1992 COLUMBIA BASIN AGRICULTURAL RESEARCH

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COLUMBIA BASIN AGRICULTURAL RESEARCH

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CONTENTS

INTRODUCTION

Staffs of the Columbia Basin Agricultural Research Center (CBARC-Oregon State University; Pendleton and Sherman Stations) and the Columbia Plateau Conservation Research Center (USDA-Agricultural Research Service; Pendleton) are proud to present results of their research. This bulletin contains a representative sample of the work in progress at these Centers. A collection of bulletins over a three-year period will give a more complete assessment of the productivity and applicability of research conducted on behalf of producers in eastern Oregon and comparable agricultural regions. Changes in staffing, programming, and facilities at these Centers during the past year are summarized below.

PROMOTIONS AND AWARDS

Don Wysocki was awarded tenure by Oregon State University, in recognition for his dynamic program in soil science and cropping systems.

Within the USDA, Larry Baarstad and Rich Greenwalt were promoted. Merit cash awards were given to Dale Wilkins and Betty Klepper in recognition of the consistently high quality of their work. Sue Waldman received a cash award for her efforts on behalf of the Equal Employment Opportunity program, especially for her work with teen-aged girls on mathematics and science programs.

STAFF CHANGES

Several transitions occurred among Oregon State University staff. Tom Chastain resigned from the crop science position to accept a grass seed agronomy position at Corvallis. Scott Case's position at the Sherman Station was eliminated in response to financial stress experienced by the Columbia Basin Agricultural Research Center. Susan Dunnagan joined the wheat breeding program as a biological research technician, to replace Karen Morrow, who resigned. Judy Elliott became the office clerical assistant after Nancy All resigned. Oman Wilcox worked as a laborer on special projects for five months at Pendleton. Rodney Rolfe accepted a position to assist with weather records and landscape maintenance at the Sherman Station. Dr. Bart Duff served for four months as a consulting economist working on the historical crop management experiments at Pendleton.

For the USDA staff, two temporary employees, Cody Johnson and Amy Cullimore worked for an 8-week period last summer on a special ARS program for Research Apprentices in Agriculture. Pat Frank resigned to take up a position at the Umatilla Army Depot. This position was abolished due to budget constraints. The temporary soil microbiology position, held by Hal Collins, terminated on September 30, 1991 and he left for a position at Michigan State University. Phaedra Hawkins resigned her position as a Federal Junior Fellow. New funds were appropriated for 1992 and a permanent soil microbiology position has become available. We expect to fill this position in the summer.

NEW PROJECTS

Dan Ball and Tom Chastain, in cooperation with Dale Wilkins and Peggy Chevalier (WSU), began a project intended to extend food legume production into low rainfall areas of Oregon and Washington. Dan Ball also initiated studies on environmental factors influencing pea injury from lactofen. This work is part of a Federal program to seek replacements for the herbicide Dinoseb. Don Wysocki initiated a project to develop suitable protocols for use in on-farm tests conducted by growers. This is a cooperative project with other extension scientists in Oregon, Washington, and Idaho, and is funded by the STEEP program. Don Wysocki and Tom Chastain also amplified the scope of their investigations on production practices for oilseed rape. Paul Rasmussen and Richard Smiley became part of an international program directed by the Rockefeller Foundation, in which issues of soil sustainability are being examined on suitable long-term experiments at six locations around the world. Dr. Bart Duff was employed to accumulate all records from the historical experiments into a single computerized data base that can be utilized by additional investigators, and can be disseminated to prevent loss by fire or other accident.

The USDA staff received a grant from the Administrator for postdoctoral research on hydrology which will involve the development of relationships between weather data and runoff data. This work will be initiated in the summer.

FACILITIES

New siding was installed on the office building at the Sherman Station and the herbicide lab and experimental chemical storage unit at the Pendleton Station were thoroughly renovated. A special Federal appropriation acquired by the Oregon Wheat Grower's League was used to construct a new greenhouse and headhouse (potting shed) at Pendleton.

Budget restrictions precluded much work on facilities. We did repair the parking lot, and we are planning to upgrade the shop building with new insulation, lighting and heating. We recently purchased a touch-tone telephone system.

TRAINING

Training by OSU staff was limited to an office management workshop attended by Gloria Eidam and Nancy All. Most technical and field staff participate in continuing education to maintain pesticide applicator licenses.

USDA staff took courses at Blue Mountain Community College, (Tami Toll, Elementary and Intermediate Algebra; Probability and Statistics, and Katherine Skirvin, Intermediate Algebra; Probability and Statistics). Larry Baarstad completed training on the repair and maintenance of agricultural tractors. Classes on government purchasing procedures named Basic Field Acquisition (Sharron Wart), and Advanced Field Acquisition (Phil Dailey). Phil Dailey also completed Personnel Management Training. Carol Brehaut and Sharron Wart finished PC Shortcuts and time and attendance record keeping courses. Betty Klepper and Paul Rasmussen both took courses on management skills. Employee Performance Evaluation training was completed by Betty Klepper, Ron Rickman, Paul Rasmussen, and Dale Wilkins. Rich Greenwalt took a course on advanced trouble shooting for microcomputers. Daryl Haasch attended "Designing a Healthy Workplace" in conjunction with our health maintenance program. Sue Waldman, installation and maintenance of the telephone system. One-third of the staff updated their Red Cross First Aid training and all eligible staff received an update of CPR training.

VISITORS

Drs. Philippe Lucas and Francoise Montfort, from the French government's experiment station at Le Rheu, concluded a one-year study leave in which they worked with Richard Smiley. Dr. Lucas examined a biological decline phenomenon occurring with Rhizoctonia root rot in the long-term experiments at Pendleton. Dr. Montfort studied the influence of fungicide seed treatments on strawbreaker foot rot and plant growth and development. Ms. Lisa-Marie Gillespie-Sasse also concluded a nine-month study period with Richard Smiley. Ms. Gillespie-Sasse participated in investigations of physiologic leaf spot of winter wheat.

The USDA staff hosted a one-month visit from Dr. Guy Lafond from the Indian Head Experiment Station in Saskatchewan, Canada. Dr. Lafond worked with Ron Rickman, Sue Waldman, and Betty Klepper on developing a modular spring wheat growth model.

Visitors hosted by staff at the Center included Isvan Jori, National Institute of Agric. Engineering, Hungary; Keith Campbell, Pocatello, ID; R. C. Ostrowski, Greeley, CO; David L. Priebe, Oregon Dept. of Agriculture, Salem, OR; Dan Nelson, Moses Lake, WA; Ron Zabudsky, Portland, OR; Alex Ogg, Pullman, WA; K. Adams, Renton, WA; Tim Leathers, NCAUR, ARS, Peoria, IL; Tanner Wray, Peggy Beavers, Keith Russell, and Ted Sibia from the National Agricultural Library staff; Gerald Crawford, Athena, OR; Jeff McMorran, Hermiston, OR; M. Sasaki, Portland, OR; Hiroshi Toyokawa, Chiba, Japan; Karen Ceniga, Pendleton, OR (United Way); Ellen Bishop, EOSC, La Grande, OR; Michael J. Smith, UC Coop Ext., Paso Robles, CA; Graham Wildermuth, Queensland Wheat Research Institute, Towoomba, Australia; Gordon Macnish, Western Australia Dept. of Agriculture, Esperance; Thayne Dutson, Bruce Sorte, and Van Volk, OSU Agric. Expt. Stn., Corvallis; Stella Coakley, OSU Dept. of Botany and Plant Pathology, Corvallis; Cm J. Weiser, OSU College of Agricultural Sciences, Corvallis.

Other visitors included numerous representatives of equipment and chemical companies, news media, wheat producers, extension agents, and faculty and staff from research and extension programs in Washington, Idaho, and Oregon.

SEMINARS

The seminar series at the Center was coordinated by Tom Chastain. Seminars included the following speakers and subjects: Istvan Jori, National Institute of Agric. Engineering, Hungary (conservation tillage and machinery in Hungary), Graham Wildermuth, Queensland Wheat Research Institute, Australia (soilborne diseases of wheat in sub-tropical regions of Australia), Ron Rickman, USDA-ARS, Pendleton (root length density of winter wheat in wet and dry seasons), Betty Klepper, USDA-ARS, Pendleton (stand establishment and seedling development on soft white winter wheat cultivars), Sue Waldman, USDA-ARS, Pendleton (sensitivity analysis of Shootgro II and MODwht, two winter wheat growth and development models), Thomas Chastain, OSU, Pendleton (planting quality of preharvest sprouted wheat seed), Ann Kennedy, USDA-ARS, Pullman, Washington (biological control of grass weeds), Russ Karow, OSU, Corvallis (around the UK in 120 days -- an agronomist's views (and slides) on UK agriculture), John Zuzel, USDA-ARS, Pendleton (temporal variation of runoff and soil erosion at a site in northeastern Oregon), Dale Wilkins, USDA-ARS, Pendleton (tillage tool for enhancing water infiltration through frozen soil), Don Wysocki, OSU, Pendleton (effect of seeding date and variety on yield and yield components of dryland Canola), Richard Dick, OSU, Corvallis (long-term effects of residue and nitrogen management on nutrient availability and soil biology), Paul Rasmussen, USDA-ARS, Pendleton (long-term agricultural experiments at Pendleton), Joni Hammond, Oregon Department of Environmental Quality, Pendleton (structure and function of the Department of Environmental Quality), Richard Smiley, OSU, Pendleton (management of soilborne pathogens affecting small grains in the rainfed semiarid Pacific Northwest), Daniel Ball, OSU, Pendleton (weed seed response to tillage and crop rotational sequences), Guy Lafond, Agriculture Canada, Saskatchewan (agronomy research at the Indian Head Experimental Farm: past, present, and future), Dale Coats, OSU, Madras (effects of post-harvest residue management on grass seed yield and quality), David Granatstein, Washington State University, Pullman, Washington (sustainable dryland farming: what does it mean?), Gordon Macnish, Western Australia Dept. of Agriculture, Esperance (an Australian perspective of Rhizoctonia bare patch of cereals and legumes).

LIAISON COMMITTEES

The Pendleton and Sherman Station Liaison Committees have region-wide representation and provide guidance in decisions on staffing, programming and facilities and equipment improvement at the Stations. Membership is by appointment by the Director of the Oregon Agricultural Experiment Station and also, at Pendleton, by the Director of the Pacific West Area, USDA-ARS. These committees provide a primary communication linkage among growers and industry and the research staff and their parent institutions. The Committee Chairman and OSU and USDA administrators encourage and welcome your concerns and suggestions for improvements needed in any aspect of the research centers or their staffs. The Pendleton Station Liaison Committee, led by Chairman John Rea (Touchet, WA.: 509-394-2430), met on November 7. The Sherman Station Liaison Committee, led by Chairman Steve Anderson (Arlington: 503-454-2513), held meetings on June 28, August 30, October 25, December 5, February 4, and May 6.

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 1991-1992. The Oregon Wheat Commission continues to provide the critical support upon which many of the Center's projects are founded. Thanks are also given to those who donated equipment for long-term use by the Center (George Moreau, Kaye McAtee, John Rea, and Joe Temple), funds, seed, and/or chemicals (Monsanto Chem. Co., CIBA-GEIGY, duPont, Wilbur-Ellis Co., Sandoz, Pendleton Grain Growers, American Cyanamid, Premier Edible Oils, San Diego State University Foundation, SeedTec International Inc., McGregor Co.), or loaned equipment or facilities (John Rea, John Correa, Frank Tubbs, James Moore, Soil Conservation Service, USDA-ARS-Pullman, OSU Dept. of Soil Science, and the Agric. Engineering Dept., Washington State University). Services in field plot tillage and seeding were also provided by Clint Reeder, Tremain Rea, Dennis Rea, and Don Meiners.

We also acknowledge those who donated labor, supplies, equipment or funding for the Pendleton Field Day: Umatilla County Ag Lender's Assoc. (Security Pacific, U.S. Bank, Inland Empire Bank, First Interstate Bank, Farm Credit Services), Kessler's Catering, American-Hoechst, Athena Agriculture Equipment, Farm Equipment Headquarters, Inc., Huntington-Price, ICI Americas, Inc., Monsanto Company, Rhone-Poulenc Ag Co., Inland Chemical Service, Inc., Maxi-Gro Fertilizer & Chemical Co., The McGregor Co., Uniroyal Chemical Company, Valent Chemical Company, Western States Equipment Company, Pendleton Flour Mills, Inc., Pioneer Implement Corp., PureGro, Smith Frozen Foods, Inc., Tri-River Chemicals, Inc., Wheatland Insurance, Pendleton Grain Growers, Pendleton Senior Center, Main Street Cowboys, Umatilla County Wheat Growers League, Farm Equipment Headquarters, Inc., Frank Tubbs, and Robert Hopper; we thank the Moro Field Day donors: Monsanto Company, Morrow County Grain Growers, Mid-Columbia Producers, Inc., PureGro, Farm Chemicals, Sherman County School District, M & S Farm Supply, Western Tillage Equipment Company, and Lean To Restaurant.

Cooperative research plots at the Center were operated by Warren Kronstad, Patrick Hayes, Chris Mundt, Russ Karow, and the Soil Conservation Service (SCS). We also thank the SCS District Conservationists in Oregon and Washington for their assistance. Additionally, we are very thankful for the ever-present assistance and leadership from the Extension Service personnel in all counties of the region, and especially from Umatilla, Union, Sherman, Morrow, Gilliam, Wallowa, and Wasco Counties and from Columbia and Walla Walla Counties in Washington. We also wish to thank the 30 farmers who have allowed us to work on their property during the past year, and who have often gone the extra mile by performing field operations, loaning equipment, donating chemicals, and adjusting their practices to accommodate our plots. The locations of these outlying sites are shown on the map that follows.

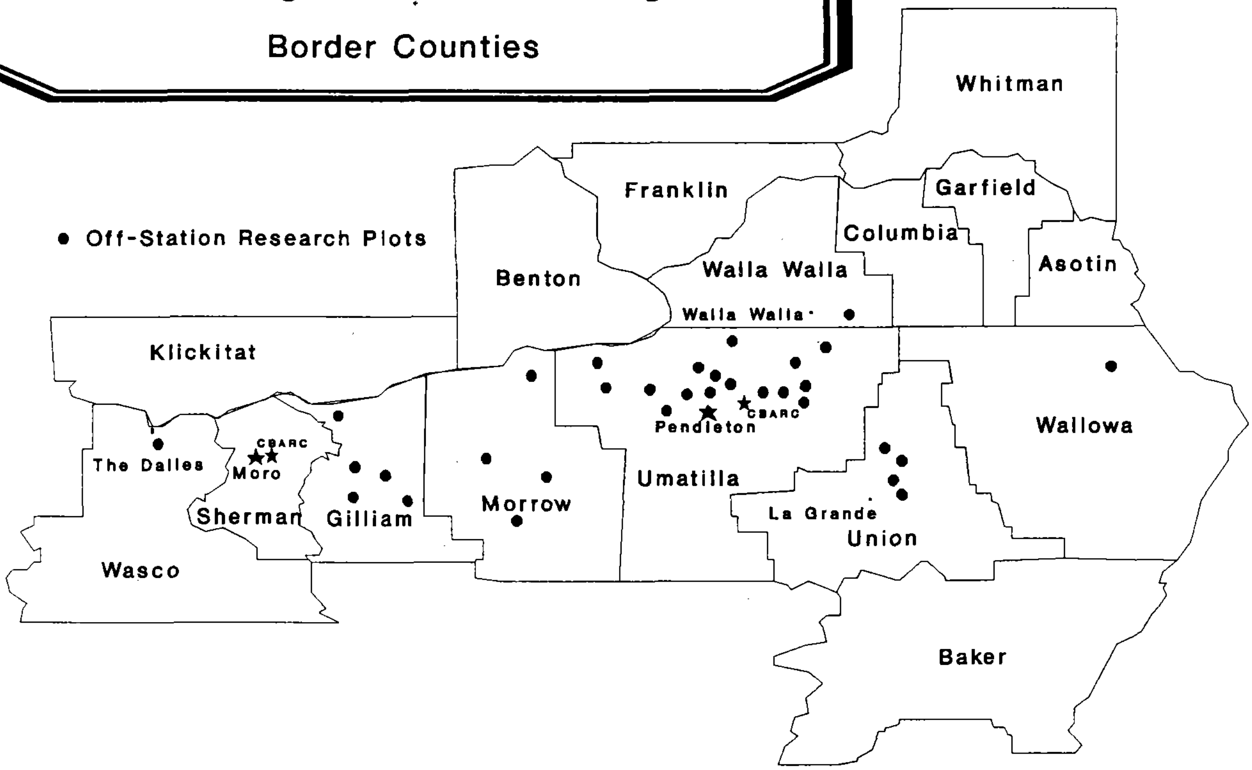
We truly appreciate the support and encouragement of growers, organizations, and businesses with a mission common to ours: to serve in the best manner possible the crop production needs of our region. We welcome your suggestions on how we may continue to improve our attempts to reach this goal.

Richard Smiley	Betty Klepper
Superintendent	Research Leader
OSU-CBARC	USDA-ARS-CPCRC

RESEARCH PLOT LOCATIONS

Eastern Oregon - Eastern Washington

Border Counties



GILLIAM, OREGON
Steve Anderson
Richard Harper
Vince Hill
Jordan Maley
Jack Osterlund
Henry Wilkins

MORROW, OREGON
Eric Anderson
Doug Drake
Jim Key
Ken Turner

SHERMAN, OREGON
Sherman Station

UMATILLA, OREGON
John Adams
Berk Davis
Doug Harper
Charles Hemphill
Hermiston Station
Fritz Hill
Bob Johns
Kaye McAtee
Orval McCormmach
Pendleton Station
Don Pinkerton
Tremayne Rea
Clint Reeder
Leon Reese
Sherman Reese
Robin Rew
Calvin Spratling
Joe Temple
Frank Tubbs
Larry Williams

UNION, OREGON
Elwyn Bingaman
Forest Bowman
John Cuthbert
Don Starr

WALLA WALLA, WA
Donald Meiners

WALLOWA, OREGON
Doug Wulff

WASCO, OREGON
Paul Schanno

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AUTHOR AFFILIATIONS

Berdahl, John, Professor, North Dakota State University, Fargo, North Dakota

Bolton, Floyd E., Emeritus Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Chastain, Thomas G., Assistant Professor, Department of Crop and Soil Science, Oregon State University, Pendleton, Oregon

Dunnagan, S. D., Biological Research Technician, Columbia Basin Agricultural Research Center, Pendleton, Oregon

Haasch, D. A., Engineering Technician, USDA-ARS, Columbia Plateau Conservation Research Center, Pendleton, Oregon

Hayes, Patrick M., Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Karow, R. S., Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Kelly, D. K., Biological Science Research Technician, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Knight, R. W., Senior Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Kolding, M. F., Senior Instructor, Hermiston Agricultural Research and Experiment Center, Oregon State University, Hermiston, Oregon

Kronstad, W. E., Distinguished Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Love, C. S., Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Moore, M. D., Senior Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Ott, Sandra, Biological Science Research Technician, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

Rowe, S. E., Faculty Research Assistant, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Schillinger, William F., Former Graduate Research Assistant, Crop Science Department, Oregon State University, Corvallis, Oregon

Scott, N. H., Senior Instructor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Smiley, Richard W., Superintendent and Professor, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

Stoltz, Michael, Umatilla County Extension Agent and Professor, Oregon State University, Pendleton, Oregon

Sutherland, D. L., Faculty Research Assistant, Columbia Basin Agricultural Research Center, Pendleton, Oregon

Uddin, Wakar, Faculty Research Assistant, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

Verhoeven, M. C., Instructor, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

Ward, Kathy J., Faculty Research Assistant, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

Wilkins, D. E., Agricultural Engineer, USDA-ARS, Columbia Plateau Conservation Research Center, Pendleton, Oregon

Wysocki, Don, Assistant Professor, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

Zwer, P. K., Assistant Professor, Columbia Basin Agricultural Research Center, Oregon State University, Pendleton, Oregon

RESIDUE MANAGEMENT FOR EROSION CONTROL

R. Rickman, D. Wilkins, C. Douglas, and R. Adleman

INTRODUCTION

Crop residues on the soil surface provide adequate protection from soil erosion by water. Most conservation management plans require certain minimum amounts of residue on the soil surface after planting. The loss of crop residue from the soil surface after harvest, through any fallow period and during planting can be controlled by the selection and operation of tillage equipment. The purpose of this manuscript is to illustrate the effects of initial residue amount, biological decomposition, choice of tillage tools, and tool operation on loss of surface residue between harvest and planting of a subsequent crop.

METHODS

The tillage implement residue burial information presented is obtained from the table of General Crop Residue Retention Factors from the 1988 SCS Tech. note no. 22. Decomposition is projected with the residue decomposition model of Douglas and Rickman (1992). Decomposition of crop residue is dependent upon: the initial nitrogen content of the residue, its placement (whether on the surface or buried), whether the field is cropped or fallowed, and air temperature. For the figures presented, weather data from the 1981-82 crop year at the Pendleton Experiment Station were used. Tillage system options were selected to illustrate the relative amount of residue burial by some common tools and the effect that timing and speed of operations can have on final residue amounts. Two starting residue amounts (4000 and 2000 lb/A) were used in the tillage systems. The tillage sequences for each system are listed in Table 1.

DISCUSSION

The initial amount of residue in a field must be known in order to make an informed choice of tillage practices. Winter wheat will usually produce from 80 to 110 lb/A residue for each bushel/A of grain produced. Tall cultivars will produce different residue to grain ratios than dwarf cultivars. The taller the cultivar, characteristically, the higher the residue to grain ratio. Unusual water, nutrient, or pest stresses, can also cause these values to change. The safest practice for providing an accurate measure of residue present after harvest is to obtain weights of bundle samples collected from a known area (such as 5 to 6 feet of a row) from several different places in a field. The grain plus residue weight of the bundles from a known area can be used with the combine harvested grain yield per acre to compute the residue weight in the field.

Residue [lb/A] = {bundle wt [lb] * 43560 [ft^2/A] / bundle area [ft^2]} - harvest yield [bu/A] * test weight [lb/bu]

bundle area [ft^2] = bundle row length [ft.] * row spacing [inches] / 12

Crop residue will begin decomposing as soon as it remains wet or comes in contact with wet soil. The loss of weight to decomposition is relatively slow but steady. Decomposition is fastest for residue buried in warm wet soil and slowest for residue laying on the soil surface.

For example, Figure 1 depicts the residue weight lost due to decomposition in an undisturbed field, contrasted with tillage system 1 (Table 1) used on two fields with different starting residue amounts. Tillage

Table 1. Tillage operations in four tillage systems.

