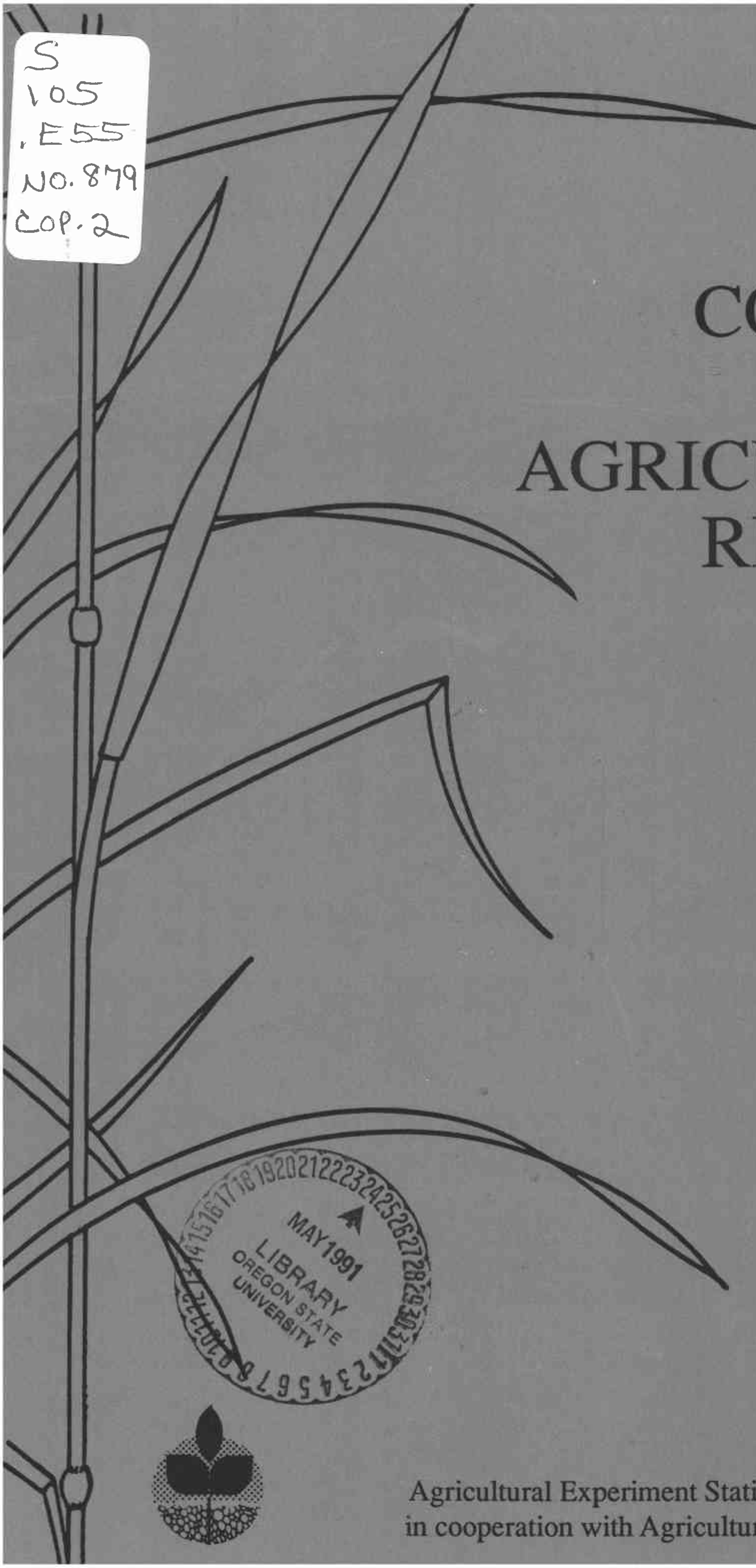


1991 COLUMBIA BASIN AGRICULTURAL RESEARCH

Special Report 879
Agricultural Experiment Station • Oregon State University
in cooperation with Agricultural Research Service • USDA

COLUMBIA BASIN
AGRICULTURAL RESEARCH

JUNE, 1991

Acknowledgement is made to Carol Brehaut, Gloria Eidam, and Patricia Frank for preparation of the manuscript.

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

Karl Rhinhart was promoted by OSU from the rank of research assistant to senior research assistant. Don Wysocki was presented a Commendation Award for service to the Oregon Chapter of the Soil and Water Conservation Society.

Within the USDA Paul Rasmussen, Ron Rickman, Larry Baarstad and John Zuzel were promoted. Merit cash awards were given to Dale Wilkins, Roger Goller, Patricia Frank, and Betty Klepper in recognition of the consistently high quality of their work. Betty Klepper received a Special Service Award from USDA-ARS and was selected for the 1991 WISE Award (Women in Science and Engineering) presented by the National Science Foundation. The Oregon Chapter of the Soil and Water Conservation Society presented Clyde Douglas with a commendation for his service to the chapter and Robert Ramig with an award to honor his outstanding service to Oregon agriculture.

STAFF CHANGES

Nancy All replaced Muriel Wilson as clerical assistant, and David Sutherland replaced Kelly Thomas as research assistant in plant breeding. Kathy Ward joined the crop science program as a research assistant. Dan Ball was appointed as weed scientist upon the retirement of Don Rydrych. Because of budget limitations, Sandra Ott was transferred from the plant pathology to the soil science program, where she continues to serve as a biological research technician.

For the USDA staff, two temporary employees, Deena Chapman and Rebecca Holowecky worked for an 8-week period last summer on a special ARS program for Research Apprentices in Agriculture. Phillip Dailey joined the USDA staff as the Administrative Assistant, replacing David Steele, who resigned. Due to severe budget limitations, the program in soil water physics had to be curtailed and Joseph L. Pikul, Jr. transferred to USDA-ARS, Northern Plains Soil and Water Research Center in Sidney, Montana. Since the technician position for this program was terminated, Douglas Nelson left in the autumn. Robert Ramig retired with 42 years of dedicated service to agriculture.

NEW PROJECTS

Dan Ball has organized a new weed science research and extension program for eastern Oregon, and "broke the ice" with a series of chemical control investigations. Tom Chastain initiated a project on physiological and genetic nature of stand establishment for small grains, and with Don Wysocki, a project on nitrogen management strategies for winter wheat production. Don Wysocki also initiated a subsoil tillage project in Gilliam County. Richard Smiley, in cooperation with visiting scientists, initiated fungicide seed treatment and placement studies for several diseases, and an investigation of the biology and control of an undescribed leaf spot disease of winter wheat. Pamela Zwer has integrated new technologies and breadth into the wheat breeding program, and served as host for the Tri-State and Western Wheat Workers Conference.

