4
Strider	7408	51	NA[1]			
Kold	6764	52				
Hundred	6666	50				
Scio	6793	51				

[1]Strider, Kold, Hundred, and Scio are known to have unacceptable malting quality.

There are no winter barley varieties approved for malting by the American Malting Barley Association (AMBA) in commercial production in the United States. The variety '88Ab536', a winter six-row developed by Darrell Wesenberg (USDA/ARS, Idaho) was the first winter variety to meet AMBA quality specifications, but it is not in commercial production. This variety was a real breakthrough in terms of combining malting quality and winter hardiness. As detailed in the following sections on genetics and breeding, '88Ab536' is a cornerstone of our winter malting barley program. There are many winter malting varieties in commercial production in Europe (mostly two-row), although most of the barley acreage in Europe is spring two-row. The North American malting and brewing industries are rather unique in their preference for six-row. There are genetic, agronomic, and economic/political issues that need to be addressed in order to make winter malting barley an American reality. The key genetic issues are malting quality and winter hardiness. The key production issues are managing protein and tillage. The key economic/political issue is Federal crop insurance.

Genetics of malting quality and winter hardiness

Both winter hardiness and malting quality are complex traits that have been problematic for traditional breeding. New tools for working with these traits, which capitalize on DNA-based technologies, are quantitative trait locus (QTL) analysis, marker-assisted selection (MAS), and gene isolation. These biotechnology tools will allow plant breeders to more rapidly develop experimental lines for assessment as potential varieties. These tools are distinct from those used for introducing foreign genes into crop plants using transgenic technologies to produce genetically modified organisms (GMOs). At this time, there are no GMO barleys in commercial production in the U.S.

Malting quality is the most important value–added trait in barley. On the one hand, a number of genes are known that are important determinants of malting quality. Examples of such genes are alpha amylases and beta amylases. However, most of the genes determining malting quality are still unknown. Over the past 10 years, tremendous progress has been made in characterizing malting quality at the QTL level. The North American Barley Genome Project (NABGP) has devoted significant resources to describing malting quality genes and QTL in the variety 'Morex' -- the North American six-row malting quality standard. 'Morex' also happens to be one of the parents of '88Ab536', which puts us a step ahead in the winter malting barley game. We now have the opportunity to validate 'Morex' malting quality QTL alleles in a new genetic background and to use this information for developing superior winter malting varieties.

The focus of our genetics efforts is the 'Strider' x '88Ab536' (STAB) doubled haploid (DH) population. 'Strider' is an agronomically attractive winter six-row feed barley. Two lines in the STAB mapping population-- STAB 7 and STAB 113--have shown a malting quality profile that is in accordance with the industry guidelines and are candidates for a second year of testing in the AMBA program (Table 1). We are now genetically "dissecting" these selections in order to understand which genes they have inherited from '88Ab536' and which from 'Strider', since our goal is to combine '88Ab536' quality and 'Strider' yield.

Winter hardiness includes characters such as low temperature tolerance, vernalization requirement, and photoperiod response. It is a pretty fair generalization to say that rye and triticale are the most winter hardy cereals, followed by winter wheat, winter barley, and winter oats. There are overlaps, so that the most winter hardy barleys are superior to some of the less winter hardy wheats, etc. Over the years, we've been systematically unraveling the complexity of these winter hardiness traits in barley using QTL tools. We have identified a region on chromosome 7 of barley that harbors genes controlling all components of winter hardiness. In '88Ab536' this same region traces to its Nebraska winter-feed barley parent. '88Ab536' is unique in that it has low temperature tolerance but it does not require vernalization nor does it have strong photoperiod requirement. This attribute--winter hardiness with no growth habit "baggage"--has some exciting implications for developing facultative varieties, as will be described below in the section on management.