System no.	Month	Day	Tillage - description	Residue buried
				(%)
1	Mar	28	Disk - 4 to 6" deep	40
	Apr	1	Sweep - 16" spacing 4 to 6" deep - with Rod weeding	10 + 5, total of 15
	May	14	Rod weeding	5
	June	14	Fertilze - with Rod weeding	10 + 5, total of 15
	Sept	1	Rod weeding	5
	Sept	11	Seed, semi-deep furrow	15
2	Mar	12	Chisel - using straight shank, 18" spacing, pull faster than 5 mph	15 + 5 + 5, total 25 - extra residue buried because of wet soil and high speed
	Mar	16	Sweep - 16" spacing, 4 to 6" deep - with Rod weeding	10 + 5, total of 15
	May	14	Rod weeding	5
	June	14	Fertilize	10
	Sept	1	Rod weeding	5
	Sept	14	Seed, semi-deep furrow	15
3	Apr	20	Chisel - using straight, 18" spacing, pull slower than 5mph	15
	Apr	28	Sweep - 16" spacing, 4 to 6" deep - with rod weeding	10 + 5, total of 15
	June	1	Fertilize and rod weeding	10 + 5, total of 15
	Sept	1	Rod weeding	5
	Sept	14	Seed, semi-deep furrow	15
4	Mar	28	Plow, no trash boards, 6 to 8" deep	85
	Apr	1	Field cultivator with Rod weeding	-15 + -5, total of 20 when done soo after plowing, actually brings some residue back to surface
	May	14	Rod weeding	5
	June	14	Fertilize and Rod weeding	10 + 5, total of 15
	Sept	1	Rod weeding	5
	Sept	11	Seed, semi-deep furrow	15

system 1 uses a disk for the initial tillage. It results in 860 and 430 lb/A of residue remaining on the surface for starting amounts of residue of 4000 and 2000 lb/A, respectively. The top line in Figure 1 illustrates that decomposition of residue reduced the initial 4000 lb/A to 2600 lb/A in 12 months. Tillage system 1 left only 1/3 as much residue on the soil surface after planting as compared to a field with natural decomposition during the same period.

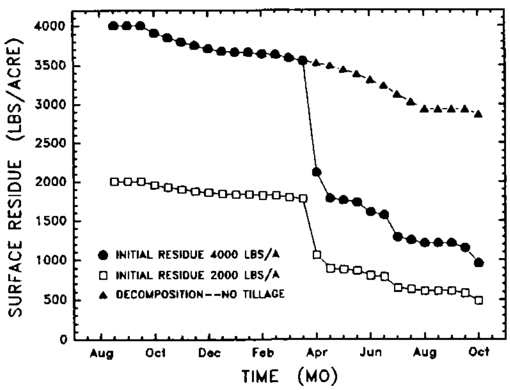

Figure 1. Effect of tillage (system 1), initial amount of residue and decomposition on amount of crop residue remaining on the soil surface during a fallow period.

In Figure 2, tillage system 1 and system 4 are compared with a starting residue amount of 4000 lb/A. When the plow is used for primary tillage (system 4), all but 320 lb/A of the residue (in contrast to 860 lb/A with the disk of system 1) is lost from the soil surface by the time planting of the next crop is complete. The difference in primary tillage implement makes a large difference in the burial of the residue. Burial with tillage implements most frequently causes a much greater loss of surface residues than decomposition.

Tillage tools bury less surface residue when soils are dry than when they are wet. Tool speed also will change the amount of residue buried. The faster the speed, the greater of residue buried. In Figure 3, systems 2 and 3 illustrate the effect of timing and speed of operation of the equipment for a starting amount of residue of 2000 lb/A. By delaying an operation by a month, allowing the soil to dry during that time, and keeping the speed of the tool below 5 mph makes the difference between leaving sufficient protective residue on the soil surface or failing to meet residue cover goals.

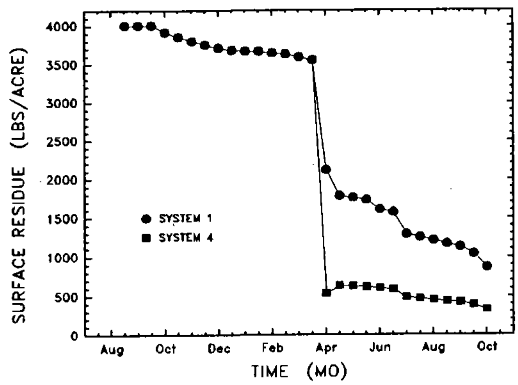

Figure 2. Comparison of amount of residue remaining on the soil surface with two tillage systems.

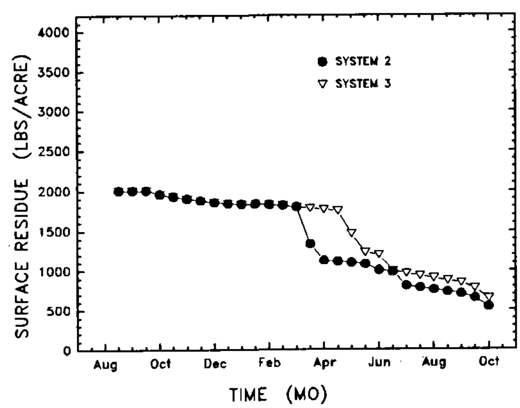

Figure 3. Effect of speed and time of tillage on the amount of residue remaining on the soil surface.

CONCLUSIONS

1. It is important to know the amount of residue in a field after harvest. The amount of residue present will determine tillage options available to achieve a desired amount of residue cover after planting - 15 months later.

2. Tillage reduces the amount of surface residue abruptly. Natural decomposition reduces surface residues slowly but steadily.

3. Implement selection, timing of use, and speed of use determine the amount of crop residue buried by any tillage operation. Conscious choice among these options provide many alternatives for maintaining sufficient cover to reduce erosion while controling weeds and conserving water.

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CEREAL EMERGENCE AND ESTABLISHMENT IN CONSERVATION TILLAGE SYSTEMS

Thomas G. Chastain and Kathy J. Ward

Suboptimal stands are a major limitation to the adoption of conservation crop production systems in dryland areas. Understanding the interactions of the seed and seedling with crop residues and soil physical factors could aid in elucidating the causes of suboptimal stand establishment and provide suggestions for remedying stand establishment problems. Rapid and uniform emergence is essential to reduce the erosive effects of rain, wind, and runoff. A rapidly emerging crop is more likely to be competitive with weeds, survive attack from pests, and to produce a crop high in yield and quality.

The water potential of seed is very low in relation to the water potential of soil, consequently, the seed takes up water from the small volume of soil surrounding it. Sufficient seed hydration for germination depends on soil water potential, soil hydraulic conductivity, seed characteristics, and seed-soil contact. Since more crop residues are present in conservation tillage seedbeds, seed-soil contact and hydraulic conductivity are reduced. Thus, less water may be available to the seed for germination and to the seedling for emergence. Seedbed conditions required for optimum stands need to be defined and the effect of suboptimal conditions on stand establishment needs to be characterized.

Cereal species and cultivars may have different water requirements for germination and emergence. These differences in water requirement may be due to seed coat properties, seed size, seed matric potential, or unknown factors. Superior stand establishment may also be attributed to greater seed weight, protein content, coleoptile length, cellular membrane integrity, and enzyme activity.

The objectives of our study were to (i) identify critical seed and soil water contents required for germination and emergence in conservation tillage seedbeds, and to (ii) identify genetic differences among winter wheat and barley cultivars for characteristics that contribute to improved stand establishment under conservation cropping practices.

MATERIALS AND METHODS

Field trials were seeded on 4 October 1990 and 3 October 1991 at the Pendleton Station of the Columbia Basin Agricultural Research Center. Three crop residue levels were obtained in 1990 by performing different skew-treading operations. High, moderate, and low crop residue cover levels were achieved in 1991 by the following primary tillage operations: chisel, disk, and plow, respectively. Crop residue levels in the seedbed were measured by the line transect method after seeding and soil water content in the seed zone was determined by gravimetric methods (Table 1). Stephens and Daws (common-type winter wheat), Hyak and Moro (club-type winter wheat), and Hesk and Boyer (winter barley) seed were sieved and placed into large and small size classes representative of the population of each crop type. Each size class was seeded so that comparisons could be made under equal plant population conditions (18 seeds/ft^2). Post-emergence stand counts were made on 12 dates after seeding in 1990 and on 20 dates in 1991.

Crop growth and development characteristics were measured on samples taken on 8 March 1991. Plots were harvested with a plot combine on 29 July 1991. Seed water uptake and germination over a range of seedbed water potentials were studied in controlled environment experiments by using polyethylene glycol (PEG) solutions.

RESULTS AND DISCUSSION

Wheat seed water content increased from approximately 5 to 30 percent in the first 24 hours after seeding, but soil water content in the seed zone did not change appreciably during the first four days after planting. Wheat radicles (seedling root) were evident one day after planting. By comparison, barley radicles were observed two days after planting. Barley needed one additional day to reach the 30 percent moisture level. Thus, the critical seed water content required for germination under field conditions is about 30 percent for both wheat and barley. Wheat and barley seedlings emerged from the soil nine days after radicle protrusion.

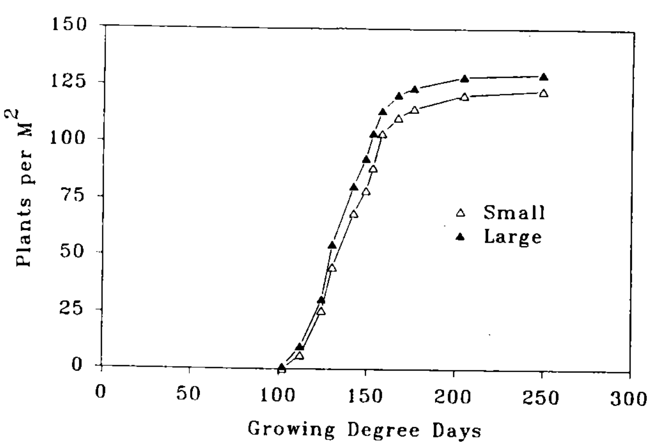

Figure 1. Influence of wheat seed size on seedling emergence in 1990. Emergence values are averaged over cultivars and crop residue levels.

Wheat seedlings produced from large seeds emerged more rapidly than small seed, but plant density was not increased by large seed in 1990 (Figure 1). Laboratory germination of large and small seed classes was not different. Field emergence rate of wheat cultivars was strongly influenced by seedling coleoptile length (Table 2). Seed size did not affect seedling coleoptile length, so the superior performance of large seed could not be attributed to coleoptile length. Moro and Stephens seedlings emerged more rapidly than Daws and Hyak seedlings in 1990, but there were no stand density differences among cultivars (Figure 2). By the following spring, plants produced from large seed were taller and heavier, had a more developed main stem, and had more T1 tillers than plants produced from small seed (Table 3). Residue cover had no effect on seedling emergence, or plant growth and development in the 1990-91 trial. Stephens and Moro plants were heavier and taller than Hyak and Daws plants. Common wheats had more T1 and T2 tillers than club wheats.

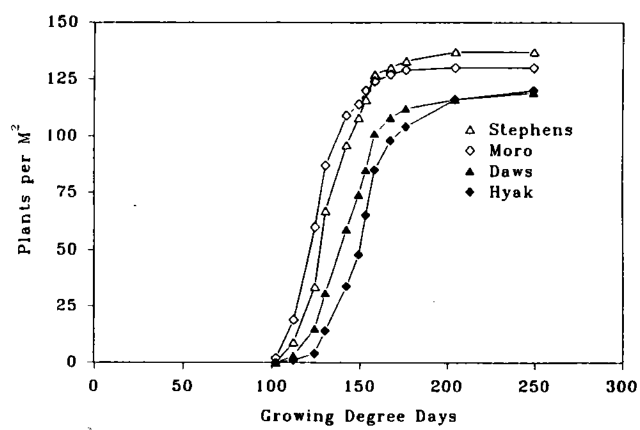

Figure 2. Seedling emergence response of common- and club-type winter wheats in 1990. Emergence response values are averaged over seed size and crop residue levels.

Crop residues had no effect on production of wheat heads and yield, but test weight was reduced by 45 percent residue cover (Table 4). Large wheat seed produced plants that had more heads than small seed, but test weight, 1000-seed weight and yield were not affected by seed size. Hyak and Daws produced fewer heads than Stephens and Moro. Stephens exhibited the best grain yield, test weight, and 1000-seed weight. Daws and Hyak produced similar grain yields, whereas Moro had less than the expected yield because of early lodging of the crop. Common wheats had higher test weights than club wheats.

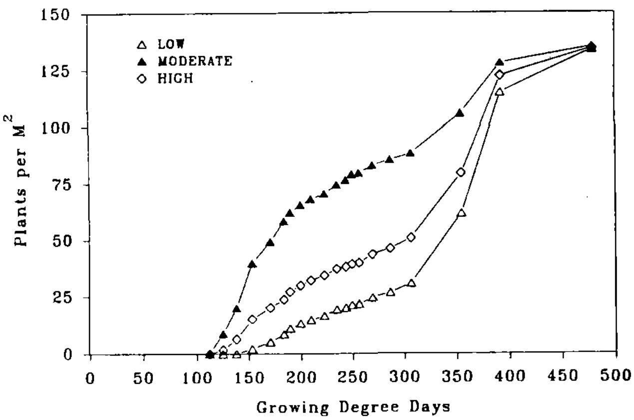

Figure 3. Effect of crop residue on wheat seedling emergence in 1991. Seedling emergence values are average over seed size and cultivar.

Emergence in the 1991-92 trial was strongly influenced by crop residue during the first 300 growing degree days after seeding (Figure 3). Emergence of wheat seedlings was more rapid in moderate residue plots (39 percent) than in high (49 percent) or low (17 percent) residue plots. Soil water content was greatest in high residue plots, but the presence of high residue levels in the seedbed likely reduced seed-soil contact and resulted in poorer water uptake by seeds. Significant rains occurred about 300 growing degree days (GDD) after seeding, resulting in much wetter seedbed conditions than those indicated in Table 1. Emergence in the high and low residue seedbeds improved dramatically after the seedbeds were thoroughly wetted so that plant densities were nearly identical among the crop residue levels at 475 GDD. Thus, high crop residue levels in the seedbed are more likely to cause poor stands when less than optimal seed zone water is present.

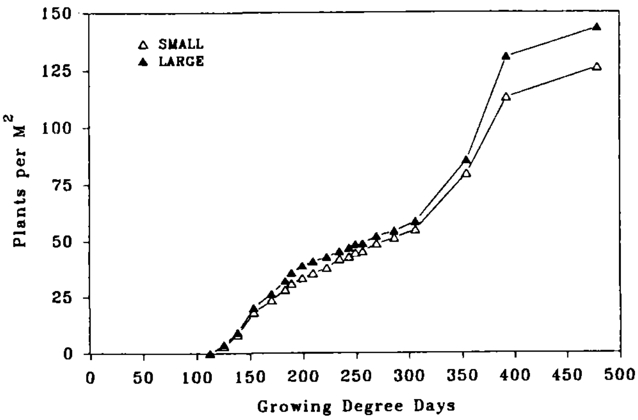

Figure 4. Influence of wheat seed size on seedling emergence in 1991. Emergence values are average over seed size and cultivar.

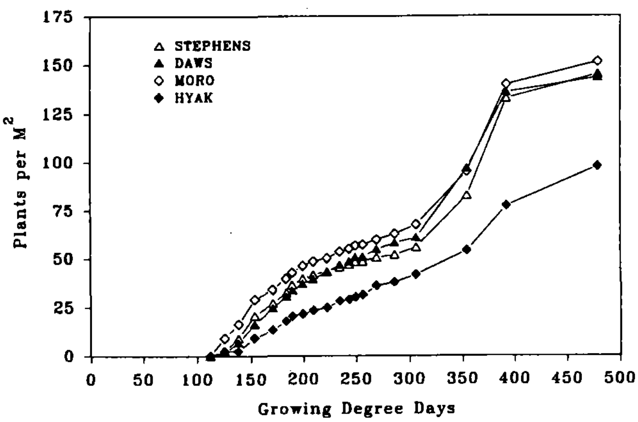

Figure 5. Seedling emergence response of common- and club-type winter wheats in 1991.

Emergence of large and small seed was similar when seedbeds were relatively dry prior to 300 GDD, but emergence of seedlings from large seed was more rapid when moist seedbed conditions were present (Figure 4). Unlike in 1990, emergence of Daws was not different from Stephens and Moro (Figure 5). Hyak exhibited poorer emergence than the other three cultivars.

Crop residue cover had no effect on barley stands or growth, but head production was reduced by 45 percent residue cover and test weight was reduced by 39 percent and 45 percent residue cover (Table 5). Barley seedlings produced from large seeds emerged more rapidly and produced higher density crop stands than small seeds. Plants grown from large seeds were heavier by spring, but seed size had no other effect on growth, development or yield. However, plants grown from large seed yielded more plump grain than plants grown from small seed. Hesk and Boyer exhibited similar emergence rates, consequently, final stand densities and grain yield were also similar. Boyer plants were heavier than Hesk plants, but produced lower test weight grain than Hesk.

Seed water uptake and germination over a range of seedbed water potentials were studied in controlled environment experiments by using PEG solutions. Water uptake by small Moro wheat seed was more rapid than large seed because small seeds have a greater surface area to volume ratio. Radicle emergence from the seed was delayed and reduced proportionally by increased water stress, but small seed exhibited better radicle emergence than large seed under stress conditions. Research on water uptake by other wheat and barley cultivars will continue.

Anticipated results of this study will be used in an interdisciplinary effort to alleviate problems associated with cereal stand establishment. The potential benefits of understanding the processes of cereal stand establishment in conservation tillage seedbeds include the identification of seedling selection criteria for improvement through plant breeding and as an aid in the design of seeding equipment.

SUMMARY

Laboratory germination of large and small seed was not different, however, field emergence of large seed was more rapid. Large seed produced larger plants than small seed, but yield was not affected by seed size. Growth, development, and yield were not affected by crop residue, but test weight was reduced by high residue in the seedbed. The critical seed water content for wheat is about 30 percent under field conditions. Cultivars that demonstrate superior emergence, growth, development, and yield in low residue seedbeds also exhibit superior performance in high residue seedbeds.

Table 1. Crop residue cover and seed zone water content at seeding.

Residue cover	1990			1991		
	Cover	Range	Water	Cover	Range	Water
	%					
Low	32	21-40	18.2	17	13-23	11.3
Moderate	39	33-48	18.5	39	31-44	12.0
High	45	36-54	19.7	49	41-60	13.6

Table 2. Effect of cultivar and seed size on wheat seedling coleoptile length.

Cultivar	Seed size	
	Small	Large
	---------- Inches ---------	
Stephens	2.7B[†]	3.0B
Daws	1.8A	1.8A
Moro	3.0B	2.6B
Hyak	1.7A	1.9A
Average	2.3	2.3

[†] Means in columns followed by the same letter are not significantly different.

Table 3. Effect of crop residue cover at seeding, seed size, and cultivar on wheat growth and development.

Residue cover	Plant density	Dry weight	Height	Mainstem Haun	Tillers				
					T0	T1	T2	T3	T4
%	#/ft^2	Grams/ft^2	In.		%-Plants				
32	11A[†]	7.2A	7.2A	5.8A	1A	51A	84A	88A	29A
39	12A	7.4A	7.3A	5.7A	2A	48A	82A	86A	29A
45	11A	7.4A	7.5A	5.8A	2A	54A	83A	86A	32A
Seed size									
Small	11A	6.6A	7.2A	5.7A	1A	43A	80A	85A	29A
Large	12A	8.2B	7.5B	5.8B	2A	59B	86A	88A	31A
Cultivar									
Stephens	13A	9.9C	8.0D	5.7B	2A	64B	87C	76A	9A
Daws	10A	6.3A	6.9A	5.8B	4B	63B	91C	94C	31B
Moro	12A	7.9B	7.5C	6.2C	1A	43A	81B	92C	67C
Hyak	10A	5.5A	7.1B	5.5A	0A	35A	71A	86B	12A

[†] Means in columns followed by the same letter are not significantly different.

Table 4. Effect of crop residue cover at seeding, seed size, and cultivar on wheat yield components.

Residue cover	Head density	Grain yield	Test weight	1000 Seed weight
%	#/ft²	Bu/A	Lbs/bu	Grams
32	37A†	80.5A	61.3B	41.4A
39	39A	76.6A	61.3B	42.0A
45	34A	76.5A	61.1A	41.5A
Seed size				
Small	34A	76.9A	61.2A	41.7A
Large	39B	78.8A	61.2A	41.6A
Cultivar				
Stephens	37B	88.3C	62.0C	53.0D
Daws	32A	78.7B	61.2B	43.6C
Moro	46C	65.7A	60.9A	32.6A
Hyak	31A	78.8B	60.8A	37.4B

† Means in columns within residue cover, seed size, and cultivar levels are not significantly different when followed by the same letter.

Table 5. Effect of crop residue cover at seeding, seed size, and cultivars on barley growth, yields, and yield components.

	8 March 1991			16 July 1991			
Residue cover	Plant density	Dry weight	Height	Head density	Grain yield	Test weight	Plump gain (6/64th)
%	#/ft²	Grams/ft²	In.	#/ft²	Lb/A	Lb/bu	%
32	11A†	9.4A	6.2A	34B	6700A	46.4B	84.7A
39	11A	11.1A	6.5A	36B	6667A	45.9A	84.6A
45	12A	10.3A	6.4A	28A	6049A	45.5A	84.3A
Seed size							
Small	10A	8.3A	6.3A	31A	6434A	45.9A	83.9A
Large	12B	12.2B	6.4A	34A	6509A	46.0A	84.1B
Cultivar							
Hesk	11A	9.2A	6.3A	32A	6475A	46.2B	85.0A
Boyer	12A	11.3B	6.3A	33A	6469A	45.7A	84.1A

† Means in columns within residue cover, seed size, and cultivar levels are not significantly different when followed by the same letter.

LATE SEASON COMPACTION EFFECTS ON SEED ZONE WATER RETENTION IN SUMMER FALLOW

William F. Schillinger and
Floyd E. Bolton

Loss of seed zone water from summer fallow in the Pacific Northwest is relatively low during most of the summer but seems to accelerate in late August and September (Russelle, 1979). This acceleration of water loss is caused by the increasingly low night time temperatures that occur in late summer which rapidly reduce soil surface temperatures while higher temperatures exist at lower depths (Boersma and Jackson, 1979). Water loss from fallow soil during the summer occurs mainly as vapor through soil pores. As water vapor moves from warm to cooler portions of the soil, considerable soil water loss may occur (Hillel, 1982).

The objective of this study was to determine if altering the physical characteristics of the surface of a dust mulch during the period of large diurnal temperature changes in August and September would reduce seed zone water loss from fallow. We theorized that compacting the soil surface would reduce soil porosity and increase the path length (tortuosity) which water vapor had to travel to reach the soil surface. We knew, however, that compaction of the soil surface would also increase the rate of heat conduction through the soil. Our hypothesis was that the positive effects of reduced pore size and increased tortuosity on water vapor movement outweigh the negative effects of increased soil thermal conductivity. If the hypothesis is true it would result in reduced loss of seed zone water.

MATERIALS AND METHODS

The two year experiment was conducted during August and September of 1990 and 1991 at the Sherman Experiment Station in Moro, Oregon. Experimental design was a randomized block with four replications. Four soil surface treatments were established:

1. Plow Control: Moldboard plow for initial tillage in late March to create a bare soil surface, followed by 3 to 4 rod weedings.

2. Plow Compacted: The same as treatment 1 except that the soil surface was compacted in August.

3. Stubble Mulch Control: Sweep plow for initial tillage in late March, followed by 3 to 4 rod weedings.

4. Stubble Mulch Compacted: The same as treatment 3 except that the soil surface was compacted in August.

On August 15 in both 1990 and 1991 the soil surface of treatments 2 and 4 were compacted by making one pass through each plot with a roller attached behind a rod weeder and pulled by a small crawler tractor. The roller, constructed from an old water heater, was 6 feet long with an 18 inch diameter. The roller weighed 1,570 pounds after it was filled with water. Following the rolling operation, soil bulk density and volumetric water content were determined from both compacted and control treatments at 0.8 inch increments to a depth of 4 inches using an incremental soil sampler developed by Pikul et al. (1979). A tractor mounted hydraulic soil probe was used to take core samples for bulk density and volumetric water determination at 2 inch increments from the

4 to 12 inch soil depth. Between September 18-21 of both 1990 and 1991 soil volumetric water content was again obtained from these depth intervals using the same procedure.