Paul Rasmussen, Clyde Douglas, and Harold Collins have initiated a new project on the release (mineralization) of nitrogen from local soils. Dale Wilkins has developed cooperative research with Floyd Bolton (OSU) and Keith Saxton (USDA-ARS, Pullman) to compare performance of conservation tillage seeders in high residue seedbeds. Clyde Douglas and John Zuzel have started work to determine the chemical constituents of runoff water. With the purchase of a new CD-ROM, John Zuzel has been able to initiate a project to define (from historical weather and streamflow records) the frequency and magnitude of runoff and erosion in the dryland areas of the Pacific Northwest.

FACILITIES

Oregon State University constructed a new storage building at the Pendleton Station, and remodelled two laboratories for agronomy, crop science, and weed science research. General maintenance was continued on all facilities at the Pendleton and Sherman Stations. The Center also served as the host site for an Oregon General Services Administration auction of surplus equipment.

Due to severe budget limitations, no facilities were developed, but we did obtain special funds to replace the leaky roof on the main office building during the year.

TRAINING

The USDA and OSU staffs jointly taught a class for Saturday Academy in the Spring of 1991. The class was attended by about a dozen local students. OSU staff participated in the annual pesticide and first aid training but not in any extraordinary courses or workshops.

Several USDA staff took courses in computer science at Blue Mountain Community College, including Sharron Wart, Tami Toll, Katherine Skirvin, Chris Roager, Daryl Haasch, and Patricia Frank. Tami Toll also took elementary algebra I. Phillip Dailey attended a seminar, "One Minute Manager" and spent one week at the ARS Area Office being trained in administrative management. Larry Baarstad attended a weed control short course and a workshop on shop safety. Dale Wilkins, Daryl Haasch, and Larry Baarstad updated their pesticide training. Clyde Douglas went to the USDA Supervisor Academy in College Station, Texas for training in leadership and management. Chris Roager attended analytical systems training and laboratory safety and health training. One-third of the staff updated their Red Cross first aid training and all eligible staff received an update of CPR training.

VISITORS

Four visiting scientists worked with OSU faculty at Pendleton. Dr. Moussa Mosaad, a wheat breeder and superintendent of the Shandaweel

Agricultural Research Center in Egypt, worked for three months with Pamela Zwer. His work focussed on the genetic resistance of wheat to the Russian wheat aphid. Three plant pathologists worked with Richard Smiley. Dr. Philippe Lucas, a plant pathologist with the French government (INRA), worked for one year on interactions between pathogenic fungi and other microorganisms in the root zones of wheat grown under different crop management systems. Emphasis was on Rhizoctonia root rot and take-all, and on the microbial collection maintained by Harold Collins (ARS - Pendleton). Dr. Francoise Montfort, also a plant pathologist with INRA in France, worked for six months on fungicide seed treatments for controlling strawbreaker foot rot and take-all. Ms. Lisa Gillespie-Sasse, a pathology graduate student at the University of Western Australia, worked for six months on leaf spot diseases affecting the production of winter wheat in eastern Oregon.

Distinguished visitors hosted by staff at the Center included Robert Reginato, Director, Pacific West Area, USDA-ARS, Albany, CA; John Byrne, President, OSU, Corvallis; Thayne Dutson, Director, Agri. Expt. Stn., Corvallis; Mike Burke, Director of Resident Instruction, OSU, Corvallis; Van Volk, Assoc. Dir., Agri. Expt. Stn., Corvallis; Kelvin Koong, Assoc. Dir., Agri. Expt. Stn., Corvallis; Bruce Sorte, Agri. Expt. Stn., Corvallis, OR; James Henry, USDA-ARS Information Service, Beltsville, MD; Julie Corliss, USDA-ARS, Pacific West Area Information Office, Albany, CA; Gerald Still, Director, Plant Gene Expression Center, USDA-ARS, Albany, CA; David Coventry, Director, Rutherglen Res. Ctr., Victoria, Australia; Wally Wilhelm and Dorothy Harrell, USDA-ARS, Lincoln, NE; Gregory McMaster, USDA-ARS, Ft. Collins, CO; Dean Kindler, USDA-ARS, Stillwater, OK; John Becherer, Exec. Dir., Conservation Tillage Infor. Ctr., Lafayette, IN; Roger Wilson, Tennessee Valley Authority; Ping Pei You, University of Western Australia, Perth; Ms. Naroatai, University of Western Australia, Perth; Tom Winn, Oregon Wheat Commission, Portland, OR; Robert McDonald, Donald O. Paterson, and Rob Cresswell, Harvest States, Portland, OR; Harry Skipper, Clemson Univ., Clemson, SC; Doug Whitelock, New Zealand; P. Cassidy and D. Gant, Tremco, Portland, OR; Rajeev Singhee, Bombay, India; S.S. Prihar, Punjab Agri. Univ., Ludhiana, India; Zheng Shou Long, Deputy Director of Shanlong Dept. of Agri., Jinan China; Li Shouquan, Assoc. Prof., Gansu Agri. Sci. Acad., Gansu, China; Wang Ganhang, Director, Dept. of Agri., Beijing, China; Zhu Dehui, Prof., Beijing Acad. of Agri. Sci., Beijing, China; a Korean wheat trade team, a Japanese flour milling team, and a delegations of Washington and Idaho farmers.

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. Visiting scientists included Ann Kennedy, Dave Bezdicek, David Granatstein, Bob Papendick, Baird Miller, Alex Ogg, and James Montgomery from Washington; Keith Campbell from Idaho; and Warren Kronstad, Chris Mundt, Patrick Hayes, Floyd Bolton, and Russell Karow from Oregon.

We also conducted a research review with the USDA-Soil Conservation Service, and a workshop with the McGregor Company.

SEMINARS

The seminar series at the Center was coordinated by Tom Chastain. Seminars included the following speakers and subjects: Daniel Westberg, North Carolina State University (Weed Scientist Candidate), Fred Salzman, Michigan State University (Weed Scientist Candidate), Daniel Ball, USDA-ARS, Ft. Collins, Colorado (Weed Scientist Candidate), Philippe Lucas, INRA, France (research activities in INRA), Alan Mitchell, Central Oregon Agricultural Research Center, Oregon State University (root anchoring by wheat and alfalfa), Ron Rickman, USDA, ARS, Pendleton (wheat model), Richard Smiley (Rhizoctonia root rot), CBARC, OSU, Pendleton, Moussa Mosaad, Shandaweel Agricultural Research Center, Egypt (wheat research in Egypt), Tom Chastain, CBARC, OSU, Pendleton (dryland rotation crops for semiarid Oregon), Dale Wilkins, USDA-ARS, Pendleton (evaluation of seeders for conservation tillage production of green peas, Robert Ramig, USDA-ARS, Pendleton (water conservation in wheat/fallow cropping systems), Francoise Montfort, INRA, France (seed treatments for eyespot of wheat), Charles Newhouse, ASCS, Pendleton (1990 Farm Program), George Clough, OSU, Hermiston (horticultural research at Hermiston), Helene Murray, OSU, Corvallis (Overview of Western Regional LISA Program), Patrick Hayes, OSU, Corvallis (breeding for cold tolerance in barley), Craig Morris USDA-ARS, Pullman (wheat grain quality and the USDA Western Wheat Quality Laboratory), Harvey Bolton, Battelle Northwest, Richland (Hanford subsurface microbiology: effect of chemical speciation on the degradation of NTA by *Pseudomonas* spp.), and David Coventry (soil acidifying processes in Australian agriculture).