Breeding strategies

When we first heard about the malting quality and cold tolerance of '88Ab536', we immediately crossed it to our two best winter feed barley varieties--'Kold' and 'Strider'--in order to combine malting quality, yield, and stripe rust resistance. The first results were the 'Strider' x '88Ab536' (STAB) and 'Kold' x '88Ab536' (KAB) mapping populations. Two lines--STAB 7 and STAB 113--are candidates for a second year of AMBA quality testing and we are planning on submitting two KAB lines --KAB 47 and KAB 51--for their first year of AMBA evaluation in 2002. All of these selections have agronomic and disease resistance advantages over '88Ab536' and they have shown acceptable quality profiles in micro malting tests. All of these selections can be spring-sown, an attribute that is discussed further in the following section on management. However, none of these selections has the yield potential of the best feed barley varieties, and all have minor deficiencies in their malting profile. To remedy these defects, we are taking two strategies. One is to inter cross the best STAB and KAB selections and to rapidly advance progeny to homozygosity (true breeding lines) via a breeding technique called single seed descent. This technique involves running several generations per year through the greenhouse, using one seed to represent the initial sample of genetic combinations that were generated in the original cross. The first of these selections, together with progeny from other winter crosses, will be grown in head rows at Hyslop Farm this winter. Our second strategy is to use molecular markers to rapidly transfer cold tolerance and disease resistance genes and QTL alleles into the best contemporary spring six-row malting varieties. We will start this project in the greenhouse this winter.

Management

Genetics are clearly a critical aspect of winter malting barley, but once the overall genetics package is in place, management comes into play. In the 2000-2001 crop year, we started a series of experiments at the Columbia Basin

Agricultural Research Center, Pendleton. The key production issues we are studying are fertility management, rate and date of seeding, tillage regimes, and options for managing winter injury. We have generated 1 year of data on nitrogen management and dormant seeding and are putting in trials this year to address the other considerations. Please see the report in this publication by Petrie et al., "Nitrogen Management for Winter Malting Barley." Grain protein is a key "gateway" character for malting barley. Malting barley growers producing a specified variety will likely be required to meet specific targets, including a grain protein specification. For six-row barley, the current AMBA specification is 11.5 – 13.5 percent. In many PNW environments we are in the position of needing to raise grain protein; in much of the rest of the world, the challenge is to keep proteins below critical thresholds. In 2000-2001, we started a series of fertility management trials to manage grain protein in winter malting barley.

Genetic improvement of winter hardiness is a key objective of the breeding program goal, but based on past experience, gains will be modest and incremental. One option for PNW environments, where winter kill is not an annual event, is to maintain existing levels of cold tolerance but "breed out" a physiological trait often found in winter varieties--vernalization requirement. The other physiological trait often found in winter varieties, photoperiod sensitivity, may be quite convenient to retain and manipulateA variety that is cold tolerant and remains in a vegetative state due to sensitivity to short days will remain vegetative over the winter and re-grow in the spring. The same variety can also be dormant-seeded or spring planted and will grow and develop normally, once day length reaches a critical threshold. Accordingly, in 2000 we launched a series of experiments with the same varieties sown under different sowing dates (from October to April) and cropping systems. These trials will be repeated this season, and we added a study in which we will simulate winter injury and re-seed into the remaining stand with the same variety in the spring. We have also planted experiments to examine the effects of chloride and zinc on agronomic and malting quality traits.

Economics

Crop insurance availability can be an important factor in the decision to produce an alternative crop such as winter malting barley. Insurance is available for barley but it will not at this time provide coverage for winterkill of fall-sown barley. Winter barley can be insured if, upon inspection in the spring, the stand is considered adequate to produce a yield equal to the Actual Production History (APH). If the stand is determined to be adequate, the winter barley is then eligible for the feed grain portion of the insurance. If the barley variety is an AMBA - approved malting variety and is under contract with an end user, it is also eligible for the malt barley price and quality endorsement. Efforts are underway to make crop insurance available for winter barley.

Contacts

There are no winter malting varieties in commercial production and the best experimental varieties are still several years away from commercialization. We do have limited seed available for on-farm trials; please contact Pat Hayes (541-737-5878) if you are interested in looking at these selections in the 2002-2003 crop year. Great Western Malting is a key player in Pacific Northwest spring malting barley, and will play a key role in winter malting barley when varieties are available. For information on spring malting barley opportunities for the 2002 crop year, please contact the following Great Western Malting Co. representatives: Kevin Anderson (360-696-5493) or Greg Friberg (360-696-5482).