RESULTS

In 1990 there was 1.72 inches of rain during the study period, almost three times the 30 year mean, of which more than 80 percent occurred between August 15-30. Differences between maximum and minimum daily temperatures were less than normal during this period of unusually high rainfall, but returned to normal upon cessation of rainfall in early September. In 1991 the opposite extreme occurred; there was only trace amounts of rainfall and differences between maximum and minimum daily temperatures were much greater than normal during August.

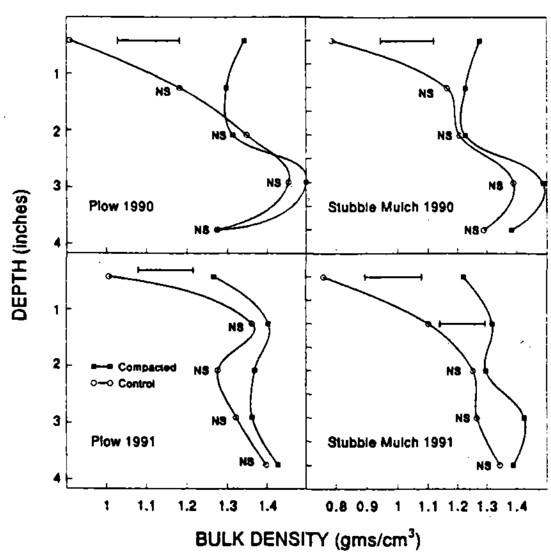

Figure 1. Soil bulkdensity in the surface 4 inches of plow and stubble mulch tillage systems as affected by compaction

The change in soil bulk density in the surface 4 inches due to compaction is shown in Figure 1. The effects of compaction were quite pronounced near the soil surface in both plow and stubble mulch tillage systems during both years. The largest bulk density difference between compacted and control treatments occurred in the top 1 inch and decreased proportionally with soil depth. Of interest, in 1990 the high bulk density rod weeding pan can be clearly seen at the 3-inch depth in both plow and stubble mulch systems, whereas it is more difficult to distinguish in 1991.

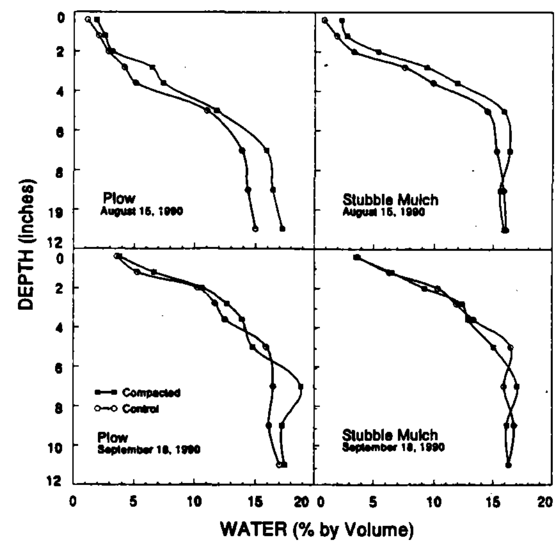

Figure 2. Soil water (% by volume) in the surface 12 inches of plow and stubble mulch tillage systems as affected by compaction in 1990.

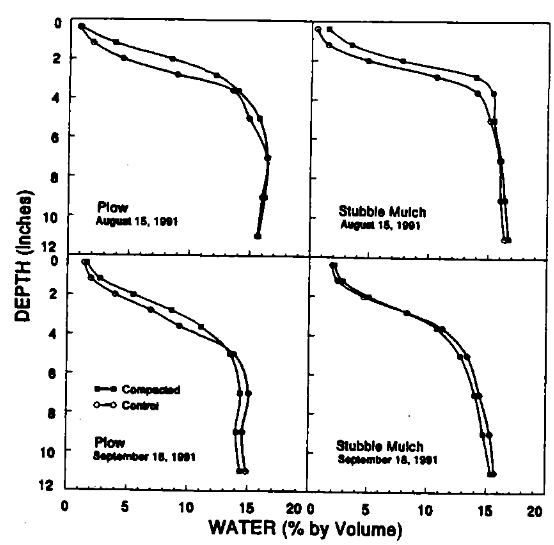

Figure 3. Soil water (% by volume) in the surface 12 inches of plow and stubble mulch tillage systems as affected by compaction in 1991.

Volumetric water content of compacted and control treatments measured on August 15-18 and September 18-21 in 1990 and 1991 is presented in Figures. 2 and 3, respectively. In 1990, significant differences in volumetric water content between control and compacted treatments occurred to a depth of 4 inches in the plow system and to 2.5 inches in the stubble mulch system. This was the result of increased bulk density and reduction of the thickness of the dust mulch layer by compaction. Total water in the 0 to 12 inch soil profile in August was increased by 14 percent in the plow and 7 percent in the stubble mulch system as an immediate result of compaction. Because of the unusually high rainfall that occurred during the 1990 study period, all treatments held more water at the end of the study period than in mid-August, thus reducing the usefulness of the 1990 data for the purpose of this study.

In 1991, significant increases in mid-August volumetric water content were in the top 3 inches measured in the compacted and control treatments for both the plow and stubble mulch systems. Total water in the 0 to 12 inch depth of compacted plots was increased by 6 percent in the plow tillage and 7 percent in the stubble mulch tillage over control treatments. Water loss occurred at a much faster rate from compacted than from control plots. The plow compacted treatment lost 15 percent of 0 to 12 inch soil water between August 15 and September 18 while only 10 percent of soil water was lost from the plow control treatment. Similarly, 16 percent of the 0 to 12 inch soil water in the stubble mulch compacted treatment was evaporated between August 15 and September 18 while the control treatment lost only 8 percent. Figure 3 clearly shows that water in the moist soil below rod weeding depth in both the compacted plow and stubble mulch systems was slightly greater than that of control treatments in August, but less than that of control treatments in September.

The results from this experiment lead us to hypothesize that the thermal conductivity of compacted treatments was higher than that for control plots, resulting in accelerated water loss from compacted plots between mid-August and mid-September. This is opposite our original thoughts which were that the compaction effects of reduced soil porosity and increased tortuosity might outweigh those of increased thermal conductivity.

CONCLUSIONS

Although water loss occurred at a faster rate in compacted treatments in this experiment, the initial effect of compaction was to significantly increase the quantity of water to a soil depth as great as 4 inches. This could have important practical implications. Growers often postpone planting winter wheat past the optimum sowing date due to lack of sufficient seed zone water. The seed zone generally extends down to 6 inches. In a relatively dry soil a small increase in water content can produce a marked increase in wheat germination and emergence rate (Hanks and Thorp, 1956). During such years of marginal seed zone water, compacting the soil surface immediately before planting with a roller similar to that used in this experiment may result in enhanced seed germination and emergence. Rate of seed zone water loss after planting on compacted soils could be expected to be less than measured in the experiment because differences in maximum and minimum daily temperature are reduced during late September and October. In addition, wheat seedlings, once emerged, would run little risk of drought injury since precipitation normally increases considerably beginning in early October.

Growers commonly conduct a final rod weeding operation immediately prior to seeding wheat to insure a clean seedbed. The roller used in the experiment was pulled behind a rod weeder because, we feel, grower acceptance of new technology is largely contingent on how well the technology fits within their accustomed field practices. A farm-scale roller could be: (1) fabricated at a relatively low cost; (2) easily pulled by conventional tractors, and; (3) hitched behind a rod weeder during the normal weeding operation prior to seeding, therefore requiring no additional field operations by the grower.

Compacting the surface of a dust mulch with a roller is a concept that has some potential for increasing economic returns in the wheat-fallow production regions of the Pacific Northwest, thus further testing of this concept appears warranted. Logical extensions of this research might include the effects of various levels of soil surface compaction by a roller on: (1) soil susceptibility to wind erosion, and; (2) the rate of wheat seed germination and emergence, and quality of stand establishment.

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SUMMER FALLOW WATER STORAGE OF NO-TILL VERSUS CONVENTIONAL TILLAGE IN THE PACIFIC NORTHWEST

William F. Schillinger and
Floyd E. Bolton

Research on soil water storage of summer fallow in the Pacific Northwest has mainly focused on comparisons of moldboard plow versus various minimum-till stubble mulch systems. Papendick and Miller (1977) reported that stubble mulching conserves more soil water compared to bare soil. Massee and McKay (1979) reported that while stubble mulching will result in cooler soil and lower initial water evaporation rate, mulched soils may, after sufficient drying time, dry to nearly the same water content as clean fallow. Ramig and Ekin (1991) found no differences in fallow efficiency (FE) between plow and stubble mulch tillage systems in a six year study conducted at two locations in eastern Oregon.

Only limited research has been conducted on water storage under no-till fallow in the Pacific Northwest. Oveson and Appleby (1971) found that total water, both in the seed zone and in the entire 1.8 m profile, was reduced in no-till plots compared to conventional spring tilled treatments in a study conducted in a 13-inch annual rainfall area in eastern Oregon. Lindstrom et al. (1974) reported similar results from a study conducted in a 9.5-inch rainfall zone in eastern Washington where spring tillage was used compared to chemical fallow.

The objective of this research was to determine rate and extent of soil water loss from no-till, stubble mulch, and moldboard plow fallow systems throughout the fallow season.

MATERIALS AND METHODS

Data reported in this study were collected between October 1989 and September 1991 at Oregon State University's Sherman Experiment Station in Moro, OR. The soil at the experiment site is a Walla Walla silt loam (mixed, mesic Typic Haploxeroll) overlying basalt bedrock. Average annual precipitation for this location is 12 inches. Precipitation during the 1989-90 and 1990-91 fallow periods was 80 and 90 percent of normal, respectively. The experiment site received less than normal annual precipitation for the past seven years.

A tillage trial was initially established in 1981 to evaluate the long-term effects of three fallow management treatments on grain yield. Two adjacent plots of land were used so that data could be collected each year from both crop and fallow phases of the experiment. As the treatments have remained on the same plots since 1981, soil biological and physical conditions within treatments were assumed to be at equilibrium. The three treatments were: (A) Moldboard plow spring tillage to create a bare soil surface, followed by 3 to 4 rodweedings; (B) sweep plow for initial spring tillage to create a stubble mulch, followed by 3 to 4 rodweedings, and ; (C) no-till, where weeds were controlled with herbicides and the soil was disturbed only at planting by a strip-till planter (Bolton and Booster, 1981). Rodweeding operations and herbicide applications were made only when needed for weed control. Each treatment was replicated four times in a randomized block design.

Data on soil water status were

collected during each of two 14-month fallow periods. Three access tubes were installed in each plot where soil volumetric water content of the 2 to 5 ft depth was measured in 1 ft increments with a neutron probe. The volumetric water content of the surface 1 ft was measured gravimetrically in two 6-inch core samples.

RESULTS AND DISCUSSION

The results of soil water storage during two fallow seasons as affected by tillage system are presented in Tables 1 and 2. During both years, initial soil water was low at time of harvest (beginning of fallow). Differences among treatments at the beginning of fallow were small but were evident by early spring prior to primary tillage. Over-winter FE was highest for the stubble mulch treatment during both years of the study. There was little difference between plow and no-till over-winter FE

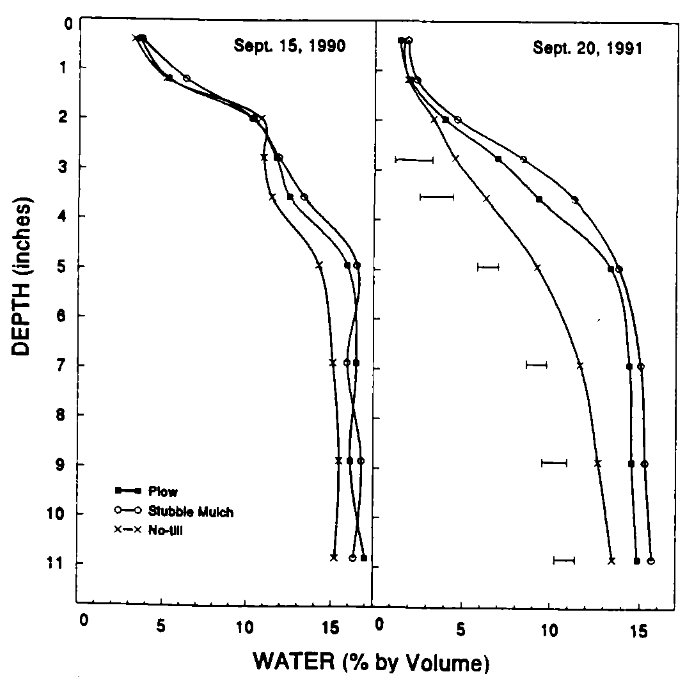

Figure 1. Seed zone water (% by volume) as affected by tillage system at the end of the 1989-90 and 1990-91 fallow seasons. Bars represent LSD 0.05 differences at each sampling depth.

Differences in over-winter seed zone water accumulation between stubble mulch and plow treatments gradually diminished during the spring and summer until, at the end of fallow in both years, there were no significant differences in seed zone water (Figure 1). Total profile water and FE, however, were significantly higher in the stubble mulch than in the plow treatment at the end of both fallow seasons (Tables 1 and 2).

The no-till system lost both seed zone and total profile water at an accelerated rate during the hot-dry summer months. Loss of water from the no-till treatment was hastened during both summers by soil capillary continuity, whereas the continuity of the capillary channels in conducting water from the subsoil to the soil surface were effectively broken in the plow and stubble mulch treatments. Tables 1 and 2 show that FE was lowest for no-till during both years. Seed zone water at the end of both fallow periods is presented in Figure 1. Unusually heavy rainfall occurring in late August minimized treatment differences in seed zone water in 1990. Diminished seed zone water in no-till is readily apparent in 1991.

Insufficient seed zone water is a major limitation to establishment of fall-sown wheat in the semi-arid Pacific Northwest. Small increases in seed zone water content can produce a marked increase in wheat germination and emergence. Low FE and accelerated seed zone water loss would appear to severely limit the potential for no-till technology on summer fallowed soils in the semi-arid Pacific Northwest.

Table 1. Water (cm) and fallow efficiency (FE) in 150 cm (5 ft.) soil profile as affected by tillage system during the 1989-1990 fallow season.

	Tillage Treatment						
	Plow		Stubble Mulch		No-till		
Date	Water[1]	FE	Water	FE	Water	FE	P-Value
10-6-89	12.51 a	-	12.16 b	-	11.73 c	-	.0240
3-20-90	21.84 ab	73	22.23 a	79	21.36 b	75	.0004
5-15-90	20.78 ab	51	21.23 a	56	19.68 b	49	.0475
6-03-90	21.02	43	22.66	53	21.52	49	.2266
7-19-90	20.53 a	38	21.66 b	45	17.78 c	29	.0001
9-15-90	20.36 a	31	21.51 b	37	18.56 c	29	.0198

[1] Within row means not followed by the same letter are significantly different at P=0.05.

FE = Fallow Efficiency % = (Net gain soil water / Fallow season precipitation) X 100.

Table 2. Water (cm) and fallow efficiency (FE) in 150 cm (5 ft.) soil profile as affected by tillage system during the 1990-1991 fallow season.

	Tillage Treatment						
	Plow		Stubble Mulch		No-till		
Date	Water[1]	FE	Water	FE	Water	FE	P-Value
7-17-90	11.53 a	-	11.66 a	-	12.89 b	-	.0003
3-20-91	19.15 a	44	21.53 b	57	20.14 c	42	.0003
4-25-91	16.83 a	28	18.81 b	37	17.86 c	26	.0000
5-18-91	17.20 a	27	18.98 b	34	19.02 b	29	.0000
6-06-91	16.70 a	24	18.19 b	30	18.04 b	23	.0002
7-24-91	16.68 a	20	18.07 b	25	16.67 a	15	.0000
8-16-91	16.37 a	19	17.46 b	22	16.47 a	14	.0000
9-20-91	15.75 a	16	16.92 b	20	15.81 a	11	.0000

[1] Within row means not followed by the same letter are significantly different at P=0.05.

FE = Fallow Efficiency % = (Net gain soil water / Fallow season precipitation) X 100.

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VARIETY AND PLANTING DATE EFFECTS ON DRYLAND CANOLA

Don Wysocki, Sandra Ott, Michael Stoltz, and Thomas Chastain

INTRODUCTION

Canola production studies at the research center are part of a program to develop alternative rotational crops with winter wheat. Currently, non-cereal crops are grown in rotation on only 5 percent of the nearly 2 million acres devoted to dryland cereal production in semiarid Oregon. This is unfortunate because an increasing amount of inputs are needed to maintain productivity on cereal cropping systems without crop rotation. The disease and weed management and soil improving benefits of crop rotation have been clearly demonstrated in the semiarid region of the Pacific Northwest and elsewhere. Growing a non-cereal crop in rotation with wheat will provide growers with opportunities to diversify and enhance their long-term economic stability and improve the sustainability of farms and soils, while reducing inputs.

Unfortunately for most of semiarid Oregon, market demand or rainfall is too low to economically produce traditional non-cereal crops such as peas and lentils. In addition, the federal farm program has historically discouraged the production of non-cereal crops in the region. However, recent changes in farm legislation permit the production of non-program crops without penalty on a percentage of the crop base. There is a need to develop management strategies for non-cereal rotation crops new to semiarid Oregon such as canola, white lupin, and small-red lentils. This paper reports some initial results of canola production trials.

Canola or low erucic acid rapeseed (*Brassica napus* or *Brassica campestris*) is a cool-season oilseed crop. It is a relatively new crop in eastern Oregon, though it has an established market and a worldwide acreage. The word "canola" was introduced by Canadians and it is an abbreviated form of "Canada oil low acid". Production acreage for canola in eastern Oregon was about 7,000 acres in 1990-1991 and about 15,000 acres for 1991-1992. Most information on dryland canola production for the Pacific Northwest has been developed by researchers at the University of Idaho, at Moscow, ID. Although Idaho researchers have done excellent work, additional research is required to develop production recommendations specific for eastern Oregon.

SEEDING DATE AND VARIETY TRIALS

The response of canola to seeding date in eastern Oregon is not known. Research in Idaho showed that late August seedings were optimum in that environment. We felt optimum seeding dates would be later in eastern Oregon because our seasonal progression is delayed by two to three weeks. Furthermore, very little is known about variety performance for winter or spring canola in eastern Oregon. To gather this basic information, we began canola variety and seeding date trials at the Pendleton Agricultural Research Center in the autumn of 1990. Winter canola trials consisted of 13 varieties planted at three planting dates, whereas spring trials consisted of three varieties seeded at two dates (Table 1).

Peas were grown in the plot area in 1989 and was in summer fallow in 1990. During the summer of 1990, a wind break of

Table 1. 1990-1991 winter and spring canola variety and seeding dates at the Columbia Basin Agricultural Research Center, Pendleton, Oregon.

Varieties			Seeding Dates
		Winter Trials	
Arabella	Ariana	Aztec	September 1
Cascade	Casie	Ceres	September 20
Dorado	Humus	Legend	October 10
Onyx	Semundo 5/87	Semundo 17/88	
Tapidor			
		Spring Trials	
Legend	Moneta	ST 400	March 7 April 1

mature Austrian pines was removed from an adjacent area. The plot area received considerable wheel traffic as a result of this activity.

In August, to relieve compact soil conditions from this traffic the plot area was chiseled twice in a criss-cross pattern, then cultivated and fertilized. The plot area received 80 lb/acre nitrogen as anhydrous ammonia. To prepare the seed bed for winter canola, the area was irrigated with 2.5 inches of water and then rodweeded. No herbicides were applied. A randomized complete block design with four replications for varieties was used. Plot size was 5 X 20 feet.

Winter canola plots were seeded with 6 lb seed/acre using a Hege plot drill equipped with a cone distributor and fitted with Gaines (hoe) openers at 12-inch row spacing. The targeted seeding depth was 1.5 inches. However, the Gaines openers did not consistently place seed at the desired depth. Seed placement actually ranged from 0.5 to 2.5 inches. Stand establishment was adequate although not uniform. Spring canola was seeded at the same seeding rate by using the same drill fitted with double disk openers at 12-inch row spacing. Seeding depth was 1 inch and stand establishment was uniform.

Canola seeded on September 1 and 20 over-wintered as small rosettes, whereas canola plants seeded on October 10 over-wintered in the three to four leaf stage. Lowest minimum over-winter air temperatures occurred in December. Data are presented in Table 2. Although minimum air temperatures were severe, even the small plants in the October 10 seeding suffered no winter kill because of the snow cover that existed during the cold period. Stands in other areas of eastern Oregon that lacked snow cover were killed by winter temperatures.

Appearance of first bloom in the earliest varieties for the September 1, September 20, and October 10 was April 2, April 10, and April 25 respectively. Differences in plant height, canopy closure, and plant maturity during April and May were small between the September 1 and

September 20 seedings. In contrast, the October 10 seeding was markedly shorter, had a much more open canopy, and plants were later maturing. Plants in the October 10 seeding were delayed in development, had a shorter growing period, and matured later when conditions were hotter and drier.

Table 2. Occurrence of lowest daily minimum air temperatures and corresponding snow cover for winter 1990-1991, Columbia Basin Agricultural Research Center, Pendleton, Oregon.

Date	Minimum Air Temperature (F°)	Snow Cover (inches)
December 20	-10	3
December 21	-25	3
December 22	-24	2
December 23	-13	2
December 24	-11	2
December 25	-8	2
December 29	-26	7
December 30	-22	7

Alleyways between plots were mown on April 24. On May 19, 1.57 inches of rain fell, causing the plots to lodge. Although lodging had a spatial pattern, it was unrelated to varieties or seeding date. Spodanam was aerial applied on July 5 to deter pod shatter. Harvest began on July 11 and was completed on July 23. Because lodging caused overlapping of individual plots, plants in each plot were hand cut and windrowed. After a 24-hour drying period, plants were hand fed through a Hege 140 plot combine equipped with canola sieves. Nominal combine adjustments were 1/8 inch concave clearance, 900 RPM cylinder speed and 1000 RPM fan speed. Yields for each seeding date are presented in Table 3.

Table 3. 1990-1991 yield of winter and spring canola by seeding date averaged over all varieties.

Seeding Date	Yield (lb/acre)	LSD
	Winter	
September 1	3090 A	360
September 20	3132 A	
October 10	2099 B	
	Spring	
March 7	1234	NS
April 1	1017	

SEEDING DATE AND VARIETAL YIELDS

Yields for fall and spring seedings averaged over varieties are presented in Table 3. Planting date had a significant effect on yield of both winter and spring canola. Yields for the September 1 and September 20 planting dates were similar. However, yield was significantly lower for the October 10 planting date; yield was 1033 lb/acre less than September 20 and seeding date. This is nearly 52 lb/acre decline for each day later than September 20. The rapid decline in yield after September 20 appears to be caused by the lack of plant development before winter. Plants sown on October 10 over-wintered in the three and four leaf stage. Consequently, plants sown late never attained the height or size of plants sown earlier since they were forced to grow over a shorter season. Moreover, flowering and grain filling in the October 10 seeding was delayed and occurred under hotter and drier conditions. On warm sunny days in April, plants in the October 10 seeding appeared to wilt or droop during midday even though soil water was adequate. The midday wilt was attributed to a relatively small root system compared to above-ground tissue and lack of canopy closure, and was not observed in earlier seeding dates. Other factors that may have contributed to decline in seed yield include: lodging, shatter, and maturity. Differences in these factors were observed in the plots, but their effect on yield was much less than reduced biomass production and delayed development. Canola sown on spring seeding dates also showed the same trend in plant development as winter seeding dates. It is recommended that spring canola be planted as early as field conditions permit.