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 Nov. 14 and Feb. 19. The Sherman Station Liaison Committee, led by Chairman Steve Anderson (Arlington: 503-454-2513), held meetings on June 14, Nov. 13, and Feb. 12.

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 1990-1991. 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, and John Rea), funds and/or chemicals (Monsanto Chem. Co., CIBA-GEIGY, duPont, Wilbur-Ellis, Sandoz, American Cyanamid, Premier Edible Oils, San Diego State University Foundation, and Steve Anderson), or

loaned equipment or facilities (John Rea, John Correa, Frank Tubbs, Soil Conservation Service, USDA-ARS - Pullman, OSU Dept. of Soil Science, and the Agric. Engineering Dept., Washington State University).

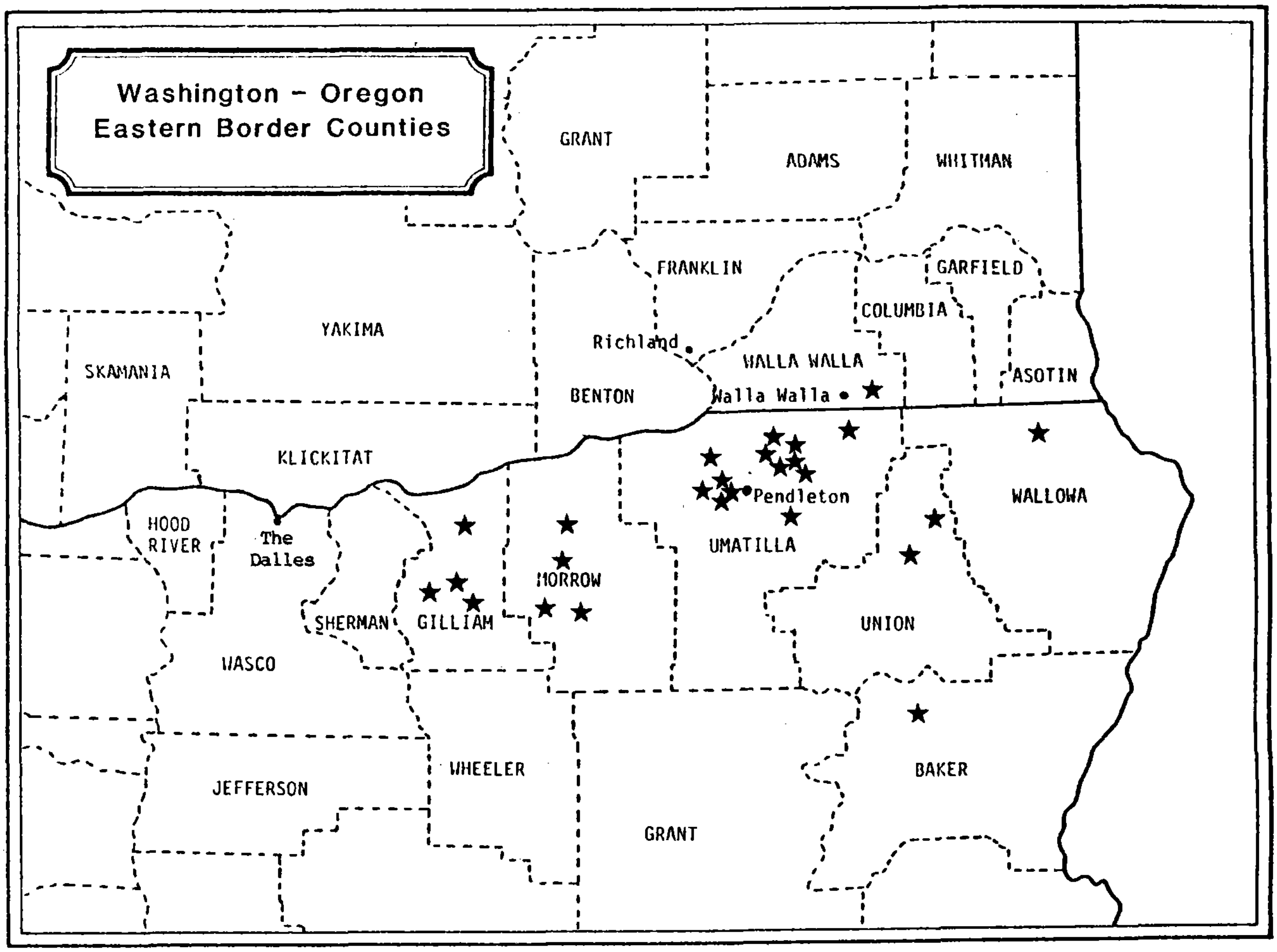
We also acknowledge those who donated labor, supplies, equipment or funding for the Pendleton Field Day: Umatilla County Ag Lender's Assoc. (Security Pacific, U.S. Bank, Inland Empire Bank, First Interstate Bank, Farm Credit Services), Kessler's Catering, American-Hoechst, Athena Agriculture Equipment, CIBA-GEIGY Corporation, Farm Equipment Headquarters, Inc., Huntington-Price, Inland Chemical Service, Inc., Maxi-Gro Fertilizer & Chemical Co., McGregor Co., Pendleton Flour Mills, Inc., Pioneer Implement Corp., PureGro, Rohm and Haas Company, Sandoz Crop Protection Corporation, Smith Frozen Foods, Inc., Tri-River Chemicals, Inc., Wilbur-Ellis Co., Wheatland Insurance, Pendleton Grain Growers, Pendleton Senior Center, Main Street Cowboys, Umatilla County Wheat Growers League, Farm Equipment Headquarters, Inc., Frank Tubbs, and Richard Hopper; we thank the Moro Field Day donors: Monsanto, Dufur Elevator Co., Morrow County Grain Growers, Mid-Columbia Producers, Inc., PureGro, Sherman Farm Chemicals, Sherman County School District, and Branding Iron Restaurant. The OSU Alumni Picnic donors were Safeway Stores and Dwight Wolfe; and the float for the Research Center's entry into the Roundup Parade was made possible by Safeway, Albertsons, and Continental Mills.