Acknowledgements

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PRECIPITATION SUMMARY - PENDLETON

CBARC - Pendleton Station - Pendleton, Oregon
(Crop year basis, ie; September 1 through August 31 of following year)

Crop Yr.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
72 Year Average	**.74**	**1.39**	**2.10**	**2.05**	**1.95**	**1.53**	**1.73**	**1.52**	**1.48**	**1.23**	**.35**	**.48**	**16.54**
1980-81	1.24	2.96	1.81	1.99	1.26	2.31	2.30	1.29	2.30	2.12	.40	.02	20.00
1981-82	1.51	1.62	2.41	3.27	2.61	1.86	1.99	1.54	.48	1.12	1.02	.50	19.93
1982-83	1.68	2.68	1.46	2.69	1.63	2.97	3.90	1.23	2.08	1.92	1.00	.68	23.92
1983-84	.82	.91	2.79	3.44	.99	2.56	3.23	2.37	2.11	2.05	.05	1.25	22.57
1984-85	.98	1.18	3.43	1.96	.69	1.49	1.33	.65	.89	1.42	.05	.98	15.05
1985-86	1.54	1.34	2.66	1.27	2.38	3.04	1.94	.83	1.79	.09	.61	.19	17.68
1986-87	1.87	.91	3.41	.95	2.08	1.31	1.85	.83	1.63	.62	.47	.06	15.99
1987-88	.04	0	1.44	1.61	2.60	.32	1.65	2.59	1.79	.94	0	0	12.98
1988-89	.40	.08	3.65	1.10	2.86	1.55	2.95	1.94	2.19	.33	.15	1.19	18.39
1989-90	.24	1.00	1.65	.49	1.43	.63	1.89	1.77	2.14	.70	.37	.76	13.07
1990-91	0	1.37	1.73	1.18	1.15	.86	1.71	1.01	4.73	2.22	.15	.24	16.35
1991-92	.03	.89	4.18	.97	.96	1.34	.85	1.29	.20	.90	1.74	.78	14.13
1992-93	.58	1.70	2.61	1.30	2.43	1.04	2.32	2.67	1.58	2.01	.47	2.60	21.31
1993-94	0	.30	.49	1.91	2.38	1.67	.52	1.18	2.88	.75	.33	.07	12.48
1994-95	.76	1.44	3.77	1.83	2.75	1.15	2.35	2.92	1.56	1.73	.22	.41	20.89
1995-96	.93	1.35	2.95	2.37	2.79	2.45	1.49	2.33	2.00	0.39	0	.05	19.10
1996-97	.66	1.99	3.05	4.23	2.74	1.60	3.00	2.46	.46	1.10	.36	.02	21.67
1997-98	.88	1.34	1.59	1.41	2.84	.87	1.43	1.30	3.12	..51	.18	.10	15.57
1998-99	1.24	0.40	4.71	2.96	1.18	2.16	1.23	.99	1.65	.61	.04	1.18	18.35
1999-00	0	1.75	2.17	1.88	2.39	3.35	3.39	.65	1.98	1.39	.31	0	19.26
2000-01	1.75	3.84	1.61	.84	1.29	.89	1.42	2.13	.75	1.47	.55	0	16.54
2001-02	0.36	1.91	1.88	1.02	1.36	1.33	1.41						
20 Year Average	**.82**	**1.38**	**2.55**	**1.89**	**1.97**	**1.69**	**2.04**	**1.62**	**1.82**	**1.16**	**.40**	**.53**	**17.87**

PRECIPITATION SUMMARY - MORO

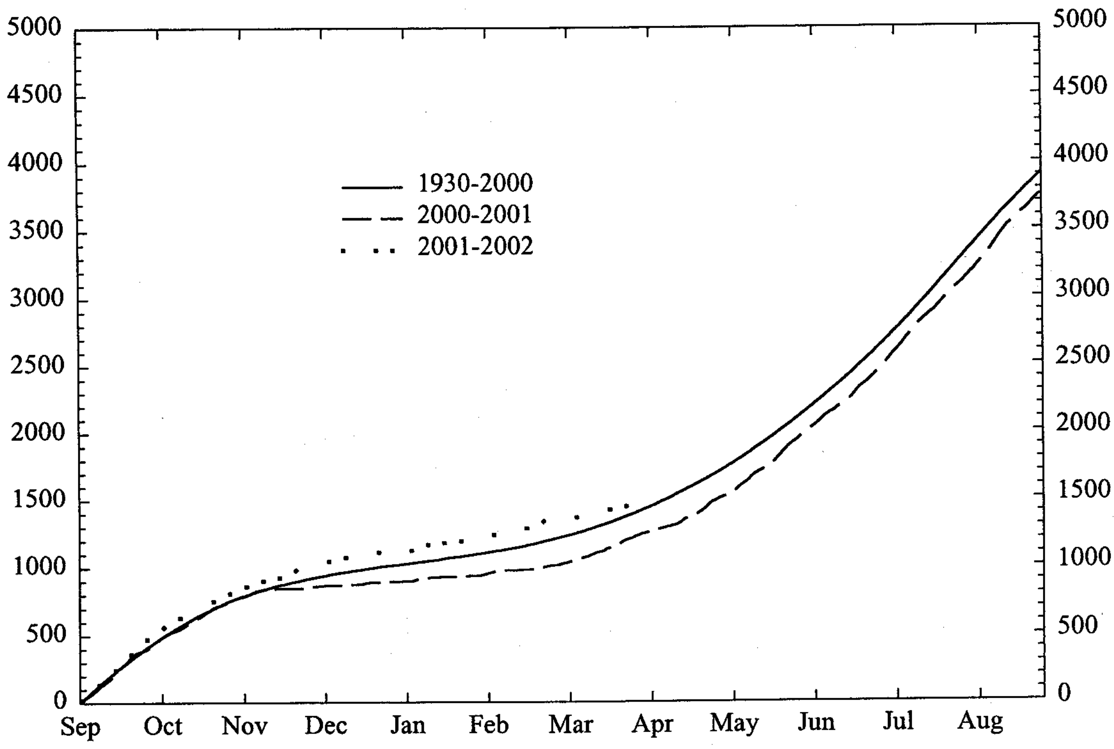
CBARC - Sherman Station - Moro, Oregon
(Crop year basis, ie; September 1 through August 31 of following year)