Yields for winter and spring varieties are presented in Tables 4 and 5. Legend is a spring variety that was planted in both the winter and spring trials. Legend was not damaged by cold when sown in fall and was the earliest maturing and shortest variety in stature in the winter trials. It suffered the worst pod shatter. Tapidor, Humus, and Casie are varieties from the breeding program at the University of Idaho, Moscow. Humus was bred as a green manure crop and an oil substitute for diesel fuel. These varieties were shorter and had smaller stalk diameter than other winter varieties. The appearance of all other varieties was similar. All of the highest yielding varieties expect Tapidor had larger stature and stalk diameter. Ceres was intermediate in size and yielded well. Shorter plants that yield well may have an advantage because they combine harvest more easily and are less subject to lodging.

RECOMMENDATIONS FOR DRYLAND CANOLA PRODUCTION IN EASTERN OREGON

Several factors must be evaluated when considering canola as a alternate or rotation crop. The most important production constraint that we have encountered is stand establishment. In most years, canola will need to be seeded into summer fallow, as recropping canola after wheat is risky. Seed should be placed into moist soil with no more than three inches of cover. We have observed emergence through four to five inches of dry dust mulch, however, we don't recommend seeding that deep. Firming the seedbed with a press wheel is important. This insures good seed to soil contact, maintains water conductivity to the seed, and minimizes soil drying. Because canola is a fine-seeded crop, finding the seed in the soil to determine seeding depth can be difficult. Also, depth of seed placement within the row can be quite variable compared to larger-seeded crops. Check seed placement carefully for consistent depth. Use higher seeding rate for later seedings or rough seedbeds. All of our plantings have been with 12, 14, or 16-inch row spacing.

It is advisable to plant only a small acreage of canola at first. Fertilization practices for nitrogen, sulfur, and phosphorus are similar to winter wheat. Canola appears to respond favorably to spring top dressing of nitrogen. A healthy, well established stand of canola planted during the optimum seeding window will out-compete annual weeds without herbicide. Thin stands or late seeding may require additional weed control measures. The only currently registered herbicide for use on canola at planting is Treflan. Canola is sensitive to carry-over of Glean. Our plots have been relatively free of disease and insects, however, as canola acreage increases expect these pests to increase as well.

Harvesting canola is slower and more difficult than small grains. Since canola is an indeterminent crop, it does not ripen uniformly and so green and ripe pods are present on the same plant. Seed shattering before harvest can be a problem. Canola is ready to harvest when seed moisture content reaches 8-10 percent and is typically mature before wheat. Once the seed reaches this water content, harvest cannot be delayed. Applying Spodnam can reduce shatter losses, but this product cannot be used to delay harvest. Rapeseed will leak from any small holes or cracks in trucks and combines, so be sure to inspect these carefully and plug any places where seed may escape.

Canola may have a favorable impact on wheat crops that follow in the rotation. Several researchers are now working on this topic. The economic return from a canola crop is not solely determined by yield. It is also important to consider the benefits that can be obtained from breaking cereal disease cycles and reduction in weed problems that can have a positive effect on wheat yield. The following are our recommendations for seeding winter canola.

1. Seed 3 to 6 pounds PLS per acre (Certified).
2. Seed mid-August through the 3rd week in September.
3. Place seed 3/4 to 1 inch into firmed moist soil with maximum of 3 inches of cover.
4. Apply N to have a total of soil N + fertilizer N of 4 pounds of nitrogen for each 100 pounds of grain yield.
5. Apply P and S according to recommendations for winter wheat (N:P 5:1, N:S 8:1).
6. Apply 2 lb/acre B if soil test is < 0.5 ppm.
7. Currently, a preplant incorporation of trifluralin (Treflan) is the only registered product for weed control in winter canola.
8. Economic losses to insects or diseases have not been observed on winter canola in eastern Oregon.

We gratefully acknowledge the financial support of Seedtec International for this research.

Table 4. 1990-1991 yield of spring canola varieties by seeding date at the Columbia Basin Agricultural Research Center, Pendleton, Oregon.

	Seeding Date			
Variety	March 7	April 1	Two Date Average	LSD
	----------lb/acre---------			
Legend	1236	792	1014	NS
Moneta	1266	989	1128	
ST 400	1199	1271	1235	

Table 5. 1990-1991 yield of winter canola varieties by seeding date at the Columbia Basin Agricultural Research Center, Pendleton, Oregon.

Variety	Seeding Date: September 1	Seeding Date: September 20	Seeding Date: October 10	Three Date Average[1]	LSD
	----------lb/acre----------				
Legend	1681	2174	1005	1620 A	544
Cascade	2073	2009	1855	1979 AB	
Humus	2890	2485	2030	2468 BC	
Onyx	2675	3033	1709	2575 BC	
Ariana	2971	3109	1646	2575 CD	
Casie	2787	2634	2622	2681 CDE	
Tapidor	2819	3041	2879	2946 CDEF	
Semundo 5/87	3780	3680	1952	3113 DEF	
Ceres	3370	3491	2553	3138 EF	
Dorado	3619	3743	2131	3164 EF	
Aztec	3470	3479	2555	3168 EF	
Semundo 17/88	3527	3874	2635	3345 F	
Arabella	4404	4044	1717	3388 F	

[1]Means followed by the same letter are not statistically different at the 95% level.

OPENER MODIFICATION FOR SEEDING CANOLA

D. E. Wilkins and D. A. Haasch

INTRODUCTION

Rapeseed varieties low in erucic acid content are called canola and are used for human consumption. Canola seeds (*Brassica napus* L. or *Brassica campestris* L.) contain about 40 percent oil and produce a high-quality oil that is low in saturated fat. The residual meal after oil extraction contains about 37 percent protein and is used for livestock feed. Canola provides a rotational option for cereal production in the dryland cropping region of the Pacific Northwest (PNW).

The principle risks associated with canola production are poor stand establishment, aphid damage, and drought (Morrison et al., 1988). Stand establishment and droughts are major concerns for the dryland farming region in the PNW. Canola seeds are more sensitive to seedbed soil temperature and water content than winter wheat (Blackshaw, 1991). Planting 1/2 inch deep into soil at about 75 degrees F and 1 bar water tension is ideal for canola. (Brotemarkle et al., 1990). Summer fallow fields have about 3 inches of dry soil mulch over moist soil. Therefore, if canola is seeded into summer fallow, placing the seed 1/2 inch into soil with 1 bar water tension is a challenge. Hoe type drills are typically used to establish cereal crops in summer fallow fields because they can be adjusted to place seeds into moist soil with a minimum of dry soil over the seeds. This research was conducted to determine if modified hoe openers could improve canola seed placement.

METHODS AND MATERIALS

A randomized complete block experimental design with four replications was used. The treatments were six different openers mounted on a John Deere model HZ deep furrow drill. In Figure 1 the six openers are shown. They included the following openers: 1) Standard HZ, 2) Modified HZ (1/2 inch wider than the standard), 3) Standard HZ with a 1/2 inch diameter stainless steel seed tube to direct the seed behind the opener point, 4) S and M opener point designed to place liquid fertilizer in a band, firm soil over the fertilizer with a beaver tail attached to the trailing edge of the opener and then place seed in a furrow 1 inch directly over the fertilizer band (made and distributed by Stoess Manufacturing Co., Washtucna, WA). Canola seed was delivered through the 1/2 inch diameter liquid fertilizer tube and deposited in the bottom of the furrow, 5) S and M opener point described in number 4 with the beaver tail removed, and 6) Moore point made by James D. Moore, Kahlotus, WA.

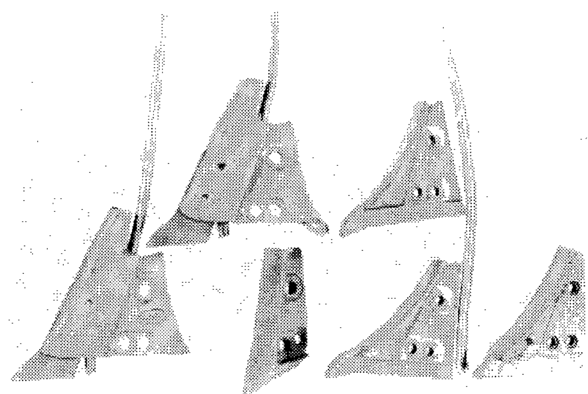

Figure 1. Opener points tested. From left to right; S & M without beaver tail, S & M, Moore, Standard HZ, HZ with 1/2 inch seed tube, HZ with shovel 1/2 inch wider than standard HZ.

Liradonna canola seed was planted at the rate of 16 lb/A on September 11, 1991. The high rate of seeding was used to minimize the sample volume needed to determine seed placement. Seeding was done at approximately 3 mph in a summer fallow field at the Columbia Plateau Conservation Research Center. The soil was a Walla Walla silt loam (coarse-silty, mixed, mesic, Typic Haploxeroll).

Soil water content was determined gravimetrically from two soil cores taken in the center of each row on the day of seeding. Also, immediately before seeding two cores were taken from each replicate. These samples were taken with a special incremental sampler that removed an undisturbed soil core 2 inches square and 4 inches long (Pikul et al. 1979). The two cores from each plot were sectioned into ten, 0.4 x 2 x 2 inch segments and composited. After determining soil water content, the soil samples were sieved and the number of canola seeds in each 0.4 inch increment were observed. The mean seeding depth and coefficient of variability (CV which is calculated by dividing the standard deviation by the mean) were determined for each of the six openers.

RESULTS AND DISCUSSION

Figures 2 and 3 show the soil water profiles created by the openers and the initial soil water conditions (immediately before seeding).

All opener points improved the soil water profile in the top 4 inches of the seedbed compared to the conditions prior to seeding. This finding is consistent with results of hoe opener performance for seeding winter wheat into summer-fallowed soil (Wilkins et al. 1983). The openers pushed dry surface soil aside and lifted moist soil to the surface. The HZ points provided a higher mean soil water content in the top 4 inches than the Moore or S and M points. Further testing is necessary to determine if the favorable seedbed soil water content created by the standard HZ point compared to the modified HZ points

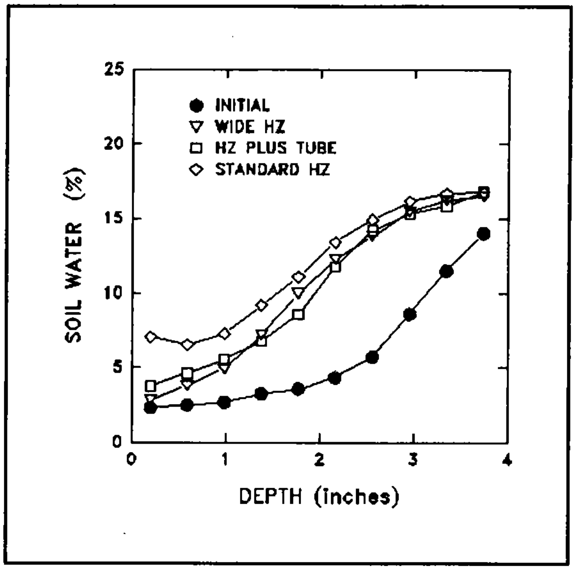

Fig. 2 Soil water content after seeding with HZ openers.

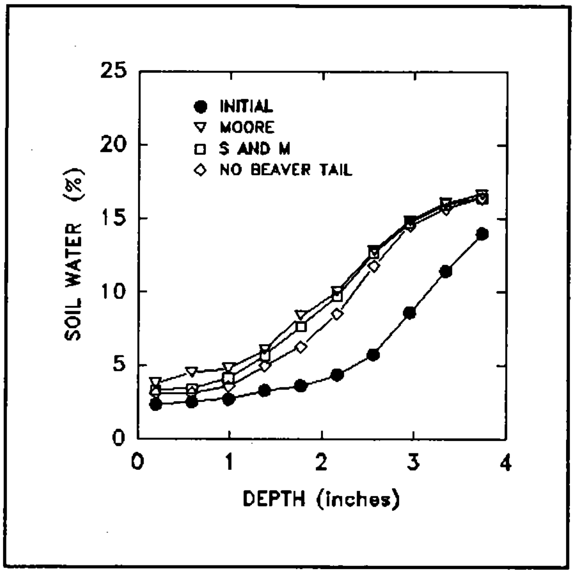

Fig. 3 Soil water profile after seeding with Moore and S & M opener points.

(Figure 2) was due to opener point design or location on the drill. Approximately 15 percent water content of Walla Walla silt loam soil corresponds to 1 bar soil water tension which is ideal for germination and emergence of canola (Brotemarkle et al., 1990). All of the openers would need to place canola seed at least 3 inches deep to provide ideal seedbed soil water conditions for germination and emergence. The recommended seeding depth is 1/2 to 1 inch (Brotenmarkle et al., 1990).

Table 1. Influence of opener on seed depth and coefficient of variability of seed depth

Opener	Mean seeding depth	Coefficient of variability
	(inches)	(%)
Modified HZ	2.7	4
HZ with small seed tube	3.3	6
Standard HZ	3.1	11
Moore	3.2	6
S and M	2.7	6
S and M without beaver tail	2.7	4

Table 1 shows the influence of the openers on seed placement. All of the openers placed the seeds accurately as indicated by the low CV values. The standard HZ had the highest variation of seed placement with a CV of 11 percent. Seed placement with the HZ point was improved by making the standard HZ point 1/2 inch wider or by directing the seed into the bottom of the furrow with a small seed tube. The beaver tail on the S and M point may have caused some soil mixing which slightly increased seed dispersion.

CONCLUSIONS

All of the openers improved the seedbed soil water content over the conditions prior to seeding. There were some small differences in soil water profiles created by the various openers but none of the openers came close to creating the ideal condition of placing seed 1/2 to 1 inch deep into soil with 1 bar soil water tension. Seed guide tubes that directed the seed behind the opener points reduced the seed dispersion slightly but all openers placed seed uniformly as indicated by coefficients of variability below 12 percent. Future work should be directed toward reduction in depth of dry soil (below 1 bar soil water tension) above the seed.

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SUMMARY OF RHIZOCTONIA ROOT ROT RESEARCH ON WHEAT AND BARLEY

Richard Smiley

HISTORY

Rhizoctonia root rot was first noticed in the United States during 1984, when the disease was found to affect production of wheat and barley in Oregon, Washington, and Idaho (Pumphrey et al., 1987; Weller et al., 1986). Since the characteristics and control of Rhizoctonia root rot in the Pacific Northwest were essentially unknown, research on this disease was emphasize from 1986 to 1991. This disease is now considered one of the most damaging root diseases of cereals in the wheat/fallow region of northeastern and northcentral Oregon. Current knowledge on Rhizoctonia root rot is summarized in this report.

OCCURRENCE AND SYMPTOMS

Moderate levels of root damage are unlikely to be noticed by casual observation. Diagnosis of the disease usually requires an examination of washed roots. The infected area of the root is usually dark brown to reddish brown in color. Severely infected roots become severed (pruned) at the point of infection. These severed roots typically taper to a finely pointed tip, called a "spear tip".

Rhizoctonia root rot occurs on wheat and barley throughout the Columbia Plateau of northcentral and northeast Oregon, even on plants that appear normal. Plants with minor amounts of root pruning appear to grow and yield acceptably. However, impairment in the plant's ability to obtain moisture as the plant nears maturation may cause at least some crop damage. The disease also may cause stunting of individual plants in a row. These plants are usually hidden by normal-height plants in the same row. The crop appears normal even though severe root rot and stunting occurs on a small percentage of well dispersed individual plants. Unless the proportion of stunted plants is significant the disease probably does not pose an important constaint to yield.

The most important damage from Rhizoctonia root rot occurs when large patches of plants become stunted. Winter wheat or barley infected during the autumn may look uniform and healthy going into winter. As growth resumes in the spring heavily infected plants do not grow as well as plants with less severe infection. Patches of distinctly stunted plants may develop, and seedlings are sometimes killed, hence the alternate name of "bare patch" for this disease. In other cases the infected plants may be able to produce enough new roots to recover from seedling infections. Even when recovery appears to be complete, yield losses are likely to be substantial and crop maturation may be delayed by two weeks or more.

ECONOMIC DAMAGE

Rhizoctonia root rot reduced wheat yields by up to 3 percent (equal to $10/acre) on an irrigated sandy loam at the Hermiston Agricultural Research and Extension Center (Pumphrey et al., 1987). Crop damage assessments on dryland fields in Umatilla County indicated that the disease reduced wheat and barley yields by at least 4 and 8 percent ($15 and $9/acre), respectively, during 1987. These estimates were based on the documentable reduction in yield inside the patches and on the total area of fields affected by stunted patches, but did not include yield constraints that also may have occurred from root rot in sections of each field that appeared "normal". Yield constraints higher than those that could be documented are believed to occur regularly. Yield reductions up to 50 percent for spring barley is described later, in the section on interactions between herbicides and Rhizoctonia root rot.

SPECIES RESPONSIBLE FOR CAUSING RHIZOCTONIA ROOT ROT

Ogoshi et al. (1990) conducted a survey of *Rhizoctonia* species and anastomosis groups (AG's; subdivisions of species that differ in genetic characteristics and host specificity) present in soil and on wheat and barley roots in the Pacific Northwest. They isolated *R. oryzae*, five different anastomosis groups of *R. solani*, and five other species of *Rhizoctonia*. *R. solani* AG-8 and *R. oryzae* were the dominant types isolated from wheat and barley roots, and the other species and AG's were found mostly in soil. Ogoshi et al. determined that both *R. solani* AG-8 and *R. oryzae* were moderately pathogenic at 68°F, and that *R. solani* AG-8 was much more pathogenic than *R. oryzae* at 50°F. They concluded that both fungi are involved in Rhizoctonia root rot of cereals. This information was very important because these fungi differ in sensitivity to carboxin (Vitavax), triadimenol (Baytan) and other fungicides (Smiley et al., 1990a).

Soil temperatures in northcentral and northeast Oregon decrease to 50°F and below during late October and do not exceed this temperature again until early April. Therefore, it was unclear whether temperatures in the field were high enough for *R. oryzae* to be an important pathogen on winter wheat and spring barley in Oregon. We therefore examined the pathogenicity of *R. solani* AG-8 and *R. oryzae* under field conditions and with cores of field soil incubated at diurnally fluctuating soil temperatures in the greenhouse. In greenhouse tests, *R. solani* caused moderate to severe disease and reduced plant growth and development at low, intermediate, and high soil temperatures. In contrast, *R. oryzae* caused only slight to moderate root rot even at the highest soil temperatures, and never suppressed plant growth or development in any of our tests. In a field test, six cultivars of winter wheat averaged 9, 129, and 140 bu/ac, respectively, where soil had been inoculated with *R. solani* AG-8, *R. oryzae*, or neither pathogen. We concluded that *R. solani* AG-8 is the primary cause of Rhizoctonia root rot on cereals in Oregon.

PLANTING DATE

Damage from *R. solani* AG-8 appears to become more pronounced as the planting date is delayed from mid-September to November. Early plantings into warm soil are more favorable to root growth than to damage by this pathogen. Roots of early-seeded plants become relatively large by early winter. The virulence of this pathogen increases as soil cools, but this is tempered by the larger root system of early seeded winter wheat. The pathogen causes more severe damage to small, late-seeded plants than to large early-seeded plants.

SUSCEPTIBILITY OF CROP SPECIES AND CULTIVARS

R.J. Cook and colleagues at Pullman, WA determined that most crops produced in the Pacific Northwest are susceptible to attack by the dominant strain (AG-8) of *Rhizoctonia solani* that occurs on cereals. The crops included wheat, barley, peas, chickpeas, lentils, and rape. It was also noted, however, that patch symptoms are seldom observed on broad-leaf crops under field conditions, and that patchiness is less on small grains that follow a legume than on those that follow a small grain. An exception occurred at the Pendleton Experiment Station, where an experiment with lentils became devastated by Rhizoctonia root rot on a field previously used for studies of this disease on no-till spring barley.

Winter and spring barleys were much more susceptible than winter wheat when both crops were grown side by side in our experimental plots. Damage to commercial fields also has consistently been more pronounced on spring barley than on winter wheat. Although moderate differences in tolerance to Rhizoctonia root rot exist among cultivars of spring wheat, barley, and oats in Australia, there is no comparable information available in the Pacific Northwest. Levels of tolerance in cultivars of winter wheat are being investigated in the wheat breeding and pathology programs at Pendleton.

CHEMICAL CONTROL

Twenty nine experiments were conducted to determine if fungicide seed treatments provided protection of winter wheat, winter barley, and spring barley against damage from Rhizoctonia root rot (Smiley et al., 1990a, 1990b, and 1991b). Twenty one fungicides or combinations of fungicides were examined during these experiments. All seed treatments were ineffective or unreliable for controlling Rhizoctonia root rot of winter wheat and winter barley. Moreover, most of the fungicides reduced the tillering capacity of winter wheat plants, and none of the fungicides consistently improved grain yields. Yields of winter barley were typically slightly lower when seed was treated rather than left without a fungicide treatment.

In contrast to the winter cereals, fungicide seed treatments on spring barley reduced the severity of Rhizoctonia root rot and increased grain yields. Spring barley responded positively to the application of Vitavax 200 (carboxin + thiram), Vitavax 34 (carboxin) + PCNB, and several others. The most consistent increase in yield of spring barley was achieved with Vitavax 34 + PCNB. This combination was also the only treatment that provided an overall increase in productivity for both winter and spring cereals.

Although many of the fungicides examined were highly toxic to *Rhizoctonia* it is difficult to apply sufficient quantities as seed treatments to provide lasting protection against Rhizoctonia root rot. This may be so because the pathogen has a very long period in which it can infect winter cereals. Damaging infections can occur during the autumn, winter, and spring. The period of infectivity is therefore much shorter for spring cereals, which grow rapidly and continuously. Treatments applied to spring cereals have a higher potential for protecting seedlings during the majority of the infection period.

FERTILIZER RATE AND PLACEMENT

Adjustments in fertilizer rates are unlikely to exert an important influence on the occurrence of Rhizoctonia root rot, except in areas where nitrogen and/or phosphorus deficiencies occur. Pumphrey et al. (1987) determined that rates and timing of nitrogen, within acceptable agronomic practices, did not influence the incidence of stunting on an irrigated sandy soil at Hermiston.

Several studies were conducted to determine the influence of fertilizer placement on severity of Rhizoctonia root rot on dryland winter wheat. In an experiment with a Yielder no-till drill equipped with 5 x 15-inch paired rows a starter fertilizer (7-7-7 + 11% sulfur & 11% iron; applied at 10 lb N/ac) was placed either 0.75-inch directly below the seed in each row or at 2.4-inch below seed depth between the paired seed rows (5-inch apart) (Smiley et al., 1990b). Both Rhizoctonia root rot and take-all became slightly more severe where fertilizer was placed below the seed rather than between rows in this no-till experiment. Grain yield was also slightly higher with between-row placement than with in-row banding.