Cooperative research plots at the Center were operated by Floyd Bolton, Warren Kronstad, Patrick Hayes, Chris Mundt, Russ Karow, Keith Saxton, 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 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 appreciated 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

OFF-STATION RESEARCH PLOT LOCATIONS



BAKER, OREGON
Daryl Leggett

GILLIAM, OREGON
Jim Rucker
Louis Rucker
Henry Wilkins

MORROW, OREGON
Charles Anderson
Eric Anderson
Frank Anderson
Doug Drake
Mark Miller
Tad Miller

UMATILLA, OREGON
John Brogoitti
Larry Coppock
Jim Duff
Doug Harper
Bob Johns
Maurice Johns
Alan Pinkerton
Fred Price
Dennis Rea
Tremayne Rea
Clint Reeder
Leon Reese
Sherman Reese
Tom Straughan
Ken Thompson
Stan Timmermann

UNION, OREGON
John Cuthbert
Gilbert Weatherspoon

WALLA WALLA, WA
Donald Meiners

WALLOWA, OREGON
Doug Wolff

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WEATHER WIZARD: WEATHER DATA PROGRAMS FOR EASTERN OREGON AND WASHINGTON

John F. Zuzel[1]

Weather Wizard is a set of microcomputer programs that provides average weather data for any location in eastern Oregon or Washington. The Oregon version is published and distributed by the Oregon State University Extension Service as Special report 831 (Zuzel and Karow, 1988). The Washington version is published and distributed by the Cooperative Extension Service, Washington State University (Zuzel and Miller, 1990).

The programs provide average weather data for any user selected time period ranging from ten days to one year. These data include average maximum and minimum air temperatures, rainfall, and degree days above a user selected base temperature. In addition, the program uses a weather generation model to calculate 10 possible daily sequences of maximum and minimum air temperature (°F), precipitation (inches), and solar radiation (langleys) for the selected time period (Hanson and Richardson, 1983). These synthetic data are based on the statistical characteristics of historical data and each sequence represents a possible weather scenario at the location for the selected time period.

The daily sequences of generated weather data are not to be considered forecasts. They do however, cover an expected range of precipitation and temperatures and as such will provide possible weather scenarios for planning activities which are weather dependent. Additionally, the program provides average weather data for any time period and is not restricted to monthly or seasonal averages. The data generation phase can consume a considerable amount of time, especially on older XT class computers. Data generation times on these machines can be in excess of 20 minutes. Because of this, an option to use previously generated files is included. The use of this option eliminates the data generation phase for subsequent sessions, although the data generation must be accomplished at least once.

Data generation procedures, in contrast to using historical records, have several distinct advantages including: 1) Storage space conservation. Eleven years of daily historical weather data is equivalent to about 200,000 characters while the parameters necessary to generate an unlimited number of years of synthetic data require only about 500 characters; 2) Flexibility. Through an averaging process, weather records can be generated for locations not having an actual weather record. Data from nearby locations with actual records are interpolated to generate data for any desired location; 3) Range. The generation process itself depends on random number generation and this insures that a wide range of precipitation and temperature data are produced.

Included on the distribution disks are data files which contain average daily weather data for 19 weather stations in eastern Oregon and 17 stations in eastern Washington. Also included are parameter files for each of the weather stations which are used in data generation. These files provide the basic data for the program. The area of coverage by state and county is

[1] Hydrologist, USDA-ARS, Columbia Plateau Conservation Research Center, Pendleton, Oregon 97801.

listed in Table 1.

OREGON COUNTIES	WASHINGTON COUNTIES
Baker	Adams
Gilliam	Asotin
Grant	Benton
Morrow	Columbia
Sherman	Franklin
Umatilla	Garfield
Union	Grant
Wasco	Lincoln
Wheeler	Spokane
	Walla Walla
	Whitman

Table 1. Weather Wizard area of application.

Two options are provided to specify the geographic location used for extracting averages and data generation. The first option requires the user to choose an existing weather station from a menu. The second option requests user input of latitude and longitude for the location of interest. This information is then used to construct the required files using actual data from the four nearest stations.

These computer programs are intended for farmers, ranchers, extension personnel, Soil Conservation Service field staff, and others whose planning process must include weather considerations.

The computer requirements are an IBM PC or PC-compatible computer using any version of PC DOS or MS DOS and a minimum of 256K of memory. Also required are a double sided disk drive or a double sided disk drive and hard disk (a hard disk is recommended). A math coprocessor is not required but is recommended to speed calculations.

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RESIDUE EFFECTS ON NITROGEN RESPONSE IN WHEAT

Paul E. Rasmussen and
Clyde L. Douglas, Jr.[1]

INTRODUCTION

Several factors affect the efficiency of nitrogen (N) utilization by cereal grains. Among the most prominent are residue effects on disease incidence and nutrient tie-up (immobilization). We conducted an experiment to quantify these effects on N response in winter wheat. Two tillage systems were established, no-till and disk-till. Straw burning and soil fumigation were compared with no treatment in the no-till system. Cereal and legume residues were compared with no residue in the disk-till system.

MATERIALS AND METHODS

Winter wheat was grown in 1987 following spring wheat in 1986 and peas in 1985. Tillage and residue treatments are summarized in Table 1. All spring wheat stubble above 4 inches was cut and removed from the field to allow uniform treatment establishment. Wheat and alfalfa residue systems were spread uniformly on appropriate plots in early September and all disk-till plots were then disked twice. Wheat straw was spread on burn plots in mid-September and burned with a slow backfire burn. Methyl bromide was applied to fumigated plots under plastic in early October. Straw (3,200 lbs/acre) was then uniformly spread on all no-till plots.

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Table 1. Tillage systems and residue management treatments.

Tillage	Residue Treatments
Disk-till	a. No residue
	b. Wheat straw @ 4600 lbs/ac
	c. Alfalfa hay @3800 lbs/ac
No-till	a. No treatment
	b. Straw burning (5440 lbs/ac)
	c. Soil fumigation (methyl bromide)

The site was sprayed with Roundup on October 2 to remove weeds and volunteer wheat. 'Hill-81' winter wheat was seeded on October 8 with a deep furrow drill. The seeding rate was 92 lbs/acre and the row spacing 10-inches. Nitrogen as urea-ammonium nitrate at rates of 25, 60, 110, and 160 lbs N/acre was banded 2-inches below the seed at planting. Sulfur and phosphorus were applied with the N at 13 and 9 lbs/acre, respectively. Late-emerging weeds were controlled in early spring with a broadleaf/grass herbicide combination. Wheat was bundle harvested in mid-July and threshed with a plot thresher to determine grain and straw yield.

RESULTS AND DISCUSSION

Wheat responded strongly to N in all treatments (Figures 1 & 2). In general, wheat yielded about 30 bu/acre without N and 75-80 bu/acre with optimum N application. Straw yield responses to N were quite similar to the grain responses. Residue management affected N response, especially when the N rate was below that required for optimum yield.