Crop Yr.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
92 Year Average	**.58**	**.92**	**1.70**	**1.62**	**1.63**	**1.17**	**.98**	**.79**	**.83**	**.67**	**.23**	**.28**	**11.40**
1980-81	.42	.79	1.73	2.95	1.52	1.22	.65	.41	1.06	1.15	.20	0	12.10
1981-82	.92	.82	1.99	4.73	1.10	.72	.55	1.45	.37	1.15	.21	.40	14.41
1982-83	1.42	1.96	1.08	1.89	1.40	2.43	2.74	.61	1.96	.39	.80	.60	17.28
1983-84	.52	.62	2.45	2.31	.17	1.07	2.34	1.32	.97	1.09	.17	0	13.03
1984-85	.53	.86	3.18	.41	.27	.97	.44	.14	.63	.92	.05	.14	8.54
1985-86	1.11	1.09	1.19	1.12	1.84	2.39	.98	.34	.35	.06	.54	.07	11.08
1986-87	1.52	.45	1.53	.78	1.68	1.10	1.54	.28	.99	.29	.78	.11	11.05
1987-88	.07	.01	.66	3.23	1.60	.21	1.25	2.21	.55	1.02	.04	0	10.85
1988-89	.56	.02	2.51	.22	1.33	.77	1.91	.84	.91	.08	.11	.50	9.76
1989-90	.07	.59	.96	.48	1.91	.17	.76	.79	1.36	.39	.15	1.43	9.06
1990-91	.29	1.27	.61	.74	.87	.60	1.43	.40	.77	1.27	.33	.16	8.74
1991-92	0	1.40	2.57	1.02	.47	1.64	.64	2.38	.04	.28	.81	.02	11.27
1992-93	.68	.85	1.50	1.68	1.42	1.47	1.68	1.22	1.42	.87	.39	.30	13.48
1993-94	.02	.09	.41	.68	1.40	.90	.55	.40	.62	.61	.11	.07	5.86
1994-95	.19	2.27	1.79	.90	3.67	1.18	1.14	1.95	.97	1.45	1.10	.17	16.78
1995-96	1.02	.64	3.20	2.20	1.86	2.43	.65	1.57	1.44	.36	.15	.03	15.55
1996-97	.55	1.56	2.63	4.18	1.57	.84	1.28	1.26	.55	.56	.13	.57	15.68
1997-98	.46	1.61	.66	.29	2.49	1.30	1.02	.66	3.15	.26	.26	.06	12.22
1998-99	.38	.16	2.57	1.34	1.34	1.00	.51	.06	.56	.11	.09	.23	8.35
1999-00	0	.83	1.62	.62	1.77	2.43	.76	.44	.48	.20	0	0	9.15
2000-01	.30	1.39	.60	.35	.43	.53	.81	.71	.34	.50	.02	.23	6.21
2001-02	.53	1.03	2.02	1.17	.68	.65	.42						
20 Year Average	**.53**	**.92**	**1.69**	**1.53**	**1.43**	**1.21**	**1.13**	**.93**	**.93**	**.62**	**.31**	**.24**	**11.45**

CUMULATIVE GROWING DEGREE DAYS

(BASE = $0^{\circ}C$)

PENDLETON



MORO