Another experiment compared the presence or absence of the same starter fertilizer on fields that were either not tilled or tilled conventionally (moldboard plow and disk) (Smiley et al., 1990b). A Great Plains no-till drill was used to place the fertilizer 0.75-inch below the seed. In conventionally tilled soil the starter fertilizer had no effect on severity of Rhizoctonia root rot, take-all, or strawbreaker foot rot, but did have a significantly positive impact on yield (increase from 87.7 to 98.9 bu/ac). In no-till soil the fertilizer increased the severity of Rhizoctonia root rot and strawbreaker foot rot, and also increased yield from 73.5 to 76.1 bu/ac. The benefits of starter fertilizer to root development far outweighed the stimulatory effect on disease. Note also that wheat yields under no-till were much less than in conventionally tilled soil. Similar observations will be discussed later.

INTERACTIONS WITH HERBICIDES

Eight field experiments and two greenhouse experiments were conducted to examine interactions between Rhizoctonia root rot and preplant and postemergence applications of the sulfonylurea herbicides Glean and Finesse (Smiley and Wilkins, 1992). The severity of Rhizoctonia root rot was always increased and the rate of seedling growth was always reduced by the presence of these herbicides. With time, however, the negative effects on seedling growth dissipated and the plants matured in a delayed but otherwise normal manner. Grain yields were never reduced by application of sulfonylurea herbicides even when weed populations in treated and untreated plots were kept uniform to eliminate this complication. As such, the herbicide-induced increase in disease on seedlings did not translate into a constraint to yield. It appears that these soil-active herbicides cause sub-clinical stresses in small grain plants. The level of stress is not high enough to visually damage the plant when root pathogens are not present. But these herbicides apparently alter the root systems such that they become more susceptible to attack by pathogens such as *Rhizoctonia*. With time, and in the presence of adequate conditions for plant growth, the wheat plant appears to have an ability to recover from this early damage. It should be noted, however, that all of our tests were conducted during years that were drier than normal. The disease becomes more pronounced when rainfall is above average. We do not know if the herbicide relationship described here also holds true during wet years.

Time intervals between application of glyphosate (as Roundup or Landmaster) and planting spring barley into *Rhizoctonia*-infested soil were evaluated in field plots in eastern Oregon and Washington. As the time interval was shortened the severity of Rhizoctonia root rot increased and grain yield decreased. When glyphosate applications were delayed until 2 or 3 days before planting, as is commonly practiced in the Pacific Northwest, spring barley yields were reduced as much as 50 percent compared to when glyphosate was applied in the autumn or early spring. Healthier, higher-yielding spring barley was associated with long intervals between spraying and planting. Disease was least when tillage or application of glyphosate was performed at least three weeks before planting. Since damage from the disease was expressed uniformly across the treated plots it was not possible to detect plant damage or yield loss by simply observing the appearance of the crop canopy. However, it was obvious in these replicated plots that plant growth was poorer and maturation was delayed in plots treated with glyphosate less than one week before planting. Inspections of root systems confirmed the relationship of growth and Rhizoctonia root rot. It should be also noted that this phenomenon is not dependent on the type of herbicide used to kill volunteer cereals and weeds. Similar observations have been made with paraquat in Australia. Additionally, glyphosate does not cause an increase in root rot or decrease in yield when it is applied to bare soil. The reason that paraquat and glyphosate cause an increase in Rhizoctonia root rot when applied to volunteer cereals or weeds shortly before planting is associated with a transfer of the pathogen from the dying roots of sprayed plants to newly emerging roots of the recently planted crop. Planting soon after applying the herbicide is now considered to be at least one reason for the disappointing yields of spring cereals in the Pacific Northwest.

TILLAGE AND RESIDUE MANAGEMENT

Tillage systems have a strong effect on severity of Rhizoctonia root rot because the pathogens survive between crops in roots, crowns, and straw. The disease is almost always more severe on fields seeded without prior tillage than with inversion tillage, and is intermediate in wheat/fallow systems where moderate to high amounts of residue are kept on or near the soil surface. However, the severity of root rot is not always related to grain yield because the effect of tillage on availability of water may be more important than root rot. For instance, it is sometimes observed that yields are higher with no-till than with inversion tillage, even though the severity of root rot was higher on plants in the no-till system.

Pumphrey et al. (1987) determined that stunted patches in irrigated winter wheat became progressively more frequent as the intensity of tillage was reduced. The experiment examined the intensity of tillage necessary to convert an alfalfa field to winter wheat. Treatments included plots tilled with a moldboard plow (no stunted patches), tilled at 6-inch depth with sweeps (8 percent of crop stunted), disrupted with a paraplow (25 percent stunting), or not tilled (41 percent stunting).

One soil conservation practice used in the Pacific Northwest is production of annual spring barley. Minimal or no tillage is the preferred method for managing this production system. Unfortunately, this practice is highly conducive to damaging levels of Rhizoctonia root rot, owing to the high susceptibility of barley to the disease, and to the predisposing influence of high carryover of the pathogen in the surface residues. We conducted an experiment to determine how frequently inversion tillage (moldboard plow and then disk) was required in an otherwise no-till system to reduce the level of damage from Rhizoctonia root rot. The experiment was conducted over a 4-year period at two 12-inch rainfall locations in Umatilla County. We found that the tillage system used before planting each crop of spring barley dictated the severity of root rot on that crop. Root rot was always more severe with no-till than with inversion tillage. When one crop was planted with tillage and followed by a crop on no-till soil there was little or no benefit from plowing extended into the second, no-till, crop. Results on the effects of tillage on severity of root rot were definitive. In contrast, the effect of these tillage sequences was not clearly defined with respect to grain yields. Yields were always higher in no-till than tilled plots at one site and the opposite generally occurred at the other site. The 4-year average yields showed a significant advantage for no-till at a site southwest of Pendleton and a near equivalence of the two treatments at a site between Helix and Holdman. These contrasting observations at two sites apparently resulted from differences in water-use efficiencies and complexities of root diseases among treatments at the two sites. At the Pendleton site, where no-till produced highest yields, a broader and more severe root disease complex was present in the inversion tillage treatments than in the no-till treatments. Diseases favored by inversion tillage at that site included take-all, Pythium root rot, and common root rot. These diseases were not observed in the inversion tillage sequence at the Helix site, and this may partially explain the fact that inversion tillage yielded equally with no-till at that location.

A further note on this experiment is also warranted. Spring barley in no-till plots at both sites matured two to three weeks later than in adjacent plots of inversion tilled soil. This delay also occurred on winter wheat outside of plots (west of Helix) that were fumigated with methyl bromide three years earlier. Rhizoctonia root rot delayed plant maturation even when grain yield was not affected by the tillage system used. This delay can become an important consideration in scheduling the harvest of spring grains before winter cereals, or in areas where additional threats to the crop can be posed by high wind, rainfall, hail, or short growing seasons.

The experiment described above compared strict no-till with near complete inversion of crop residues. However, Rhizoctonia root rot occasionally also becomes moderately severe in wheat/fallow systems where the tillage system includes chisel plow and rod weeding. For instance, the winter wheat field used for assessment of economic damage (reported earlier) was managed as follows. The stubble was burned in August after the 1985 crop was harvested. A chisel plow was used shortly after the burn and again in April, 1986. The field was also cultivated in April. Fertilizer was applied by shanking in May. Rod weedings occurred during May, July, August, and September. A pre-plant application of Chem-Hoe and Glean was made on September 17 and "Dusty" winter wheat was seeded on September 25. A spring application of urea was applied in February, 1987. Damage from Rhizoctonia root rot was estimated at 3.3 bu/acre, even with this active crop residue management and weed control program.

Observations on commercial fields also indicate that the higher amounts of Rhizoctonia root rot in no-till do not necessarily translate into comparatively poorer grain yields. Two observations are described to illustrate this point. Rhizoctonia root rot became debilitating to spring barley but not to winter wheat after each crop was planted without tillage for three consecutive years in the 12-inch precipitation zone of Umatilla County. Root rot also occurred on the wheat, but there were no stunted patches and the grain yields were satisfactory.

Two 12-acre winter wheat fields on a farm in the 14-inch precipitation zone of Umatilla County are currently in their 11th year for comparing annual cropping without tillage or with inversion tillage, and also with an inversion tilled wheat/fallow rotation (Stanley Timmermann, unpublished). The average yields for these fields are 43, 45, and 69 bu/ac, respectively. Production totals at this site have remained higher with annual no-till than with the tilled wheat/fallow rotation. Also, there is no recent evidence that stunted patches occur in any of these management areas. However, stunted plants are randomly dispersed within the rows in all fields. Wheat in the tilled wheat/fallow rotation had 5 percent of the tiller population stunted as a result of Rhizoctonia root rot in 1987. In contrast, the annual cropped no-till field had 38 percent stunted tillers in areas planted with the Yielder drill and 23 percent stunted tillers in areas planted with an experimental drill that places seed into a narrow rototilled strip. Yields were equal for each drill in the no-till fields. Crop yields were 62 and 85 bu/ac in the annual no-till and the tilled wheat/fallow fields, respectively.

Another interesting phenomenon is also occurring on the experiment described above. Grain yield for annual winter wheat was heavily favored by no-till during a year of very low rainfall. When this atypical event was excluded from the data, it was clear that yields in the no-till field (NT) were consistently improving with respect to those in the tilled field (T). The ratio (NT/T) for grain yields in these annually cropped fields has increased steadily during the experiment. A linear regression shows this relationship to be statistically significant ($p = 0.01$, $R^2 = 0.877$, slope = 0.044 bu/ac/yr). A similar phenomenon is occurring on comparable 6-year-old annual winter wheat plots in Sherman County, where a progressive increase in NT/T ratio for grain yield is also significant ($p = 0.04$, $R^2 = 0.896$, slope = 0.213 bu/ac/yr). In contrast, no such trend has been observed for comparable tillage systems of annual spring barley at three locations, or for a winter wheat/fallow rotation in Sherman County. These observations suggest that the soil ecosystem evolves toward adaptation to the no-till system in annual winter wheat, perhaps through an increasing importance of microbial antagonists toward pathogenic species of *Rhizoctonia*.

RHIZOCTONIA ROOT ROT DECLINE

Cores of soil were collected from two fields and used to produce four successive plantings of winter wheat in the greenhouse. The soils were collected from a field used for no-till annual spring barley and from another used for an inversion tilled wheat/fallow rotation. Soils in the greenhouse were infested before each planting with *Rhizoctonia solani* AG-8, *R. oryzae*, or neither. *R. solani* reduced the growth of plants during the first two or three crops. During the third or fourth crops in soils well colonized by the

TILLAGE & RESIDUE

Root rot is usually reduced as the frequency of tillage is increased and the amount of residue on or near the surface is reduced. Exceptions do occur. Complete burial of infected roots, crowns, and straw is useful for suppressing or eliminating damage from this disease.

DRILL DESIGN

Opener designs that cause maximum soil disturbance at seeding assist in managing this disease. These openers apparently act by pushing the infected root and crown residues away from the seed zone and the developing seedling.

PLANTING DATE

Information is not yet available. *R. solani* is capable of active growth over a wide temperature range, and is especially pathogenic at soil temperatures below 60°F. *R. oryzae* grows best and causes low to moderate damage at temperatures above 60°F.

FERTILIZERS

Within the normal limits of production in eastern Oregon, soil fertility management does not appear to have an important effect on severity of Rhizoctonia root rot. Application rates and timings should not be altered in an attempt to manage this disease. It is well known, however, that nutrient deficiencies exacerbate this and other diseases of plant roots.

CHEMICAL CONTROL

Acceptable fungicides for specific control of Rhizoctonia root rot are not available for winter cereals. Vitavax 34 + PCNB was, however, the best of the registered seed treatments studied, and was particularly effective in generating a yield response on spring barley.

HERBICIDES

Sulfonylurea herbicides increase the severity of this disease. However, yield losses have not been documented from this interaction. Nevertheless, it is wise to avoid overlaps and other excess uses of these herbicides, and to closely monitor treated fields. Damage to yield can become extremely important if spring cereals are planted shortly after glyphosate is applied to volunteer cereals and weeds. Attempt to lengthen the time between spraying out volunteer cereals and weeds, and then planting back a spring cereal. An interval of three or more weeks can increase the yield by 20-50 percent.

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'DIVIDEND': A POTENTIAL SEED TREATMENT FUNGICIDE

Richard W. Smiley and Wakar Uddin

INTRODUCTION

'Dividend' is the proposed trade name of a new seed treatment being developed for controlling diseases of several crops. This fungicide is already marketed in several other countries and was submitted in February, 1992 for consideration by the U.S. Environmental Protection Agency. If registration, is granted commercial applications would probably begin in 1994. The common name assigned to this compound is difenoconazole. Developmental testing, as 'CGA 169374', was performed by CIBA-Geigy Corporation.

Dividend applied to wheat seed appears to be particularly effective against common bunt, dwarf bunt, flag smut, loose smut, *Septoria* seedling blight, seedborne *Fusarium* that causes scab, and early season powdery mildew and rust. In addition, this fungicide appears to suppress common root rot and take-all on wheat, and leaf stripe and foot rot on spring barley. We tested the fungicide on winter wheat in nine experiments at seven locations in eastern Oregon during the past two years. Our objectives were to determine the efficacy of this fungicide for controlling smut diseases in eastern Oregon, determine strengths and weaknesses of the fungicide against a broad range of other diseases, and evaluate effects of the fungicide on plant growth, plant development, and grain yield. Observations were made of Dividend's effect on nine diseases (Table 1), plant growth and development, and yield of four winter wheat cultivars. This report summarizes the current status of our experience with Dividend in eastern Oregon.

MATERIALS AND METHODS

Table 2 provides a list of locations, wheat cultivars, planting dates and depths, and diseases monitored in the nine experiments. Except for take-all, the experiments were conducted as follows. Seed of winter wheat was treated with Dividend 3FS (0.25, 0.5, or 1.0 fl oz/cwt), Vitavax 200F (3 fl oz/cwt), or neither fungicide. Seed was planted into moist soil using a Hege plot drill equipped with a cone-seeder and hoe openers at 12-inch spacing. Plots were typically 5 x 16 ft, had five replicates per treatment, and were arranged in a randomized complete block design.

Assessments of plant disease, growth, and development varied for each experiment. The following were typically used to quantify diseases; dwarf bunt (percent smutted heads on stunted tillers), flag smut (percent smutted plants), strawbreaker foot rot and sharp eyespot (percent tillers with eyespots, except as noted otherwise), Rhizoctonia root rot (continuous rating scale with 0 = no root rot, 3 = lesions on most lateral roots, and 5 = lesions on most main root axes), Pythium root rot and take-all (percent roots with lesions), common root rot (percent subcrown internodes with lesions), and speckled snow mold (percent affected plants).

Plant growth, development, and yield were assessed as follows. Whole plant samples were collected from plots up to three times: early winter, early spring, and early summer. Seedling leaf height, shoot weight, and plant development (Haun stage) were measured. Each tiller present was identified by its order on the plant (T_0,

T_1, T_2, T_3, T_4). Numbers of roots crossing an axis 3- and 5-cm below the seed were counted. All plots were harvested with a Hege plot combine for measurement of grain yield. Test weights were measured for most experiments.

The take-all experiment differed in that the a drill was customized with two cone seeders rather than one, two different application procedures were used, and Baytan 30F was included in the test. One cone was used for placement of wheat seed (72 lb/ac) and the other for placing a band of starter fertilizer (granular 9-9-9-11S-11Fe, at 88 lb/ac) four inches directly below the seed. Fungicides were delivered either as a seed treatment or as an amendment adsorbed onto fertilizer granules. The base level rate for applying fungicide was adjusted to provide the same amount of active ingredient per acre by seed treatment or banding on fertilizer granules. Base rates for Dividend and Baytan were 2.0 and 2.6 fl oz/cwt, respectively. Seed treatments were applied at 1X and 2X the basic rate, and banded applications were made at rates equivalent to 1X, 2X, and 4X the basic rate. The seed treatment controls were either no fungicide or Captan 400 (2 fl oz/cwt). Vitavax 200 was not used in the take-all experiment.

Supplemental spores (inoculum) of pathogenic fungi were applied to some experiments to assist in achieving uniform disease coverage in sufficient quantities to allow good evaluations of the fungicide. This was done for some experiments in which the target disease was flag smut, dwarf bunt (in 1989-1990, but not 1990-1991), or strawbreaker foot rot. Spores of *Tilletia controversa* were sprayed in a band onto soil directly over the seeded row immediately after planting. Spores of *Urocystis agropyri* were mixed with wheat seed after fungicide treatments were applied but immediately before planting the seed. Spores of *Pseudocercosporella herpotrichoides* were sprayed onto seedling foliage one or more times during early to mid-winter. Supplemental inocula of the pathogen was not applied in experiments designed for take-all and dwarf bunt tests conducted in 1990-1991.

RESULTS

<u>DWARF BUNT EXPERIMENT - FLORA: 1990-1991</u>: During the spring on Hill 81 there were no statistical differences among treatments for Rhizoctonia root rot (<0.5 on 0 to 5 scale), take-all (<3 percent roots), Pythium root rot (<1 percent roots), common root rot (2-11 percent plants), and snow mold (<5 percent plants) (Table 3). Percentages of headed tillers stunted by dwarf bunt was significantly ($p<0.001$) affected by fungicide, cultivars, and fungicide x cultivar interaction. Dwarf bunt was eradicated by Dividend seed treatments, was not affected by foliar application of Tilt, and was enhanced by Vitavax 200. Lewjain was highly resistant to dwarf bunt. Yield was significantly ($p<0.001$) affected by fungicide but not ($p>0.10$) by cultivar or fungicide x cultivar interaction. Dwarf bunt caused about 20 percent reduction in yield for Hill 81.

<u>DWARF BUNT EXPERIMENTS - HAINES and ELGIN: 1990-1991</u>: Dwarf bunt did not occur on these experimental areas during 1991. However, observations were made on other diseases that were present on the experimental area (Table 4). During the spring Dividend at O.5 fl oz/cwt and Vitavax 200 tended to minimize Rhizoctonia root rot, Pythium root rot, strawbreaker foot rot, and common root rot, but had no significant impact on take-all. The high rate of Dividend was most

effective against speckled snow mold. Yield of Hill 81 differed among treatments at Elgin but not Haines. Yield of Hill 81 at Elgin was not correlated with disease variables. Grain yield for Lewjain was not affected significantly by fungicide treatments at Elgin.

<u>DWARF BUNT EXPERIMENTS - ELGIN and PENDLETON: 1989-1990</u>: Dwarf bunt did not occur on either of these experiments, in spite of the high level of inoculum applied during the autumn and the attempts to favor disease by placing a mat of straw over the plot during the winter. Yields of Hill 81 and Lewjain did not differ among treatments.

<u>FLAG SMUT EXPERIMENT - PENDLETON: 1990-1991</u>: During the autumn there were no statistical differences among treatments for root numbers 2-inches below the caryopsis, Haun plant growth stage, plant height, percentages of any tiller class, Rhizoctonia root rot (1.7 on 0 to 5 scale), Pythium root rot (<1 percent roots), and common root rot (2 to 12 percent plants). Flag smut was severe in this study and was eliminated by Dividend but not by Vitavax 200 (Table 5). Yield loss from flag smut was significant ($p < 0.001$; $r^2 = -0.740$; $y = -0.14x + 35.5$). Although Dividend caused an apparent increase in percentage of plants with strawbreaker foot rot, the high severity of flag smut in the inoculated and uninoculated controls undoubtedly precluded the normal development of foot rot. Control of flag smut presumably enabled a more natural development of foot rot.

<u>STRAWBREAKER FOOT ROT EXPERIMENTS - PENDLETON and MORO: 1990-1991</u>: During early spring, at the time when foliar applications were made in mid-March, nearly all plants were infected at both locations. Most infection occurred on T_1 and T_2 tillers which, together with T_0, contribute most to grain yield. At Moro none of the treatments differed significantly during assessments of diseases (foot rot and Rhizoctonia root rot) and plant growth (root numbers, shoot height and development stage, and tiller numbers) during winter and spring. Dividend seed treatment improved grain yield (Table 6), but there was no effect of foliar sprays on diseases or yield. At Pendleton, Dividend significantly reduced the percentage of infected plants during winter and spring, mostly through a protective effect on T_1. The 0.5 fl oz/cwt rate was more efficient than the lowest and highest rate. By early summer, however, the numbers of infected plants and the disease indices did not differ among Dividend treatments and the control. As such, Dividend delayed the rate of foot rot appearance at Pendleton but did not suppress disease on mature plants at either location. Foliar sprays applied in mid-March were more effective than seed treatments for reducing the rate of foot rot progress. Foot rot indices at Pendleton were reduced by all three foliar fungicides. Benlate strongly suppressed foot rot and increased grain yield by 59 percent. Dividend did not have any effect on root or tiller numbers, plant height or development stage, length of subcrown internode, or Pythium root rot. Rhizoctonia root rot severity was significantly reduced by Dividend during the winter but the protective effect became undetectable by spring.

<u>TAKE-ALL EXPERIMENT - ECHO: 1990-1991</u>: Take-all was reduced by certain treatments of Dividend or fertilizer, but not by Baytan (Table 7). Whiteheads were reduced by both fungicides, but not significantly. There were no statistical

differences among treatments for Rhizoctonia root rot (rating <1 on 0-5 scale), strawbreaker foot rot (<5 percent plants), sharp eyespot (0-25 percent plants), plant growth stage, and shoot weight. Both fungicides reduced T_0 tillering when applied as seed treatments, and increased T_0 when applied below the seed. This resulted in a shift in emphasis from T_0 to T_3 tillers, which inherently reduces the yield potential for winter wheat. Root numbers were increased by Dividend but not Baytan. Yield was not influenced significantly by either fungicide. Fertilizer placement under the seed did not affect yield as long as seed was treated with Captan. Note, however, the strong influence of Captan on yield response when fertilizer was not banded below the seed.

EXPERIMENTS IN PROGRESS (1991-1992): Seed treatment experiments in progress include target diseases of Cephalosporium stripe (at Heppner), Fusarium (dryland) foot rot (at Arlington and Moro), strawbreaker foot rot (at Pendleton), and dwarf bunt (at Flora).

SUMMARY

Diseases Controlled: Our experience confirms the superb ability of Dividend to control smut diseases. Very low rates of treatment are effective for this use. The fungicide suppressed strawbreaker foot rot, common root rot, Rhizoctonia root rot, and take-all under the usual conditions of intermediate disease incidence and/or severity. However, in our inoculated tests at Pendleton and Moro strawbreaker foot rot became extraordinarily severe on nearly every tiller. Likewise, common root rot at Haines affected more than 90 percent of the subcrown internodes. Dividend was not able to overcome extreme pressures from either of these diseases. A strong rate response occurred with speckled snow mold, with the highest level of control achieved with the highest rate of application. The placement of Dividend or Baytan on fertilizer below the seed was as effective as seed treatment for suppressing take-all.