Both straw burning and soil fumigation increased wheat yield at low to moderate rates of N application compared to intact residue treatments (Figure 1). This yield advantage largely disappeared when sufficient N was applied, and yield was about the same with burning, fumigation, and standing residue when fertilized with 180 lbs N/acre. The yield increase with burning and fumigation occurred even though disease symptoms were not highly-evident. However, both pythium and take-all were present in wheat samples taken from related studies. It appears that burning either altered the immediate availability of N or affected antagonistic soil organisms, since its effect closely parallelled that of fumigation. While burning is not recommended for tilled systems, its detrimental effects may be much less in no-till, especially when annual cropping replaces a wheat/fallow rotation.

Incorporation of wheat straw in disk-till depressed both grain and straw yield at low rates of N application (Figure 2). Grain yield was 10-15 bu/acre less with straw than without when N fertilization was inadequate. This reflects the significant temporary tie-up of N by microorganisms that can affect fertilizer efficiency. When adequate N was applied to meet the needs of both the plant and the microbe, grain yield was as high or higher than yield with no residue addition or with legume addition.

Grain yield where legume residue was incorporated with a 25 lb/acre N application was 69 bu/acre, compared to 45 with no residue. The legume residue contained 70 lbs N/acre, and much of this N was available to the plant. Only about 30 lbs of fertilizer-N per acre was needed to reach optimum yield, compared to more than 100 lbs N/acre with no residue and almost 150 lbs N/acre when straw was incorporated.

With adequate N application, grain yield was about the same between tillage and no-till. All of the N, S, and P were banded below the residue layer which is necessary in no-till systems for maximal efficiency of fertilizer. The 1987 crop year had moderate drought stress late in the growing season which probably limited yield potential. Greater moisture conservation with no-till may have offset some of the potential stress and permitted yield equality with tilled systems.

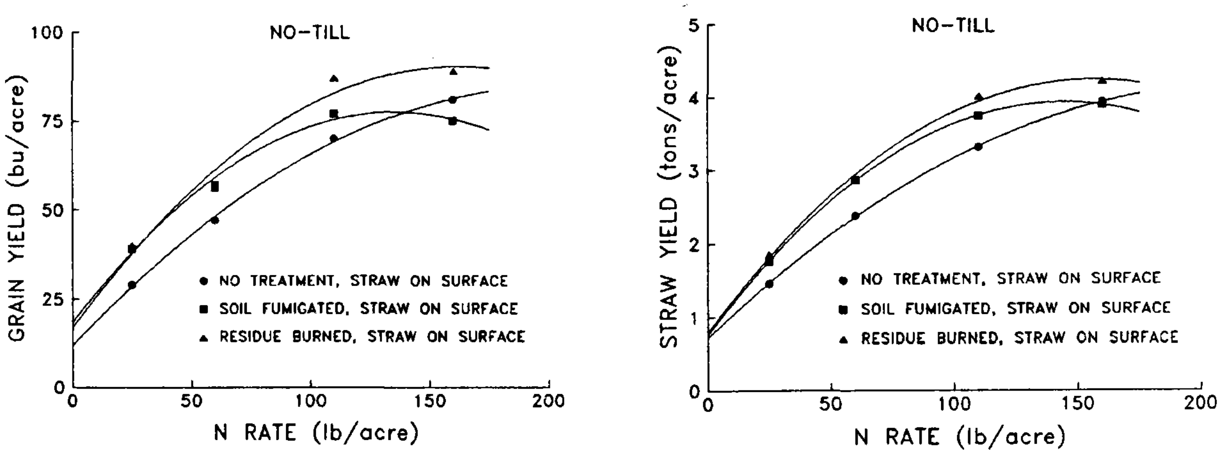

Figure 1. Grain and straw response to N in a no-till system, as affected by soil fumigation and straw burning.

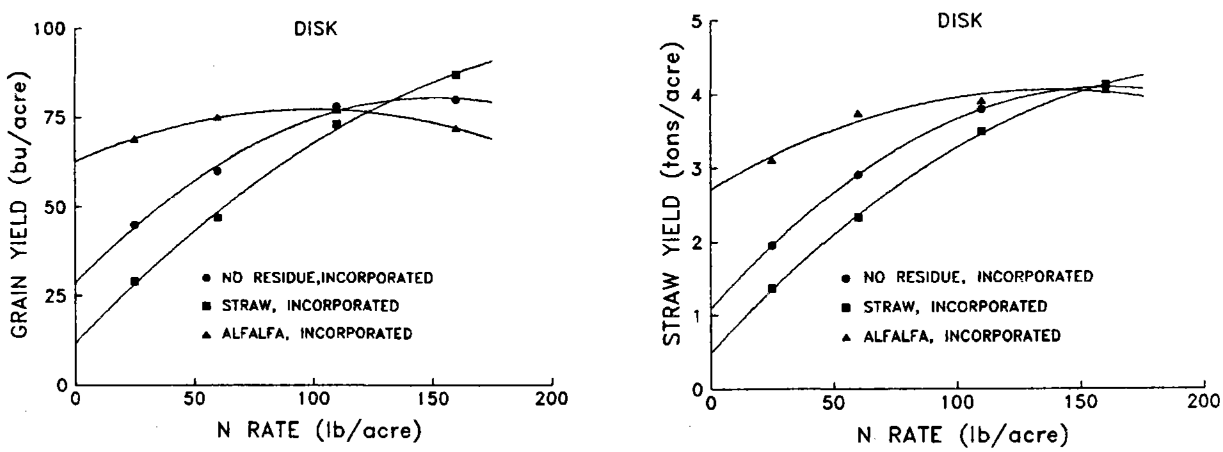

Figure 2. Grain and straw response to N in a disk-till system, as affected by straw, alfalfa, or no residue incorporation in soil.

ESTIMATING CEREAL RESIDUE DECOMPOSITION

C. L. Douglas, Jr., and R. W. Rickman[1]

Crop residues provide an inexpensive, effective contribution to controlling water erosion. The gradual loss of surface residues to decomposition may reduce their protective benefits below desired levels. Residue decomposition rates must be known if farmers are to keep enough crop residue on the soil surface to control soil erosion, while providing efficient use of tilling and planting equipment. Residue decomposition is greatest in the Pacific Northwest dryland areas during the spring and fall when soils are warm and wet. It is too cold in the winter and too dry in the summer for much decomposition to occur. When there is adequate water in the soil for microorganisms to actively decompose residue, residue decomposition is controlled by temperature. The objective of this study was to predict cereal residue decomposition using accumulated heat units based on daily mean air temperature.

Data collected at the Columbia Plateau Conservation Research Center (CPCRC) from 1979 to the present (Douglas, et al., 1980) indicate that residues on the soil surface decompose 60 percent slower than when incorporated. Incorporated residue in a cropped field decomposed only 80 percent as fast as in a fallowed field. Also, decomposition of buried residues occurs in two phases. In the first phase , readily soluble components are used rapidly. Decomposition during the first phase is more rapid if initial N content of the residue is greater than 0.55 percent than if less than 0.55 percent. In the second phase, decomposition rate is not dependent on initial N concentration of the residue, and is much slower than the first phase decomposition rate.

The concept of determining cereal residue decomposition rates using accumulated heat units (AHU) is based on the premise that regardless of location, if adequate moisture is available, decomposition rate is linearly related to temperature. Accumulated heat units are determined by adding daily average temperatures greater than 0° C (Klepper, et al., 1982) from the date residue is placed or relocated in a field to the date of interest.

MATERIALS AND METHODS

Four equations were developed by fitting decomposition data collected at the Columbia Plateau Conservation Research Center (CPCRC) to the general equation $Rr = Ir * \exp(k * fN * fW * AHU)$, where Rr is residue remaining, Ir is initial residue, k is a general decomposition equation, fN is a nitrogen function depending on Ir, fW is a water function depenging on residue and field management, and AHU is accumulated heat units. The equations relate AHU to decomposition in fallowed and cropped fields for residue both buried and on the soil surface. These equations, used to describe residue decomposition, can be combined to form computation sequences that account for various tillage cycles and residue nitrogen contents. These four sequences were evaluated by comparing them to actual decomposition data sets from seven states in the United States (Alaska, Idaho, Indiana, Missouri, Oregon, Texas, and Washington). Included

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in these data sets were soft white and hard red spring and winter wheats, winter and spring barley, durum wheat, triticales, soybeans, and corn.

RESULTS AND DISCUSSION

Table 1 shows decomposition for four residue and environmental sequences as described by combinations of the four equations. Sequences A and B are for buried residues with greater than and less than 0.55 percent initial N content, respectively. Sequences C and D are for surface residues with the same N contents as A and B, respectively. Note that buried residues decompose in two phases, while surface residues decompose very slowly and essentially occurs in only one phase. Figure 1 shows the relationship of computed to actual decomposition for a few of the cereals evaluated. Decomposition curves generated by using the equations to mimic the various changes of decomposition conditions estimated the actual decompositon curves within a range of 76 to 99 percent, with most within 95 percent.

The relationship of AHU to time for your area of interest, and initial N content of the residue, is all that is required to estimate loss of residue to decomposition during a crop or fallow season. This relationship for CPCRC is shown in columns 1 and 2 in Table 1.

These computation sequences can help determine the residue remaining on soil surfaces after specified time intervals and tillage operations. Knowing the amount of residue remaining at any time is important in determining if soil erosion is being controlled effectively and if conservation compliance requirements are being met.

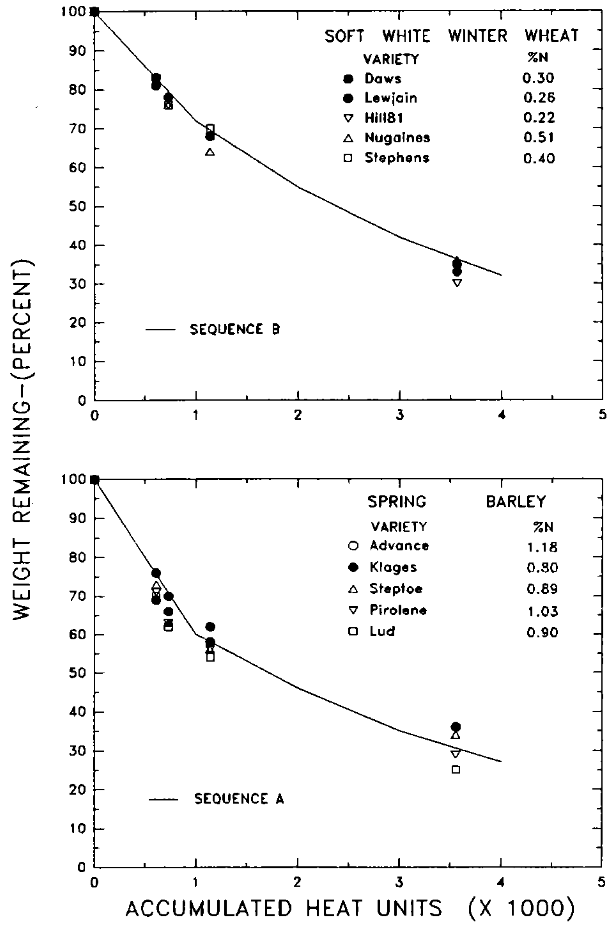

Figure 1. Relationship of computed to actual residue weight remaining (%) for selected cereals.

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Table 1. Examples of percent residue remaining as estimated by computation sequences for both buried and surface residues.

Accumulated heat unit	Approximate time interval	Buried Residue				Surface Residue	
		Seq. A[1]		Seq. B		Seq. C	Seq. D
		Phase 1	Phase 2	Phase 1	Phase 2		
	mo.[2]	% residue remaining					
0	0	100		100		100	100
1000	4	60[3]	60	72	72	85	90
2000	8		40		55	72	81
3000	12		27		42	62	72
4000	16		18		32	52	65
5000	20		12		25	44	58

[1] Seq. = Sequence
[2] Assuming residues are placed in the field on 1 September.
[3] The % residue remaining at the end of phase 1 is the % residue remaining at the beginning of phase 2.

PLANTING QUALITY OF PRE-HARVEST SPROUTED WHEAT SEED

T. G. Chastain, B. L. Klepper, and D. E. Wilkins[1]

The negative effects of pre-harvest sprout damage on wheat grain quality have been widely publicized. Soft white wheat, the predominant market class grown in the Pacific Northwest, has the least resistance to pre-harvest sprouting among market classes. The germination process, initiated during sprouting, results in the production of carbohydrate-degrading enzymes that are responsible for reduced milling and baking quality. Growers and seed companies would like to know whether sprouted seed can be used as planting stock. Unfortunately, only limited information has been available regarding the field performance of sprout-damaged seed. The objectives of this research were to 1) determine the effect of sprout damage on wheat emergence, growth, development, and yield; and to 2) develop visual criteria for determining field performance of a sprouted seed lot.

MATERIALS AND METHODS

Field trials were planted at the Columbia Basin Agricultural Research Center near Pendleton on October 6, 1989. Certified Stephens wheat seed that was naturally sprouted by rain was used in an experiment to examine the effects of planting depth and fungicide seed treatment (Vitavax-200) on emergence, growth, development, and yield. Vitavax-200 was applied at a 3 oz. per 100 lbs. seed rate. Treated Stephens seed that was not sprouted was used as the control in this trial. Plots were seeded with a small plot drill equipped with hoe-type openers. The seeding rate was 18 seeds/ft^2 and the seeding depths were 1.4- and 3.2-inches.