Plant Growth and Development: Negative effects on plant growth and development were either not measured or were not critical in these experiments with Dividend. The fungicide did not reduce plant height, shoot weight, subcrown internode length, or numbers of roots. Slight increases in these growth parameters were occasionally observed. In the take-all experiment both Dividend and Baytan reduced numbers of T_0 tillers, but increased numbers of higher order tillers. The phytotoxic effect on tillering was eliminated when the fungicides were banded on fertilizer below the seed rather than applied to the seed surface. Yields were generally improved by Dividend, and in only one experiment was a slight, statistically insignificant, depression observed (dwarf bunt test at Haines during 1990-1991).

Grain Yield: Twelve data sets were available for an overall assessment of Dividend's effect on yields of winter wheat in eastern Oregon. Data included experiments with the cultivars Hill 81 (5 tests), Lewjain (4), Stephens (2), and Tres (1). The experiments were performed at Flora (1 site), Elgin (2), Haines (1), Pendleton (3), and Moro (1). Although dwarf bunt, flag smut, and strawbreaker foot rot were the target diseases for these experiments, other diseases also occurred, as described throughout this report. Mean yields for the 12 tests were 60.5, 64.5, 65.0, and 64.2 for the control and Dividend at 0.25, 0.5, and 1.0 fl oz/cwt, respectively. These means did not differ significantly ($p=0.12$) from one another because of high variability from site to site. Vitavax 200 was included in six of the 12 experiments. Mean yields for the six experiments were 62.0, 65.8, 67.6, 69.8, and 70.7 for the control, Vitavax 200, and Dividend at 0.25, 0.5, and 1.0 fl oz/cwt, respectively. Analysis of variance indicated that these means differed significantly (p=0.05, LSD=6.1).

Conclusion: Consistent improvement of yield by Dividend and lack of negative effects on seedling growth and development indicates that this fungicide is likely to become an important adjunct to disease management programs on winter wheat in the Pacific Northwest.

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Table 1. Diseases of winter wheat monitored in nine experiments in eastern Oregon.

Disease	Pathogen
Common root rot	*Bipolaris sorokiniana(=Cochliobolus sativus)*
Dwarf bunt (TCK smut)	*Tilletia controversa*
Flag smut	*Urocystis agropyri*
Pythium root rot	*Pythium* species
Rhizoctonia root rot (bare patch)	*Rhizoctonia solani* AG-8 & other AG groups
Sharp eyespot	*Rhizoctonia cerealis*
Speckled snow mold	*Typhula incarnata*
Strawbreaker foot rot (eyespot)	*Pseudocercosporella herpotrichoides*
Take-all	*Gaeumannomyces graminis* var. *tritici*

Table 2. Information on locations, wheat cultivars, planting dates and depths, and target diseases for nine experiments with Dividend seed treatments.

Town	Cooperator or Site	Planting Date	Seed Depth	Irri-gated	Cultivar(s)	Target Disease
Echo	John Brogoitti	10-29-90	1.5	yes	Stephens	take-all
Elgin	Gilbert Weatherspoon	09-29-89	1.5	no	Hill 81, Lewjain	dwarf bunt
Elgin	Gilbert Weatherspoon	09-12-90	1.5	no	Hill 81, Lewjain	dwarf bunt
Elgin	Doug Wulff	09-12-90	1.5	no	Hill 81, Lewjain	dwarf bunt
Flora	Daryl Leggett	09-12-90	1.5	no	Hill 81	dwarf bunt
Haines	Experiment Station	10-04-89	2.0	no	Hill 81, Lewjain	dwarf bunt
Pendleton	Experiment Station	09-20-90	3.0	no	Stephens	strawbreaker foot rot
Pendleton	Tom Straughan	09-18-90	5.0	no	Tres	flag smut

Table 3. Dwarf bunt experiment at Flora: 1990-1991.

	Stunted tillers/100 ft row		Yield (bu/ac)	
Treatment and rate	Hill 81	Lewjain	Hill 81	Lewjain
Control	40	0	69.8	71.6
Dividend 3FS 0.25 fl oz/cwt	0	0	81.2	76.3
Dividend 3FS 0.50 fl oz/cwt	0	0	87.6	79.4
Dividend 3FS 1.00 fl oz/cwt	0	0	84.9	88.8
Vitavax 200F 3.0 fl oz/cwt	74	3	73.7	75.3
LSD (p=0.05)	34	ns	12.4	12.0

Table 4. Diseases on "dwarf bunt" experiments at Haines and Elgin: 1990-1991.

Treatment and rate (fl oz/cwt)	Hill 81 Rhizoctonia root rot (0-5)	Take-all (%rts)	Pythium root rot (%rts)	Strawbreaker foot rot (%tllrs)	Common root rot (%plts)	Speckled snow mold (%plts)	Yield (bu/ac)	Lewjain Yield (bu/ac)
HAINES								
Control	1.5	4	17	0	93	12	71.5	-
Dividend 3FS 0.25	1.2	6	15	0	96	32	63.2	-
Dividend 3FS 0.50	1.1	9	14	1	92	13	66.1	-
Dividend 3FS 1.00	2.0	7	16	0	81	5	73.0	-
Vitavax 200F3	1.4	5	14	0	97	21	59.9	-
LSD (p=0.05)	0.5	ns	ns	ns	11	19	ns	-
ELGIN								
Control	2.6	5	14	45	60	-	66.1	71.6
Dividend 3FS 0.25	1.8	7	15	31	48	-	76.9	75.2
Dividend 3FS 0.50	1.9	6	11	18	28	-	74.6	72.6
Dividend 3FS 1.00	2.0	6	12	27	58	-	69.8	73.7
Vitavax 200F 3	1.8	5	6	32	33	-	77.2	79.4
LSD (p-0.05)	0.3	ns	4	ns	16	-	7.7	ns

Table 5. Flag smut experiment: 1990-1991.

Treatment and rate (fl oz/cwt)	Common root rot (%)	Strawbreaker foot rot (%)	Flag smut (%)	Yield (bu/ac)
Noninoculated control	9	19	54	31.1
Inoculated control	12	18	96	21.3
Dividend 3FS 0.25	9	24	1	32.7
Dividend 3FS 0.50	2	48	0	38.2
Dividend 3FS 1.00	8	35	0	33.9
Vitavax 200F 4.00	9	22	49	29.0
LSD (p=0.05)	ns	15	23	4.7

Table 6. Strawbreaker foot rot experiments at Pendleton and Moro: 1990-1991.

Treatment and rate	Pendleton: Strawbreaker foot rot (June 10) % Plants	Incidence[1]	Severity[2]	Pendleton Yield (bu/ac)	Moro Yield (bu/ac)
Control	100	3.7	3.7	62.5	32.2
Dividend 3FS 0.25 fl oz/cwt	100	3.7	3.7	60.8	35.5
Dividend 3FS 0.50 fl oz/cst	100	3.7	3.7	65.5	36.0
Dividend 3FS 1.00 fl oz/ac	100	3.6	3.6	59.2	35.5
Tilt 3.6E 4 fl oz/ac	99	3.4	3.4	71.3	34.2
Punch 25E 2 fl oz/ac	95	3.0	3.2	72.0	31.8
Benlate PNW 50DF 16 oz/ac	47	1.0	2.0	99.4	33.3
LSD (p=0.05)	4	0.2	0.2	11.8	3.6

[1]Incidence was determined by evaluating the cross-sectional area of infected stem (0 = none; 1 = 1-10%; 2 = 11-30%; 3 = 31-60%; 4 = 61-100%), then calculating the sums of tillers in each class times their class rating (0-4), and then dividing by the total of all plants (healthy and diseased).

[2]Severity was determined as with incidence, except that the calculation was restricted to diseased plants.

Table 7. Take-all experiment at Echo: 1990-1991.

Treatment and rate[1] (fl oz/cwt seed or lb fertilizer)	Band or seed trtmt.	Take-all (% roots)	Whiteheads /100 ft. row	Yield (bu/ac)
Non-fertilized control	-	21	18	60.4
Non-fertilized + Captan 400 2.90	S	25	44	76.0
Fertilized control[2] + Captan 400 2.0	S	25	45	74.3
Dividend 3FS 2.0	S	13	24	72.7
Dividend 3FS 4.0	S	11	17	75.4
Dividend 3FS 0.85	B	20	33	77.8
Dividend 3FS 1.7	B	8	28	73.3
Dividend 3FS 3.4	B	12	10	70.6
Baytan 30F + Captan 400 2.6+2.0	S	15	9	76.5
Baytan 30F 1.3	B	18	36	75.7
Baytan 30F 2.6	B	19	8	78.7
Baytan 30F 5.4	B	19	13	86.2
LSD (p=0.05)		8	ns	13.3

[1]Fungicide rate (1X and 2X) supplied equivalent amounts of product/ac on seed (72 lbs/ac) or fertilizer (88 lbs/ac).

[2]Fertilizer was banded below the seed for all treatments of Dividend and Baytan, regardless of the application method for the fungicides. The fertilized control with Captan seed treatment is the appropriate comparison for fungicide treatments.

NEW WINTER WHEAT VARIETIES

R. S. Karow, W. E. Kronstad and
M. F. Kolding

Three new winter wheat varieties have been released by the Oregon State University Agriculture Experiment Station. These varieties are Gene, MacVicar, and ORCR8313. Variety descriptions and performance data for the Columbia Basin are given below. MacVicar and ORCR8313 are joint releases with the Idaho Agricultural Experiment Station.

Small foundation seed increases were planted for 1992 harvest and seed allocations were made in May. Allocations were based on planted acreage and projected yields. Small amounts of unallocated seed may be available if actual yields exceed projections. Seed cost will be $0.50 per pound or higher. Growers desiring seed should contact the OSU Foundation Seed and Plant Materials Project.

Breeding efforts leading to development of these new varieties were funded in part by the Oregon Wheat Commission.

GENE

Gene is a white-chaffed, awnless, early-maturing, short-statured common soft white winter wheat developed by the OSU Department of Crop and Soil Science Wheat Breeding Project. This project is headed by Warren Kronstad. Gene is unique among Pacific Northwest varieties in it's early maturity (2-10 days earlier than Stephens) and awnless head characteristics. It has good resistance to *Septoria tritici*, a disease common to western Oregon and Washington, and to both stripe and leaf rusts. Yield potential is excellent with best performance observed in western Oregon and higher rainfall areas of the Columbia Basin. Gene is susceptible to *Septoria nodorum* and to common bunt. Use of bunt controlling seed treatments on Gene is recommended. Winterhardiness is similar or inferior to that of Stephens, therefore, Gene is not recommended for areas where winter injury is common. Gene is named after Gene Gross in recognition of the many contribution he made while working at the Klamath Falls Experiment Station. Gene was tested under the experimental designation OR8300801.

MACVICAR

MACVICAR is a high yielding common soft white wheat developed by the OSU Feed Grains Breeding Program lead by Matt Kolding. MacVicar has white chaff, height and heading date similar to Stephens and good-to-excellent lodging resistance. MacVicar was developed through use of an intensive, early-planting induced disease screening process. It may have tolerance to some of the diseases associated with early planting - barley yellow dwarf virus and assorted foot rots. It has resistance to stripe rust, is moderately susceptible to leaf rust and susceptible to mildew and common bunt. It appears to be especially adapted to the Treasure Valley and lower elevation irrigated areas, but has performed well across all environments. Quality has been average or better and protein levels have been consistently lower than those of other commonly grown varieties. The name MacVicar is in recognition of the many contributions made by Dr. Robert MacVicar, past-president of OSU, to the University and the State Of Oregon. MacVicar was tested under the experimental designation ORFW75336.

ORCR8313

ORCR8313 is an awned, white-chaffed hard red winter wheat with wide adaptation. ORCR8313 was developed by the OSU Department of Crop and Soil Science Wheat Breeding Project headed by Warren Kronstad. Grain yields have been greatly superior to those of other older Pacific Northwest hard red winter wheats. ORCR8313 has a greater level of stripe and leaf rust resistance than other hard reds, but is not resistant to common or dwarf bunt. Seed treatments should be used when ORCR8313 is grown in areas where bunts are common problems. ORCR8313's straw strength is only moderate and lodging could be a problem under irrigation or high rainfall conditions, especially if nitrogen fertility is high. ORCR8313 is not adapted to areas where a high degree of winter hardiness is required. Quality has been equal to that of other commonly grown hard red winter wheats. ORCR8313 is to be named after Neil Hoffman in recognition of the many contributions he made while superintendent at the Malheur Experiment Station. The names "Neil" and "Hoffman" were presented for USDA approval, but both were found to be already in use. The name "Hoff" has been proposed as an alternative.

Table 2. Height and test weight data over sixteen eastern Oregon site years for eight winter wheat varieties.

Variety	Height	Test weight
	in	lb/bu
MacVicar	33	59.3
Madsen	33	59.9
Malcolm	32	60.2
Stephens	31	60.2
Batum	34	58.9
ORCR8313	33	61.6
Wanser	38	60.2
PLSD (5%)	NS	1.3
CV (%)	23	3

Table 1. Reactions of eight winter wheat varieties to seven major wheat diseases.

Variety	Market class	Stripe rust	Leaf rust	*Septoria tritici*	Powdery mildew	Strawbkr foot rot	Cephalo stripe	Common bunt
Gene	SWW	MR	MR	R	MR	MS	MS	S
MacVicar	SWW	MR	MS	MS	S	MR	S	S
Madsen	SWW	R	MR	MR	MR	R	MS	R
Malcolm	SWW	MR	MS	MS	S	MS	MS	R
Stephens	SWW	MR	MS	S	MS	MR	S	R
Batum	HRW	MR	MS	MS	S	S	MS	R
ORCR8313	HRW	MR	MR	MR	MR	MR	S	S
Wanser	HRW	S	S	MR	MR	MS	S	S

Table 3. Yield data (bu/a) for eight varieties over eight eastern Oregon locations in 1990 and 1991.

	Gene SWW	MacVicar SWW	Madsen SWW	Malcolm SWW	Stephens SWW	Batum HRW	OR8313 HRW	Wanser HRW	PLSD (5%)
1990									
Arlington	40	32	32	31	34	33	29	30	7
Athena	97	96	93	96	94	81	67	49	10
Helix	78	81	80	93	81	85	65	56	13
Heppner	64	63	68	59	64	60	49	44	8
LaGrande	109	128	122	116	128	106	109	86	14
Lexington	65	53	46	43	57	56	40	40	11
Moro	38	51	45	51	47	47	38	32	6
Pendleton	101	96	93	104	101	87	84	43	8
Average	74	75	72	74	76	69	60	48	8
1991									
Arlington	14	12	32	20	23	33	0	21	6
Athena	103	100	100	88	96	92	75	56	16
Helix	91	67	68	66	62	70	43	69	16
Heppner	35	39	36	36	33	44	34	29	7
LaGrande	102	108	112	109	107	88	99	66	17
Lexington	34	24	30	27	34	25	23	19	4
Moro	53	54	53	53	52	60	40	39	8
Pendleton	76	83	78	82	83	65	67	79	11
Average	64	61	64	60	61	60	48	47	9

BREEDING FOR DISEASE RESISTANCE IN SOFT WHITE WINTER WHEAT

C. S. Love, D. K. Kelly,
R. W. Knight, W. E. Kronstad,
M. D. Moore, S.E. Rowe,
N. H. Scott, and M. C. Verhoeven

The goal of the wheat breeding program in Oregon State University's Crop and Soil Science Department is to develop high-yielding, disease resistant wheats with superior end-product uses. Although cultivars are currently being developed which represent hard white, hard red, and durum market classes, the primary focus of the wheat breeding program is on the development of soft white winter wheats. A shuttle-breeding approach is utilized during the early stages of variety development to expose various generations to a wide range of environmental conditions and stresses. Promising lines are advanced into yield trial nurseries and planted at three locations, Chambers Farm in the Willamette Valley, Barnett-Rugg Ranch northeast of Pendleton, and the Kaseberg Ranch, Sherman Branch Experiment Station near Moro.

Although the breeding material is exposed to a wide range of climates and cultural practices over several years, reliable environmental conditions conducive to disease development do not occur each year, and disease responses cannot be consistently characterized. For this reason, supplemental disease screening nurseries, specific to selected pathogens, are employed to further characterize advanced lines and early generation populations derived from specific hybridizations. This report will briefly summarize the methods employed in breeding for resistance to common and dwarf bunt, Cephalosporium stripe, strawbreaker foot rot, and foliar pathogens.

The bulk of the disease resistance breeding work conducted in eastern Oregon focuses on common and dwarf bunt. This cyclic breeding system involves 1) making specific hybridizations between winter wheats adapted to Oregon and breeding lines resistant to dwarf bunt; 2) screening early generation material at Pendleton with selected physiological races of the common bunt fungus; and 3) yield trial testing near Flora where severe natural infections of dwarf bunt occur each year. Lines with fewer than 2 percent infected tillers under severe disease pressure at Flora are selected and recycled through the common bunt screening nursery to characterize the resistance genes.

Common bunt screening is conducted at the Columbia Basin Agricultural Research Center using four physiological races of the common bunt fungus, *Tilletia tritici*. These races, T-16, T-30, R-39, and R-43, have been selected because they identify lines containing resistance genes Bt 5, Bt 8, Bt 9, and Bt 10. These genes offer the most effective resistance to dwarf bunt, and our program concentrates on incorporating these genes into adapted germplasm.

Promising lines are then advanced into more extensive yield testing, or returned to Corvallis and used as parents in hybridizations with adapted cultivars such as Stephens and Hill. In addition to germplasm identified in our screening program, resistant lines have also been obtained from dwarf bunt research programs in Idaho, Utah, and Montana. However, dwarf bunt breeding in these states has recently declined, and new germplasm is not readily available.

The 1992 common bunt screening nursery, sown 6 November 1991 on the experiment station near Pendleton, is comprised of 46 potential parents and advanced breeding lines from the soft white winter wheat breeding program, and 36 club wheats from Pamela Zwer's breeding program. The 1992 dwarf bunt yield trial was sown 12 September 1991 near Flora. This non-inoculated trial includes nine entries; four check varieties ranging in susceptibility from very susceptible to resistant, and five previously-identified resistant lines from the breeding programs at Corvallis, Hermiston, and Pendleton. One of the most promising lines in the 1992 dwarf bunt yield trial, the breeding line OR 880494 (OR7946/Hill//Hill), was selected from the 1991 dwarf bunt yield trial because it had very low disease incidence, and yielded very well. This line compares very favorably with Stephens in yield potential in trials over all locations in the state, and will be tested further to verify resistance to dwarf bunt.

Efforts in the soft white winter wheat breeding program continue to focus on identifying resistance or tolerance to Cephalosporium stripe, one of the most serious diseases of winter wheat in eastern Oregon. Although moderately resistant cultivars such as Hill, Daws, and Cashup are available, much of the winter wheat acreage in the state is seeded to higher-yielding, susceptible cultivars such as Stephens or Malcolm. In some years, environmental conditions conducive to Cephalosporium stripe do not occur, and susceptible cultivars yield well. However, in other years, or in certain regions, severe Cephalosporium stripe develops, and yields of susceptible cultivars can be reduced by as much as 50 percent. Our goal is to develop a tolerant, high-yielding soft white winter wheat for use in areas in eastern Oregon where severe Cephalosporium stripe develops. However, there are no adapted resistant cultivars available and screening involves testing a large number of lines from crosses made between winter types developed under severe disease pressure, and adapted lines.

Initial screening for resistance is conducted on early generation material in the greenhouse. The roots of seedlings are severed at the 2-leaf stage, then the plants are dipped into a suspension of *Cephalosporium gramineum* spores and planted into pots in the greenhouse. Disease severity is recorded as a combination of the percentage of plants which develop stripes, and the severity of striping. Lines with low disease severity scores are advanced into a replicated yield trial the following year. This trial is located in a grower's field near Adams, is seeded two weeks before the optimum planting date in order to ensure adequate plant development and optimum infection. The trial is inoculated by spreading artificially-infested oat kernel inoculum over the plots in early fall. Rain washes spores off the oats into the soil, and infection occurs as spores enter the roots. There are no known resistance genes to this disease, and it is difficult to screen for resistance in the field, given the complexity of environmental conditions necessary for infection to occur. For these reasons, a truly resistant adapted soft white winter wheat will be difficult to develop. We will continue screening breeding material for tolerant lines, but are also exploring other options, such as mixtures of moderately tolerant cultivars, to control this disease.

Strawbreaker foot rot, a serious disease of winter wheat throughout the state, is controlled primarily with benomyl, a carbendazim-generating (MBC) fungicide. Strains of the causal fungus, *Pseudocercosporella herpotrichoides*, resistant to MBC fungicides, have been found in Oregon with the first occurrence noted in 1989 near Pendleton in an intensively-managed irrigated circle with a history of benomyl use. The frequency of occurrence of these benomyl resistant strains increases with repeated fungicide use, consequently, control of the disease is reduced. Other practices such as crop rotation, or the use of resistant cultivars, will become increasingly important in controlling this disease.

Developing strawbreaker foot rot resistant cultivars for Oregon has been an objective of the soft white winter wheat breeding program for several years. The primary source of resistance utilized in this program is the cultivar Rendezvous, an awnless soft red winter wheat from Great Britain. Rendezvous is very resistant to foot rot, but is not well adapted to eastern Oregon. This line has been used in crosses with adapted cultivars since 1987, and progeny from these crosses are currently in yield trial testing, as well as in disease screening nurseries. Foot rot resistance screening is conducted in both the greenhouse, and in the field, on selected F_4 populations. Field screening involves inoculating ten individual head rows of each F_4 population with a conidial suspension of *P. herpotrichoides* spores, and selecting rows that show no symptoms of the disease. These populations are also inoculated as 2-leaf stage seedlings in the greenhouse, and disease symptoms (lesions) are quantified. Resistant lines are selected for inclusion in inoculated yield trials the following year. In past years, the foot rot breeding work has been conducted at the Columbia Basin Agricultural Research Center near Pendleton. However, because of problems involved in traveling to make timely pathogen inoculations and fungicide applications, the screening nursery was moved to Hyslop Farm near Corvallis in 1990. The cool wet winter weather in the Willamette Valley encourages disease development, and a larger number of populations can be screened than when the research plots were planted in Pendleton.

Research efforts aimed at developing soft white winter wheats resistant to the most common foliar disease present in the state, barley yellow dwarf virus (BYDV), stripe and leaf rust, septoria tritici blotch, and powdery mildew, are concentrated in the Willamette Valley where the climate is the most conducive to disease development. All of our breeding materials, including parental lines, segregating populations, and advanced breeding lines in yield trial testing, are planted at this location, ensuring maximum exposure of the germplasm to these diseases. We rely on the development of natural epiphytotics of BYDV, leaf rust, septoria tritici blotch, and powdery mildew for screening purposes. In most years, significant infection occurs, and disease reactions can be characterized. We do however, induce infections of stripe rust by planting inoculated 4-leaf stage Nugaines seedlings into the field in the center of spreader rows. Spreader rows are mixtures of susceptible wheats planted at regular intervals throughout the nursery. Spore dispersal begins as the infected Nugaines seedlings produce spores, which infect the susceptible wheats in the spreader rows, creating an artificially induced epiphytotic. If environmental conditions are favorable, and sufficient spore production and dispersal occurs, all of the lines in the nursery are exposed to infections of stripe rust, and susceptible lines begin showing symptoms.

Symptoms of each of the foliar diseases are recorded several times each growing season. Re-selection over several generations ensures that the level of resistance of lines which make it as far as yield trial testing is high. This continuous exposure and selection cycle is responsible for the release of the very successful cultivar Stephens. This variety has been in commercial production for 15 years, a remarkable feat, give that the typical "useful" life of a released variety is from five to seven years. It is hoped that the new release Gene, a semi-dwarf, early, awnless soft white winter wheat with excellent resistance to septoria tritici blotch and rust, will exhibit the same type of overall durable resistance as Stephens.