In another trial, the emergence of nine cultivars of soft white common and club, and hard red winter wheat was measured. Each cultivar was adjusted from the naturally occurring level of sprouting so that 50 percent of the seeds planted were visibly sprouted. This adjustment eliminated inherent genetic differences among cultivars with regard to sprout damage level thereby allowing field performance comparisons. Also planted in this trial was a sprouted Stephens seed lot that was divided into four categories by visual severity of sprout damage to the seed. The four categories developed to quantify sprout damage of seed were based on the following visual criteria:

Category	Visual Sprout Criteria
A	No visual evidence of sprouting, no exposure of the embryo
B	Seed coat over embryo is broken or ruptured resulting in partial embryo exposure
C	Major break in seed coat fully exposing embryo
D	Physically damaged embryo

Crop growth charateristics were measured at the 3-leaf and the 5-leaf stage of development on three 60-cm sections of crop row from each plot. Plots were harvested with a plot combine on July 18, 1990.

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RESULTS AND DISCUSSION

Four fundamental seedling emergence patterns were observed (Figure 1). The A seed, with or without fungicide seed treatment, demonstrated the best emergence performance (pattern 1). The emergence of A seed was not statistically different from normal seed (not plotted here). This means that emergence was not affected by sprouting when no visible evidence of sprout damage was present, as was the case for A seed. The second pattern (2) exhibited reduced emergence compared to the first (1) pattern and represented B and C seed that was not treated. The third (3) pattern showed poorer emergence than the second (2) pattern and represented B and C seed that was treated. Seedling emergence was markedly reduced when sprouted seed had ruptured seed coats and was further reduced when sprouted seed was treated with a fungicide. Direct exposure of the embryo to the seed treatment contributed to poor emergence of treated sprouted seed. The final pattern (4) was indicative of D seed, both treated and untreated. Sprouted seed exhibiting physical damage to the embryo should not be planted.

Wheat growth at the 3-leaf stage of development was retarded by 36 percent when plants were grown from untreated, sprouted seed, and was reduced by 45 percent when grown from treated, sprouted seed. Similar responses were also observed at the 5-leaf stage of development (Table 1). Only Vitavax-200 seed treatment (standard seed treatment for the region) was evalauted, however, it is expected that other treatments would cause similar or perhaps greater reductions in emergence and plant growth. Sprouted seed produced plants that had fewer T_1 tillers but had more T_3 tillers. Suprisingly, grain yield from plots

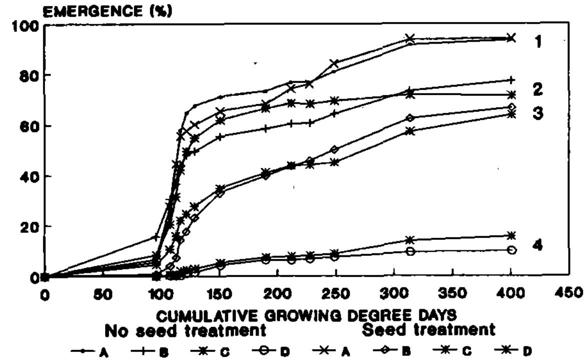

Figure 1. Emergence response of four visually-identifyied categories of pre-harvest sproouted wheat seed.

planted with treated, sprouted seed was not significantly different from that planted with normal, treated seed (Table 1). Test weight of grain from normal plants was slightly greater than from plants produced from sprouted seed.

Table 1. Effect of pre-harvest sprouted seed on wheat growth, development, and yield.

Characteristic	Sprouted seed: No Vitavax	Sprouted seed: Vitavax	Normal seed: Vitavax	LSD 0.05
At 5-leaf stage				
Plants/meter crop row	35	27	50	7
Tillers-T_0 (%)	29	42	39	NS
Tillers-T_1 (%)	71	83	90	4
Tillers-T_2 (%)	93	91	92	NS
Tillers-T_3 (%)	62	68	54	10
At harvest				
Heads/meter crop row	117	107	134	11
1000-seed weight (grams)	49.3	49.9	49.7	NS
Test weight (lbs/bu)	61.6	61.5	62.0	0.3
Yield (bu/acre)	92	90	94	NS

Shallow seedings (1.4 inches) of sprouted wheat seed produced better stands and yield than deep seedings (3.2 inches) (Table 2). Deep seedings produced fewer T_0 (coleoptile) tillers than shallow seedings. This is also the usual response of wheat seedlings produced from normal seed to deep seedings.

Table 2. Effect of planting depth on growth, development, and yield of pre-harvest sprouted wheat.

Characteristic	Depth 1.4 in.	Depth 3.2 in.	LSD 0.05
At 5-leaf stage			
Plants/meter crop row	42	32	8
Tillers-T_0 (%)	58	16	16
Tillers-T_1 (%)	88	80	NS
Tillers-T_2 (%)	88	96	7
Tillers-T_3 (%)	56	67	NS
At harvest			
Heads/meter crop row	133	105	25
1000-Seed weight (grams)	49.5	49.8	NS
Test weight (lbs/bu)	61.7	61.7	NS
Yield (bu/acre)	95	90	3

Although club and hard red cultivars showed lower natural levels of visible sprout damage than common white cultivars (54 and 16 percent vs. 79 percent), it was evident that all cultivars emerged similarly (Figure 2) if they had the same amount of visible sprout damage (50 percent). Given that seed from all cultivars performed in a similar manner once sprouted, an emergence index is being developed to predict the emergence potential of sprouted seed lots. Preliminary field testing shows good agreement between index values and actual emergence of the spouted wheat. The formula uses the relative amounts of the four visible sprout categories present in the seed lot and the emergence of Stephens wheat having similar visible sprout composition. The emergence index for sprouted seed could be used to determine whether a sprouted seed lot should be planted. It could also be used to adjust the seeding rate of a desirable seed lot or to blend in the correct amount of normal seed to improve the crop stand.

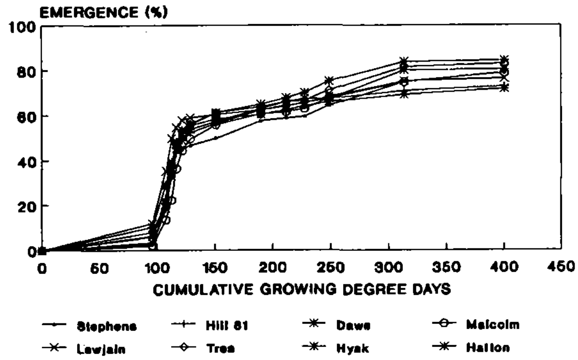

Figure 2. Emergence response of pre-harvest sprouted seed of selected soft white common and club, and hard red winter wheat cultivars.

Our study demonstrates that sprouted wheat seed produced poorer stands and crop growth than normal seed. Treating sprouted seed further reduced stands and crop growth. It was evident that shallow seedings of sprouted seed resulted in better stands than deep seedings. Grain yield of plants produced from sprouted seed was not different than yield of plants grown from normal seed. These field trials are continuing and have been expanded to include performance evaluations of commercial lots of sprouted wheat seed.