CLUB WHEAT BREEDING PROGRAM

P. K. Zwer, D. L. Sutherland,
and S. D. Dunnagan

The primary goal of the club wheat breeding program is to provide growers with club wheat varieties with improved disease resistance, higher yield potential in both low and high rainfall environments, and quality characteristics inherent to this class. Research is primarily conducted at the Sherman and Pendleton Research Stations. The breeding program encompasses several research areas that provide information used in the selection of improved varieties. The disease resistance component focuses on several diseases that cause significant yield losses in club wheat: stripe rust, strawbreaker foot rot, and Cephalosporium stripe. The insect tolerance component is centered on breeding for tolerance to the Russian wheat aphid (RWA) in winter and spring club backgrounds. Quality evaluations identify lines possessing superior milling and baking characteristics. Yield trials provide a way or method to compare agronomic traits of advanced club lines in comparison to released varieties. The integration of research areas provides effective selection criteria to identify superior club wheat lines.

DISEASE RESISTANCE

Stripe Rust. Stripe rust, incited by *Puccinia striiformis*, has historically caused significant yield losses in the club wheat varieties grown in the Pacific Northwest (PNW). Club wheat varieties are resistant when first released, however the pathogen is genetically variable, allowing the fungus to overcome the resistance in the wheat plant. The interaction between wheat varieties and *P. striiformis* is a relationship important in the development of durably resistant club varieties.

Stripe rust research is conducted in the greenhouse and the field. Susceptible seedlings are inoculated with *P. striiformis* spores to increase the supply of inoculum for greenhouse experiments. Inoculum is also provided by Dr. R. Line, USDA-ARS, Pullman. Forty-five pathotypes of *P. striiformis* have been described in the PNW, however one of two pathotypes usually predominates depending on the club wheat varieties grown. Seedlings of advanced club breeding lines are evaluated with the types isolated from the northeastern Oregon, so that resistant material is identified. Early and late generation breeding materials, located in the field, are also inoculated. Susceptible single plant selections are tagged in these populations and resistant head selections are maintained for the next generation. More than 21,000 heads were selected from 900 F_2 populations and sown into headrows. In addition, 15,900 F_4 to F_7 headrows were selected from 24,800 headrows on the basis of stripe rust reaction and agronomic characters.

Strawbreaker Foot Rot. Foot rot or eyespot, caused by *Pseudocercosporella herpotrichoides*, is a fungal pathogen that infects wheat at or near the soil surface. The pathogen survives on crop residue and is dispersed to the wheat crop by rain. *P. herpotrichoides* causes dark, elliptical lesions in the leaf sheaths and stems. The disease may kill the plant, however, more frequently plants lodge due to weakened culms which result from lesion penetration.

The club wheat breeding program evaluates genetic resources as well as advanced club lines for tolerance to strawbreaker foot rot in the field. Selected material is planted into two rows and replicated twice. The nursery is inoculated with *P. herpotrichoides* in late autumn during cold, wet periods. Figure 1 shows the results from the 1990-91 strawbreaker foot rot evaluation nursery. The evaluation scale was 0 to 4, where 0 was immune, 1-2 tolerant and 3-4 susceptible. Twenty-five tillers from each entry in the two replications were evaluated. The 270 entries were primarily susceptible, however 28 lines and varieties were tolerant. The two most tolerant lines (score of 1) were a triticale, Flora, and an advanced club line. Seven lines, possessing average scores in the 1.5 range, were from diverse backgrounds; China, New Zealand, the Netherlands, France, and one advanced club line from the breeding program. An additional 19 tolerant lines classified with an average score of 2 were of similar parentages. Table 1 presents quality, yield, and strawbreaker foot rot data for eight advanced club lines grown in the advanced yield trial at Pendleton, 1990-91. The table shows that the advanced club lines have combinations of several favorable characters.

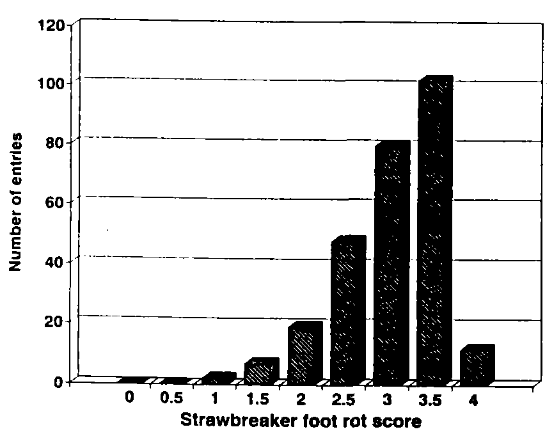

Figure 1. Distribution of entries evaluated for strawbreaker foot rot resistance.

INSECT RESISTANCE

Seedling. RWA spread into the PNW in 1987. The insect commonly causes yield losses between 35 and 60 percent, posing a serious threat to wheat producing regions in the United States as well as countries around the world. The aphid causes interveinal chlorotic white and purple streaks in the leaves, stunted growth, and sterility. The insect can feed from the time of seedling emergence through to maturity. RWA removes assimilates from leaf vascular tissue, disrupting cell walls and chloroplasts. A reduction in the photosynthate as well as a reduction in chlorophyll results in reduced seedling growth. Furthermore, water relations within the plant are disrupted, resulting in symptoms similar to drought stress. The leaves remain rolled due to the collapse of bulliform cells in the leaf epidermis, which interferes with development of future leaves. Yield losses in northeastern Oregon have primarily been sustained in spring grains. Winter wheat crops have avoided large yield losses by the ability of the wheat plant to tiller and out-grow the effects of the aphid during the winter months. Although RWA can survive the winter temperatures in this region, the reproductive capabilities are significantly reduced, resulting in a population decrease.

RWA tolerant genetic resources were identified in greenhouse evaluation studies conducted at the Pendleton Research Station. Seedling evaluations identified tolerant lines that were used in the crossing program. A total of five lines has been used in the development of tolerant winter and spring club wheat varieties over the last three years.

Adult-Plant. Although the genetic resources were tolerant to RWA in the seedling stage, no information was available for the reaction of the adult plant in the field. Experiments were designed to determine the usefulness of the genetic resources in the adult plant at the Pendleton Research Station. Two lines, PI294994 and PI137739 were crossed into the club wheat background. The F_2 populations were sown into thin-planted 80 ft^2 plots in the autumn. Cages, constructed of PVC pipe for the frame and covered with insect netting, were secured over five plots in April. The plants were beginning to joint when the aphids were introduced into the cages. Plants in the susceptible population produced very little seed, whereas plants in the population with a tolerant parent produced healthy plants. Preliminary results indicate the crosses segregated for one and possibly two genes depending on the tolerant genetic resource utilized in the cross. Thus more than 75 percent of the plants showed tolerant responses to RWA infestation.

The genetic resources identified in the seedling evaluation procedure also provided protection for the adult plant in the field. The material, crossed into winter and spring club backgrounds, will provide field protection for the plant.

QUALITY

The superior soft wheat quality characteristics inherent in club wheat are responsible for the small albeit significant role of this class in PNW wheat production. Club wheat is required for the export class, western white, however production has not paralleled demand. Numerous reasons, primarily stripe rust susceptibility and lower yield potential in comparison to common wheat varieties, explain lower club wheat production levels. A concerted effort to maintain and enhance club wheat quality characteristics, while introducing genetic diversity to improve disease resistance and yield potential is essential for the development of competitive club wheat varieties.

Early and late generation material is assessed for milling and baking characteristics by the Western Wheat Quality Laboratory, USDA-ARS, Pullman, WA. Early generation lines are evaluated for grain protein and hardness, two characteristics that are excellent early selection criteria. Advanced generation material have a spectrum of milling and baking characteristics evaluated, such as test weight, grain hardness, grain protein, flour yield, flour ash content, milling score, flour protein, mixograph, cookie diameter, top grain score, and sponge cake score. Table 2 shows selected quality characteristics for promising advanced club lines, grown at the Pendleton Research Station in the 1990-91 growing season. The plus symbol indicates lines with characteristics superior to the standard mean.

YIELD POTENTIAL

Yield trials are conducted at the Sherman and Pendleton Research Stations each year. There are three levels of testing; preliminary, advanced, and elite yield evaluations. Advanced breeding lines that perform above the nursery average in the preliminary yield trials are promoted to the advanced yield trials. The elite yield trials are composed of the superior performing lines identified in the advanced yield trials. The number of advanced club lines being evaluated in yield trials increased in the 1991-92 growing season. The elite and advanced yield trials grown at the Sherman and Pendleton Research Stations are composed of 36 and 30 entries, respectively. The preliminary yield trials, comprised of seven experiments each with 45 entries, were sown at the Pendleton Station. Advanced club lines, grown in the yield trials, are evaluated for a number of agronomic traits including stand establishment, winter hardiness, frost tolerance, disease resistance, heading date, height, lodging, shattering resistance, yield, and test weight.

Genetic differences in yield potential exist between breeding lines. The semi-dwarf trait enhanced the wheat plants response to nitrogen fertilization thereby increasing yield. Other agronomic traits, as listed above, also influence the yield potential of advanced breeding lines. Thus advanced breeding lines that perform well in the yield trials have combinations of desirable agronomic traits in the region of testing. Table 3 shows the height and yield of promising advanced club lines. Note the lines are the same as the promising quality club lines in Table 2.

Elite Club Lines. Four club lines, OR855, 87-636, 85HR5350, and 85HR6537, are being evaluated for potential variety release. Tables 4 and 5 show the yield, test weight, and height for 87-636, 85HR5350, and 85HR6537 for several years at locations around central and northeastern Oregon.

Table 6 shows the yield and test weight of OR855 in comparison to Tres and Hyak. Table 7 presents data collected from locations around northcentral and eastern Oregon for yield. Disease reactions and agronomic traits are presented in Tables 8 and 9.

Regional Yield Testing Program. Winter grain yield trials were planted at eight locations around northcentral and eastern Oregon in 1990-91. The yield data for varieties grown in these locations for several years are presented in Tables 10 and 11. The Club Wheat Breeding Program will continue to conduct winter and spring grain yield trials at the Pendleton and Sherman Research Stations as well as two additional locations in Morrow and Union Counties.

CONCLUSION

The promising advanced club breeding lines identified in the research areas are used in the crossing program and are considered for varietal release. Many times advanced lines are inferior in one or two important traits and cannot be considered as a potential release. The material, however, is valuable in the crossing program as an adapted club parent. The lines are intercrossed with material that will improve the deficiencies and brought through the program again. The frequency of advanced breeding lines with promising attributes increases in the program with the recycling of lines that are not suitable for varietal release the first time.

Advanced lines not suitable for release are used in the crossing program conducted in the greenhouse. The pollen-bearing anthers are removed (emasculated) from the wheat plant, so that a desired parent can be matched for the pollination. The emasculated plants are clustered around the pollen parent to make the cross. The seeds that develop represent the F_1 generation and the beginning of the club wheat improvement process.

Advanced lines that possess promising quality, disease resistance, and yield potential are considered for release. The material is submitted into the Western Regional Yield Nursery for performance data in the tri-state area. The lines are evaluated by a variety release committee and once approved, are increased for release.

Table 1. Quality and yield data for advanced club lines with strawbreaker foot rot resistance grown at CBARC, Pendleton, 1990-91.

Line or variety	Test weight	Grain protein	Grain hardness	Milling score	Cookie diameter	Yield	Strawbreaker foot rot score
	lbs/bu	%			cm	bu/a	1-4
91CL0005	62	7.4	35	87.6	9.61	98	1.9
91CL0021	62	7.7	44	88.2+	9.69	85	2.0
91CL0015	62	7.7	43	87.6	9.37	91	1.2
91CL0003	61	7.6	38	85.3	9.81	101	2.4
91CL0006	60	7.8	38	85.1	9.70	98	2.5
90CL0132	62	7.3	42	83.6	9.46	92	2.1
91CL0008	64+	8.7	49	90.5+2	9.70	72	2.5
90CL0137	62	8.5	36	85.7	9.49	96	2.6
Elgin	62	8.9	39	84.7	9.81	57	3.7
Tres	62	8.1	41	83.7	9.69	81	3.6
Hyak	61	7.4	38	88.8+	9.52	66	3.0

+ Significantly different from check varieties mean.

Table 2. Milling and baking quality for advanced club lines grown at Pendleton, 1991.

Line or cultivar	Test weight	Grain protein	Grain hardness	Milling score	Cookie diameter
	lbs/bu	%			cm
85HR5326	59	7.8	50	91.4	9.65
85HR5444	61	7.6	38	89.9	9.41
H85A1482	62	6.8	37	91.0	9.52
85HR5333	60	7.2	37	89.9	9.79+
85HR5639	63+	7.2	42	91.4	9.65
85A74-36	62	7.9	50	91.8+	9.60
H85A244	60	7.2	39	90.9	9.65
H85A211	60	7.0	29	91.2	9.71
800423	61	8.0	39	90.2	9.60
Standard mean	61	7.4	40	89.7	9.49

Table 3. Yield and height for advanced club lines grown at Moro and Pendleton, 1991.

Line or cultivar	Moro Ht	Moro Yield	Pendleton Ht	Pendleton Yield
	in	bu/a	in	bu/a
85HR5326	25	50	37	88
85HR5444	27	56	40	80
H85A1482	26	54	45	88
85HR5333	27	55	41	84
85HR5639	26	60	33	76
85A74-36	23	55	41	93
H85A244	24	60	37	84
H85A211	27	50	36	91
800423	28	52	35	89
Tres	28	56	39	85

Table 4. Agronomic characters for advanced lines at Arlington, Heppner, Lexington and Moro for several years.

Line or cultivar	Arlington No. yrs.	Ht.	Test wt.	Yld.	Heppner No. yrs.	Ht.	Test wt.	Yld.	Lexington No. yrs.	Ht.	Test wt.	Yld.	Moro No. yrs.	Ht.	Test wt.	Yld.	Avg. yld.
		in	lb/bu	bu/a		in	lb/bu	bu/a		in	lb/bu	bu/a		in	lb/bu	bu/a	bu/a
87-636	3	22	61	30	3	30	59	42	3	28	59	40	4	29	61	57	43
85HR5350	1	23	60	24	1	29	62	33	1	25	58	26	2	25	56	42	33
85HR6537	1	24	61	29	1	29	59	33	1	25	59	26	2	25	59	50	37
Elgin	2	22	59	22	2	38	59	38	2	29	59	32	2	29	60	39	32
Tres	3	21	57	24	3	29	58	35	3	27	58	41	4	28	59	40	36
Hyak	2	23	56	21	2	28	57	41	2	28	58	45	2	28	57	34	35

Table 5. Agronomic characters for advanced club lines at Athena, Helix, La Grande, and Pendleton for several years.

Line or cultivar	Athena No. yrs.	Ht.	Test wt.	Yld.	Helix No. yrs.	Ht.	Test wt.	Yld.	La Grande No. yrs.	Ht.	Test wt.	Yld.	Pendleton No. yrs.	Ht.	Test wt.	Yld.	Avg. yld.
		in	lb/bu	bu/a		in	lb/bu	bu/a		in	lb/bu	bu/a		in	lb/bu	bu/a	bu/a
87-636	2	42	60	77	2	35	60	62	3	39	58	109	4	40	62	87	87
85HR5350	1	42	62	76	1	33	62	66	1	41	57	95	3	38	60	82	81
85HR6537	1	45	61	87	1	34	61	70	1	46	60	93	3	42	62	90	87
Elgin	2	50	60	55	2	42	63	56	2	49	60	74	3	48	61	54	57
Tres	2	45	60	76	2	38	63	70	3	41	58	102	4	43	62	87	82
Hyak	1	42	60	81	1	36	63	80	2	39	57	103	2	38	61	79	86

Table 6. Yield and test weight for OR855, Tres and Hyak.

Cultivar	No. site years	Yield	Test weight
		bu/a	lb/bu
OR855	30	61	60
Tres	30	58	59
Hyak	30	58	58

Table 7. Yield for OR855, Tres and Hyak at eight locations in northcentral and eastern Oregon.

Location	No. of years	Cultivar or line yield bu/acre		
		OR855	Tres	Hyak
Arlington	4	31	28	29
Athena	3	75	78	81
Heppner	4	45	40	43
LaGrande	4	115	101	107
Lexington	4	44	44	39
Moro	4	52	48	48
Pendleton	3	82	84	78

Table 8. Disease reactions for OR855 in comparison to Tres and Hyak.

Variety or line	Stripe rust	Leaf rust	Cephalosporium stripe	Strawbreaker foot rot	Dryland foot rot	Common bunt
OR855	R	MS	MR	MS	T	MR
Tres	S	MR	S	MS	T	S
Hyak	MS	R	S	R	T	S

Table 9. Agronomic traits for OR855, Tres and Hyak.

Cultivar or line	Height (cm)	Heading date from Jan. 1	Lodging resistance	Winter hardiness
OR855	81	142	R	6
Tres	84	146	R	5
Hyak	81	140	R	5

Table 10. Yield for winter grain varieties grown at Arlington, Heppner, Lexington, and Moro, 1985-1991.

Line or cultivar	Arlington No. yrs.	Arlington Yld.	Heppner No. yrs.	Heppner Yld.	Lexington No. yrs.	Lexington Yld.	Moro No. yrs.	Moro Yld.	Location average yield
		bu/a		bu/a		bu/a		bu/a	bu/a
HARD RED									
Andrews	4	29	4	39	4	40	4	48	39
Batum	4	33	4	45	4	37	4	61	44
ORCR8313	3	33	4	36	4	40	4	45	40
Wanser	4	27	4	36	4	35	4	39	34
SOFT WHITE									
Basin	3	29	3	52	3	28	4	57	41
Cashup	3	29	3	38	3	28	4	58	32
Daws	7	33	7	40	7	47	7	50	42
Dusty	7	35	7	44	7	44	7	53	44
Hill81	7	33	7	42	7	46	7	49	43
Lewjain	6	36	6	43	6	46	6	53	44
Madsen	4	33	4	47	4	43	4	54	44
Malcolm	7	33	7	43	7	49	7	54	45
OR830801	1	14	1	35	1	34	3	65	46
Oveson	7	31	7	38	7	46	7	48	41
Stephens	7	36	7	45	7	54	7	52	47
CLUB									
Hyak	4	30	4	45	4	41	5	53	45
OR855	5	37	5	44	7	48	6	52	46
Tres	7	33	7	37	5	42	7	49	42
TRITICALE									
Flora	3	33	3	43	3	50	3	63	47
Whitman	2	27	2	41	2	53	2	49	42

Table 11. Yield for winter grain varieties grown at Athena, Helix, La Grande, and Pendleton, 1985-1991.

Line or cultivar	Athena		Helix		La Grande		Pendleton		Location average yield
	No. yrs.	Yld.	No. yrs.	Yld.	No. yrs.	Yld.	No. yrs.	Yld.	
		bu/a		bu/a		bu/a		bu/a	bu/a
					HARD RED				
Andrews	4	77	3	56	4	105	4	69	78
Batum	4	80	3	69	4	100	3	70	81
ORCR8313	4	75	3	51	4	109	3	69	78
Wanser	4	59	3	56	4	84	4	55	64
					SOFT WHITE				
Basin	3	85	2	55	3	110	3	75	84
Cashup	3	89	2	52	3	119	3	69	85
Daws	5	82	4	69	7	98	6	75	83
Dusty	5	82	4	70	7	98	6	80	84
Hill81	5	86	4	70	7	101	7	76	85
Lewjain	5	83	4	66	6	102	5	81	85
Madsen	4	88	3	63	4	113	5	75	86
Malcolm	5	87	4	73	7	99	7	81	86
OR830801	1	103	1	91	1	102	3	68	83
Oveson	5	82	4	71	7	97	7	75	82
Stephens	5	85	4	69	7	95	7	78	83
					CLUB				
Hyak	3	93	3	65	4	113	6	73	83
OR855	5	79	4	67	5	110	5	84	86
Tres	5	80	4	68	7	95	7	78	82
					TRITICALE				
Flora	3	81	2	77	3	110	2	77	88
Whitman	2	76	1	98	2	117	2	89	95

GWEN, PI 554155, syn FB77796
A NEW WINTER BARLEY

* Mathias F. Kolding, John Berdahl, Warren Kronstad, and Mary Verhoeven

* Writers note: Oregon Agricultural Experiment Station has approved the release of 'Gwen' and has submitted the supporting data to the Experiment Station directors in Idaho and Washington for their consideration on 2/3/92.

INTRODUCTION

Gwen, (PI 5541155, FB77796) was developed by the Oregon Agricultural Experiment Station to provide an early maturing winter hardy barley for the low rainfall and shallow soil regions of Oregon.

Gwen is moderately resistant to barley leaf scald caused by prevalent races of *Rhynchosporium secalis* east of the Cascade mountain range in Oregon. It does exhibit symptoms of Barley Yellow Dwarf Virus in fall plantings, but appears to adjust to the causal agent of those symptoms and produce normal yields of high quality grain. No reports of other diseases which may cause economic yield reductions have been received.

HISTORY

OH B67-23 was crossed with Lakeland in the winter-malting program at Corvallis and in the winter-feed barley program at Pendleton during 1972. Bulk populations were traded back and forth between the programs so it is speculative whether the cross was made under the direction of Mathias F. Kolding or Dr. John Berdahl.

Selections from this cross were tested under various designations, but were placed in the background due to a more intense interest in selection E-804 from a Lakeland/Kamiak cross. Eventually, however, that selection appeared less winter hardy, and later maturing than the FB77796 selections. Grower interest waned after a series of mild winters. FB77796 was one of several selections that appeared very hardy in the 1977-1978 fall planted barleys at the Experiment Station near Union, Oregon. Heads were picked and seed increased in head rows from that population in 1978-1979. Several rows were kept for preliminary yield estimate trials. Several years later, 240 heads were picked and planted from head-row 913. Off-types were discarded; the rest was bulked as a seed source for regional trials and H6001 added to designate this bulk. Heads were picked in 1989, planted and harvested as breeders or pre-breeders seed in 1990. One-half of that seed was planted at HAREC for the 1991 crop.

DISCUSSION

Tables 1 through 3 are summaries of the Western Regional Winter Barley Nursery grown near Hermiston. Although the nursery is irrigated, nitrogen applications on that sandy soil are generally limited to applications of 95 to 120 pounds per acre. Water applications are usually behind evapo-transpiration for cereals. The nursery is managed in a stress situation to magnify disease damage that is especially associated with Barley Yellow Dwarf Virus, and the root disease complex in irrigated sandy soils. The trials are usually planted during the last week of September or the first week of October. Consequently, grain yields are not very high, although they are close to 4 tons per acre in some years. Under the above practices, it appears that Gwen, has had higher grain yields (Table 1), ranked higher for test weight (Table 2) than eight named varieties, and has a good survival rate, (Table 3).

Further evidence of Gwen's winter survival is given in Table 4 where it is reported to survive as good as Dicktoo and Kearney winter barleys across 45 station years of tests.

Table 5 gives three by-year (1985-1986, 1986-1987,and 1987-1988) summaries and summarizes those years as excerpted from the Western Regional Winter Barley Nursery Final Reports. The three year summary suggests that: Gwen yielded better than Kamiak and Wintermalt, but less than Boyer over 27 station years. Gwen test weights were equal to or better than Kamiak and Wintermalt and better than the eight other named checks over 24 station years.

Gwen is taller than the sample mean, but shorter than Kamiak. Gwen heads during the same period as Wintermalt and Kamiak, which is earlier than the other eight checks. Gwen appears to have less lodging than Kamiak, Wintermalt, and Hesk. Gwen kernel plumpness as assorted over a 6/64 slotted screen is equal to Kamiak and Eight Twelve, and better than the other checks.

Gwen is intended as a replacement for Kamiak and to fit in the Kamiak area of adaptation (high, dry, and early). Gwen is shorter, stiffer strawed, and yields better in yield trials than Kamiak. It has just as good kernel plumpness, and, if not superior, it has a better test weight.

GWEN

'Gwen' PI 554155, winter barley is named after Mrs. Gwen Mitchell. First, we want to recognize her enduring work, contributions, and interest in her community. Second, we want to symbolically honor the spouses of the branch experiment station workers in Oregon. Branch station workers have had a tendency to focus a major portion of their energies on their projects, and they spend a lot of time away from the home to attend meetings. Though much credit is given the workers for their effort and sacrifice of time, it is really the spouses and family member's time that is sacrificed.

Gwen Mitchell

WESTERN REGIONAL WINTER BARLEY NURSERY SUMMARIES

Table 1. Western Regional Winter Barley Nursery; a five-year grain yield summary of winter barleys tested at the Hermiston Agricultural Research and Extension Center, Hermiston, Oregon.

	Yield						
Name	1987	1988	1989	1990	1991	Average	Percent of Kamiak
	cwt/ac						
1 Kamiak	47	62	48	65	33	51	100
2 Schuyler	55	58	47	72	43	55	108
3 Boyer	50	58	49	70	39	53	104
4 Hesk	41	60	39	74	34	50	98
5 Scio	42	76	42	72	29	52	102
6 Eight Twelve	57	69	38	69	33	53	104
7 Showin	51	77	42	61	23	51	100
8 Hundred	41	69	45	62	31	50	98
9 Gwen (FB77796)	45	67	66	72	40	58	114

Stand Error at 5% = 4.25
Overall Mean = 52.51

Table 2. Western Regional Winter Barley Nursery; a five-year test-weight summary of winter barleys tested at the Hermiston Agricultural Research and Extension Center, Hermiston, Oregon.

	Test Weight					
Name	1987	1988	1989	1990	1991	Average
	lbs/bu					
1 Kamiak	47	51	49	47	46	48.0
2 Schuyler	43	50	48	47	47	47.0
3 Boyer	47	50	46	47	48	47.6
4 Hesk	46	49	48	44	45	46.4
5 Scio	46	49	50	45	48	47.6
6 Eight Twelve	47	48	49	45	49	47.6
7 Showin	47	48	47	45	46	46.6
8 Hundred	46	48	48	46	47	47.0
9 Gwen (FB77796)	48	50	50	47	49	48.8

Standard Error at 5% = .7416
Overall Mean = 47.40

Table 3. Western Regional Winter Barley Nursery; percent winter survival* of 9 winter barleys planted September 24, 1990 and exposed to a sudden December ** freezing at the Hermiston Agricultural Research and Extension Center.

Name	Rep 1	Rep 2	Rep 3	Rep 4	Average
	- - - - - - - - - - - - -	- - - - - -	Percent survival	- - - - - -	- - - - - - - - - - - - -
1 Kamiak	70	30	85	75	65.5
2 Schuyler	60	40	75	30	51.2
3 Boyer	85	85	85	85	85.0
4 Hesk	30	10	30	40	27.5
5 Scio	30	05	30	20	21.2
6 Eight Twelve	60	30	65	50	51.2
7 Showin	20	10	30	30	22.5
8 Hundred	30	05	20	60	28.8
9 Gwen (FB77796)	85	85	85	85	85.0

* Survival estimates determined on February 20, 1991.

** Minimum air temperatures were 34, 11, 03, -12, -12, -05, -03, -03, 08, 14, 15, -18, -14, 04, 04 for December 17, 1990 through December 31, 1991 respectively, with no snow cover until a skiff was deposited during the slight warm-up.

Table 4. Three year (1987-1989) percent of winter survival summary from the Uniform Barley Winter Hardiness Nursery* comparing Gwen with Dicktoo, Kearney, Tennessee Winter, and Trebi barleys.

Variety	Habit	1987	1988	1989	Average	Number of Stations**
		- - - -	Percent Survival	- - - -		
1 Gwen	winter	75.8	79.0	67.3	74.1	45
2 Dicktoo	winter	86.8	77.0	67.9	76.1	45
3 Kearney	winter	80.2	73.9	73.5	75.3	45
4. Tenn. W.	winter	43.2	35.0	31.0	35.6	45
5 Trebi	spring	16.0	21.3	14.3	15.3	45
LSD (0.05)		9.2	8.8	11.8		
Number of stations		11	18	16		45

* Compiled and coordinated by Dr. H. G. Marshall, and D. P. Livingston, USDA, ARS, The Pennsylvania State University.

** Number of stations reporting differential winter damage and included in averaging.

Table 5. Agronomic summary for winter barleys tested in the Western Winter Barley Nursery*.

1986, 1987, 1988

Variety	Yield	Test Weight	Height	Date Headed	Lodging	Over 6/64
No. of Stations	27	24	26	22	17	6
	cwt/ac	lbs/bu	inches	Jan 1	%	%
1 Kamiak	47.1	49.5	37.1	131.8	45.7	70
2 Schuyler	51.9	48.3	34.6	137.5	24.6	59
3 Boyer	55.3	47.6	33.8	138.2	14.5	64
4 Hesk	54.0	47.7	33.6	136.8	31.1	61
5 Mal	52.5	47.3	34.2	139.8	23.4	61
6 Scio	53.7	48.4	32.3	136.1	11.6	66
7 Eight Twelve	52.6	48.7	31.8	134.8	20.0	72
8 Showin	51.9	47.5	29.4	136.8	15.0	53
9 Hundred	53.8	46.8	31.5	139.8	19.8	47
10 Wintermalt	48.5	49.2	35.2	130.8	48.9	64
11 Gwen (FB77796)	53.1	50.6	34.5	132.1	13.2	71
Sample Means	52.22	48.33	33.45	135.9	24.35	62.5
Standard Deviation	2.421	1.115	2.092	3.137	12.71	7.6
Calculated by TSINGLE, MSUSTAT 1986, 3.20 @ 95% probability						

* From final reports of the Western Regional Winter Barley Nursery coordinated by Dr. Darrell Wesenberg, USDA, ARS, Aberdeen, Idaho.

BARLEY BREEDING FOR THE COLUMBIA BASIN

Patrick M. Hayes

WINTER MALTING BARLEY

Background:

This program is supported by Busch Agricultural resources, Inc., Great Western Malting, Inc., and the American Malting Barley Association. Winter habit malting barley varieties will offer the Industry an alternative source of a quality product. The intent is to capitalize on the yield and quality stability of fall-planted vs. spring planted grain. Winter malting barley would offer growers an alternative to the prevailing winter wheat monoculture. No winter barley varieties have been approved by the American Malting Barley Association (AMBA). Winter barley acreage now exceed spring barley acreage in Europe and winter malt types dominate export markets. European winter malting varieties grown in the United States do not have quality profiles acceptable to the United States industry, nor do they have the yield potential required by US producers. Winter barley, in general, is less cold tolerant than winter wheat. This fact, coupled with the disadvantageous position of barley in the Farm Program and low feed barley prices, has led to modest, static winter barley acreage.

Objective:

Develop winter habit malting barley varieties with quality acceptable to US Industry and agronomic characters acceptable to US producers. The emphasis is on 6-row types.

Strategy:

Simultaneously advance breeding material and characterize the genetics of cold tolerance, malting quality, and resistance to Barley Stripe Rust, race 24 (BSR).

- The breeding program is based on introgressing exotic germplasm into the Pacific Northwest winter feed barley germplasm base. The exotic germplasm consists of Great Plains winter barleys as sources of cold tolerance; West European winter barleys as sources of malting quality; East European and Soviet winter barleys as sources of cold tolerance; and US spring barleys as sources of malting quality.

- The breeding strategy is a loosely structured recurrent selection program based on the accelerated advance of doubled haploid progeny derived from two and three-way crosses.

- Initial selection of DH lines is based on kernel plumpness and maturity. Subsequent selection is based on yield and quality performance in replicated, multi-environment tests.

- The development restriction fragment length polymorphism of RFLP maps in selected DH populations will assist in mapping the loci involved in cold tolerance, certain malting quality parameters, and resistance to BSR, race 24. With markers flanking genes of interest, molecular marker assisted selection will be initiated in F2-derived DH lines and through modified backcross strategies.

- Germplasm: Material from all US programs is evaluated via the regional nursery network and through specific exchanges. Several hundred introductions from France, Germany, UK, and the USSR are evaluated each year.

- Crossing strategy: The DH program was initiated with a structured partial circulant diallel mating that was used to create a recurrent selection population that is subjected to selection for both cold tolerance and percent extract. The population consists of 300 DH lines derived from 15 F1 combinations. The breeding effort is based on material from this population and an additional 20 to 40 crosses made each year, using both domestic and exotic germplasm.

- Evaluation strategy: Approximately 1000 DH lines are produced annually. Lines are evaluated in 3 m, 1-row plots at Corvallis. Approximately 30 percent are discarded, based on maturity, disease reaction, and poor kernel sizing. Selected lines are advanced to one or two-replicate trials at two locations, including Pendleton. Selection is based on the full spectrum of quality and agronomic parameters. Selections are advanced to multiple location trials and used as parents in generating the next cycle of DH lines.

Results:

Results for the first cycle of doubled haploid evaluation are presented in Tables 1 through 4. To underscore the efficiencies of the doubled haploid technique, if conventional breeding procedures had been used, these lines would have reached this stage of evaluation in 1996. It is particularly noteworthy that both 6-row and 2-row lines have high kernel plumpness values and that there are certain 2-row lines with reasonable agronomic performance. Plaisant is a French 6-row winter malting type that sets the low standard for export malt.

Table 1. Yield of selected 6-row DH winter lines at Pendleton, OR. 1990/1991.

Line	Type	Pedigree	Yield
			(kg/ha)
1907677	6	Pla/Nov	4829
1907767	6	Sci/1861112	4731
1907993	6	" "	7093
1908002	6	" "	5351
1908100	6	Nov/Fla	4940
1908184	6	·186016/Ste	8305
Plaisant	6		4942
Scio	6		6169

Table 2. Yield of selected 2-row DH winter lines at Pendleton, OR. 1990/1991.

Line	Type	Pedigree	Yield
			(kg/ha)
1907951	6	1841007/1861009	6104
1907982	6	" " "	5523
1907996	6	" " "	5316
1907997	6	" " "	5495
1908016	6	" " "	5526
1908030	6	" " "	6380
1908103	6	Nov/Fla	6186
Plaisant	6		4942
Scio	6		6169

Table 3. Quality of selected 6-row DH winter lines at Pendleton, OR. 1990/1991.

Line	Type	Protein	Plump	Extract	Dp	α	S/T
			(%)				
1907677	6	10.2	85.1	76.9	37	22.3	33.6
1907767	6	11.2	98.9	77.7	70	23.7	46.2
1907993	6	8.9	72.3	81.2	74	35.1	48.9
1908002	6	10.9	98.7	82.1	57	21.5	36.7
1908100	6	9.2	98.3	77.2	53	19.1	34.4
1908184	6	11.0	94.1	78.8	46	21.8	39.3
Plaisant	6	10.5	90.9	78.8	63	19.4	35.3

Table 4. Quality of selected 2-row DH winter lines at Pendleton, OR. 1990/1991.

Line	Type	Protein	Plump	Extract	Dp	α	S/T
			(%)				
1907951	2	12.9	98.8	76.2	92	23.5	33.5
1907982	2	12.8	99.3	77.7	86	27.7	37.6
1907996	2	10.8	92.5	79.9	58	23.6	41.8
1907997	2	12.7	99.9	76.1	72	22.1	36.8
1908016	2	12.0	98.7	78.4	54	21.5	34.5
1908030	2	11.9	99.0	78.6	56	24.2	42.2
1908103	2	11.9	97.9	75.5	67	22.5	41.0
Plaisant	6	10.5	90.9	78.8	63	19.4	35.3

Special studies:

- Cold tolerance and malting quality gene mapping: LT50 screening of the Dicktoo X Morex DH lines is underway. Approximately 40 restriction fragment length polymorphisms (RFLPs) have been identified and mapped. Preliminary data indicates clustering of cold tolerance factors on chromosome 7.

- Barley Stripe Rust, race 24: DH lines have been produced from the cross of a barley yellow dwarf virus (BYDV)-resistant Bowman and a BSR, race 24 resistant CIMMYT selection (out of the Lignee/Teran background). DH progeny have been screened in Mexico.

Resistance is not monogenic. Two to three genes are probably involved.

SPRING BARLEY

Background and objectives:

This research is supported by the Oregon Grains Commission and is designed to contribute to the profitability of Oregon barley production. This objective will be realized by:

1) Assisting grower decision making by providing yield and quality data on current and potential cultivars from testing sites in key barley growing regions of the state.
2) Developing 6-row and 2-row spring feed barley varieties with superior agronomic and quality characteristics.
3) Strengthening an inter-disciplinary cooperative network for barley research.

Results:

The 1992 trials at CBARC include (i) an OSU variety comparison trial, (ii) screening trials from WSU, and (iii) the Steptoe X Morex doubled haploid trial that is part of the North American Barley genome Mapping Project. We are producing approximately 300 DH lines/year for the spring program, with an emphasis on plump 6-row types with no dormancy and low winterhardiness. The first of these lines will be in trials at CBARC next year.

UPCOMING RELEASES

ORWM8407 is a 6-row winter barley that is competitive, in terms of yield and other agronomic traits, with current feed barleys. This line has some malting quality, but its primary feature is resistance to Barley Stripe Rust, race 24. Agronomic and quality data are summarized in Tables 5 and 6.

ORS-2 is a 6-row spring barley that has done well, in terms of yield and agronomic traits, both locally and regionally (Table 7). This line may fit into the "export" class of malt barleys (Table 8).

Table 5. Agronomic data: ORWM8407 and check varieties. Western Regional Winter Nursery. (16 station years).

Variety	Yield	Test weight	Height	Heading date
	(bu/acre)	(lb/bu)	(inches)	
ORWM 8407	109.8	49.3	32.0	145
Kamiak	93.2	49.8	36.1	137
Boyer	112.1	47.3	32.5	146
Hesk	105.5	47.8	33.3	146
Scio	103.7	48.5	31.3	144
812	104.4	48.6	30.4	145
Hundred	106.8	46.4	30.3	147

Table 6. Malting quality ORWM8407.

Year	Location	Agency	Protein	Extract	F-C	visc.	S/T	DP	α
90	Corvallis	GW	10.7	78.5	2.7	1.49	38.5	131	45.5
89	Corvallis	AB	11.0	78.4	3.9	-	38.7	106	36.1
88	Pendleton	CCRU	8.5	76.1	3.7	-	34.1	94	23.6
87	Pendleton	GW	11.9	78.4	4.2	1.53	39.5	115	40.6
86	Moro	AB	11.8	75.9	1.1	1.52	33.8	109	39.4
85	Pendleton	AB	12.0	77.7	4.4	1.66	378	115	50.7
$\bar{x}$			10.8	77.3	3.3	1.55	35.7	102	35.3

Table 7. Agronomic data: ORS-2 and check varieties. Western Regional Spring Barley Nursery (34 station years).

	Yield (lbs/acre)	TW (lbs/bu)	Heading date	Height (in)	Percent plump	Lodging %
ORS-2	5223	48.9	179	28	72	17
Steptoe	5156	48.5	174	33	83	34
Morex	4228	50.5	175	37	79	48
Exp. $\bar{x}$	4236	50.4	177	32	76	31

Table 8. Malting quality ORS-2.

Year	Location	Agency	Protein	Extract	F-C	visc.	S/T	DP	α
90	Klamath	GW	12.0	79.5	1.0	1.49	47.3	121	66.9
90	Columbia Basin	GW	11.9	79.5	1.5	1.49	47.4	121	66.8
		GW	13.1	78.8	1.5	1.51	46.9	159	68.5
		GW	13.5	80.4	1.5	1.52	45.8	166	70.3
89	Madras	CCRU	13.8	76.5	3.2	-	37.0	122	43.5
88	Madras	CCRU	13.8	76.7	3.3	-	33.7	186	35.6
87	Klamath	AB	11.0	78.5	1.8	1.47	50.1	139	48.8
86	Corvallis	CCRU	10.8	77.1	1.8	-	41.7	110	39.0
86	Madras	CCRU	13.3	79.1	3.9	-	44.0	100	35.0
Average			12.6	78.5	2.2	1.50	43.8	136	52.7

ESTIMATE[1] OF CULTIVATED ACRES FOR AGRONOMIC ZONES IN THE PACIFIC NORTHWEST[2]

Prepared by Richard W. Smiley
December 1991

	Estimate of Cultivated Acres in Zones (in 1,000's)				
Agronomic zone[3]	Columbia Plateau in Oregon[4]	NC & NE Oregon[5]	SC & SE Washington[6]	N Idaho[7]	Total
1	(no estimates were made for Zone 1)				
2	5	150	706	922	1,778
3	100	100	584	0	684
4	170	198	928	0	1,126
5	1,265	1,265	3,440	0	4,705
6	123	323	964	30	1,317
Total	1,708	2,036	6,622	952	9,610

[1] Resources for the estimates: 1) Douglas et al., 1990. Agronomic Zones for the Dryland Pacific Northwest. PNW Exten. Publ. 354; 2) cultivated acreage reports in soil survey maps for individual counties, and 3) geographic distribution of cultivated land in each county.

[2] Survey was restricted to the principal production areas for small grains in the Pacific Northwest, including northcentral and northeast Oregon, southcentral and southeast Washington, and northern Idaho.

[3] Agronomic Zone limits are defined as 1) cold-moist (<700 Growing Degree Days, >16 inch precipitation), 2) cool-moist (700-1,000 GDD, >16 in. ppt'n.), 3) cool-deep-moderately dry (700-1,000 GDD, >40 in. soil depth, 14-16 in. ppt'n.), 4) cool-shallow-dry (<1,000 GDD, <40 in. depth, 10-16 in. ppt'n.), 5) cool-deep-dry (<1,000 GDD, >40 in. depth, 10-14 in. ppt'n.), 6) hot-very dry (>1,000 GDD, <10 in. ppt'n.).

[4] Includes Umatilla, Morrow, Gilliam, Sherman, and Wasco Counties.

[5] Includes Hood River, Wasco, Sherman, Gilliam, and Morrow Counties in northcentral Oregon, and Umatilla, Union, Wallowa, and Baker Counties in northeast Oregon.

[6] Includes Douglas, Kittitas, Grant, Yakima, Benton, and Klickitat Counties in southcentral Washington, and Lincoln, Spokane, Adams, Whitman, Franklin, Walla Walla Columbia, Garfield, and Asotin Counties in southeast Washington.

[7] Includes Kootenai, Benewah, Latah, Nez Perce, Lewis, and Idaho Counties in northern Idaho.

ESTIMATE OF CULTIVATED ACRES FOR AGRONOMIC ZONES IN THE PACIFIC NORTHWEST

	Estimate of Percentages of Cultivated Acres in Zones				
Agronomic zone[3]	Columbia Plateau in Oregon[4]	NC & NE Oregon[5]	SC & SE Washington[6]	N Idaho[7]	Total
1	(no estimates were made for Zone 1)				
2	3	7	11	97	19
3	6	5	9	0	7
4	10	10	14	0	12
5	74	62	52	0	49
6	7	16	15	3	14

SUMMARY OF RESEARCH STATIONS THAT REPRESENT CULTIVATED ACRES IN AGRONOMIC ZONES OF THE PACIFIC NORTHWEST

Zone	Representative Experiment Station(s)	Columbia Plateau in Oregon	NC & NE Oregon	Pacific Northwest
1	None			
2	Pullman, Moscow, & Pendleton	3	7	19
3	Pendleton[1]	6	5	7
4	Moro[2]	10	10	12
5	Lind & Moro	74	62	49
6	Prosser & Hermiston	7	16	14

[1] Pendleton is in the transition between Zones 2 & 3

[2] Moro is in the transition between Zones 4 & 5

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
62 Year Average	.74	1.33	1.96	2.09	1.91	1.51	1.72	1.50	1.46	1.25	.34	.47	16.28
1971-72	1.42	1.72	3.14	3.93	1.15	1.70	2.11	1.35	1.50	.91	.76	.35	20.04
1972-73	.49	.66	1.14	2.47	.89	.89	1.27	.58	1.03	.12	0	.09	9.63
1973-74	1.77	1.24	5.86	4.40	1.29	2.00	1.50	3.64	.38	.33	1.30	0	23.71
1974-75	.02	.35	1.56	1.76	3.73	1.68	.97	1.72	.68	.69	.05	1.38	14.59
1975-76	0	2.16	1.47	3.40	2.13	1.09	1.69	1.65	1.21	.58	.04	2.58	18.00
1976-77	.44	.53	.47	.59	.90	.57	1.72	.46	1.70	.31	.12	2.21	10.02
1977-78	1.54	.69	1.79	3.19	2.27	1.71	1.40	3.50	.81	1.27	.59	1.37	20.13
1978-79	1.61	0	1.68	2.28	1.31	1.54	1.74	1.82	1.15	.18	.12	2.08	15.51
1979-80	.17	2.56	2.31	1.05	2.85	1.55	2.12	1.20	2.45	1.42	.23	.18	18.09
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						
20 Year Average	0.89	1.20	2.29	2.15	1.81	1.58	1.96	1.60	1.65	0.97	.37	.81	17.28

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
82 Year Average	.60	.90	1.69	1.66	1.62	1.15	.99	.76	.83	.70	.22	.29	11.41
1971-72	1.36	.45	1.50	1.03	2.25	.26	1.44	.40	.45	1.70	.07	.55	11.46
1972-73	.57	.43	.83	1.60	1.09	.34	.40	.21	.34	.25	0	.07	6.13
1973-74	.90	.85	3.70	3.99	1.29	.97	1.30	1.18	.38	.02	.41	0	14.99
1974-75	0	.37	1.02	1.39	2.01	1.47	1.25	.46	.53	.84	.40	1.26	11.00
1975-76	0	1.17	1.34	1.26	1.25	.93	.95	1.06	.14	.06	.79	1.06	10.01
1976-77	.04	.10	.43	.20	.18	.63	.50	.08	2.70	.28	.37	.90	6.41
1977-78	.88	.22	2.00	3.22	2.80	1.31	.74	1.42	.43	.44	.59	1.32	15.37
1978-79	.33	.01	.79	.69	1.59	1.54	.99	1.06	.28	.10	.07	1.12	8.57
1979-80	.53	2.59	2.23	.65	3.41	1.83	.94	.89	1.27	1.37	.16	.11	15.98
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	.89	1.09	.17	0	12.95
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
1990-92	0	1.40	2.57	1.02	.47	1.64	.64						
20 Year Average	.60	.73	1.59	1.64	1.48	1.05	1.16	.78	.82	.64	.31	.49	11.29

CUMULATIVE
GROWING DEGREE DAYS
(BASE = 0° C)