HIGH TEMPERATURE SODIUM HYPOCHLORITE TREATMENT EFFECTS ON *TILLETIA CONTROVERSA* (TCK) TELIOSPORES AND WHEAT SEED

T. G. Chastain and K. J. Ward[1]

Contamination of wheat grain grown in the Pacific Northwest by teliospores of the dwarf bunt fungus, *Tilletia controversa* Kühn (TCK), causes lost international marketing opportunities for the region. A zero tolerance standard for TCK teliospores on wheat grain has been established by the People's Republic of China, a major potential export market for Pacific Northwest grain producers. Fungicide seed treatments and agronomic practices have been largely ineffective for controlling this disease. Although several winter wheat cultivars are resistant to dwarf bunt, most cultivars grown in the region are susceptible. Dwarf bunt infestations occur primarily in areas within the region that are prone to prolonged snowcover. Moreover, nearly all of the region's grain is contaminated by teliospores during shipment to export terminals since the same transportation system handles grain from both infested and uninfested areas. Soil-borne teliospores of TCK appear to be more important than seedborne spores for infecting wheat plants. Nevertheless, the importance of seedborne teliospores in maintaining soil-borne inoculum cannot be discounted. The potential for spreading dwarf bunt to previously uninfested wheat production regions such as the People's Republic of China seems unlikely; however, this possibility has been a matter of great concern.

One possible solution to this problem is to kill TCK teliospores on wheat grain destined for export markets and on seed for domestic planting and international germplasm exchange. Disinfestant agents that have been investigated for grain and seed contaminated by fungal spores include hot water, aerated steam, heated dry air, hot vegetable oil, and chemical treatments such as sodium hypochlorite (NaOCl). Our previous studies showed that 2 percent NaOCl solutions severely damaged TCK teliospores, exposing the highly protected spore cells to the oxidizing action of NaOCl. Commercial laundry bleach usually contains 5.25 percent NaOCl.

Until recently, viability of TCK teliospores could only be determined by a 2-month germination test due to prolonged dormancy. This dormancy made it difficult to screen treatments for their ability to reduce teliospore viability. We developed an assay that measures activity of lipase, an important enzyme required for germination of TCK spores. If spores do not contain lipase, they cannot germinate and, in turn, infect the wheat plant. Extracts from live spores fluoresce in the presence of fluorescein diacetate (FDA), an indicator for lipase activity. No fluorescence is observed when spores are dead. The FDA lipase assay has reduced the time required to assess the viability of TCK spores from 2 months to less than 5 hours. We used the FDA lipase assay to identify high temperature NaOCl as the most promising agent for killing TCK teliospores on wheat grain and seed.

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The objectives of this research were to (1) evaluate the effectiveness of high temperature NaOCl treatment for killing TCK teliospores on wheat seed, and (2) to determine the effect of high temperature NaOCl on wheat seed quality.

MATERIALS AND METHODS

Stephens and Daws winter wheat seed lots were exposed to aqueous sodium hypochlorite (NaOCl) solutions in laboratory flasks submerged in a water bath for 15, 30, and 60 seconds. Water bath and solution temperatures were 50°C (122°F), 55°C (131°F), and 60°C (140°F). Concentrations evaluated were 0.5, 1.0, 2.0, and 5.0 percent NaOCl prepared from commercially available bleach (5.25 percent NaOCl). After NaOCl exposure, flasks were immediately removed from the water bath and the seed were triple-rinsed with distilled water. Four replicates of 100 seeds were exposed to each NaOCl concentration, time, and temperature combination. The effect of NaOCl treatment on seed germination was evaluated by the Association of Official Seed Analysts standard germination test.

Teliospores of TCK were exposed to the same NaOCl concentration, temperature, and exposure time combinations. Teliospores were rinsed by the same procedure used for seed and were recovered from the rinsate by filtration. Teliospore viability was determined by the FDA lipase method. Teliospores were homogenized in 3 drops cold phosphate buffer for 1-2 minutes in a glass tissue grinder. The lipase extract was obtained by centrifugation at 4°C in phosphate buffer solution. The extract was added to microwell plates containing FDA and incubated for 1-5 hours at 20°C. The plates were evaluated under ultraviolet illumination and viability level was recorded.

The effect of seed moisture content prior to treatment on the ability of Stephens wheat seed to withstand high temperature NaOCl was investigated. Seed moisture contents were 7, 9, and 11 percent. These were obtained by adding the appropriate amount of water to 7 percent moisture content seed and allowing them to equilibrate at room temperature in a sealed container. The resultant moisture content was confirmed by drying samples for 24 hours in an oven at 100°C (212°F). The seed was exposed for 30 seconds to 1 percent NaOCl heated to 55°C (131°F). Seed germination tests were performed as previously indicated.

RESULTS AND DISCUSSION

Teliospore viability was not affected by 0.5 percent NaOCl when the temperature was less than 60°C and when exposure time was less than 60 seconds (Table 1). At a NaOCl concentration of 1 percent, viable spores were found only in the 15 second exposure treatment when NaOCl temperature was 50°C. Teliospores were killed by all temperature-time exposure combinations when NaOCl concentration was 2 percent or greater.

Germination of Stephens seed was generally not reduced by NaOCl heated to 50 and 55°C regardless of exposure time, but was reduced at 60°C when exposed for 60 seconds (Figure 1). Germination was reduced by NaOCl concentrations greater than 2 percent.

Daws was more susceptible to high temperature NaOCl treatment than Stephens (Figures 2,3,4). Germination was generally not affected by 0.5 percent

Table 1. Effect of high temperature NaOCL treatment on viability of TCK teliospores.

NaOCL concentration	Time	Temperature (C°) 50	55	60
%	seconds	FDA assay result		
0.5	15	+	+	-
	30	+	+	-
	60	-	-	-
1.0	15	+	-	-
	30	-	-	-
	60	-	-	-
2.0	15	-	-	-
	30	-	-	-
	60	-	-	-

+ = fluorescence detected in spore extract (lives spores) and - = no fluorescence detected (dead spores).

NaOCl, but was proportionally reduced at progressively higher NaOCl concentration, exposure time, and temperature. Seedling coleoptile length of both cultivars was not reduced when seed was exposed for 30 seconds or less to 1 percent NaOCl when treatment temperature was 55°C or less (Figures 2 and 3). Therefore, the safest NaOCl concentration for killing teliospores on seed of both cultivars while maintaining seed quality was 1 percent when treatment temperature did not exceed 55°C.

Seed moisture content can be an important factor in determining the susceptibility of seeds to heat treatments for pathogen control. Germination of Stephens wheat seed, however, was similar regardless of moisture content prior to NaOCl treatment. Our study has also shown that after one year storage at room temperature, germination of high temperature NaOCl-treated seed was not different than untreated seed.

Since small samples (100seeds/flask) were evaluated in this study, only wheat seed quality characteristics were evaluated. A prototype machine for killing TCK spores on large quantities of wheat grain using high temperature NaOCl has been constructed by Dr. Ralph Cavalieri at Washington State University. This device is currently being used to determine the effect of the high temperature NaOCl treatment on wheat milling and baking quality. A full-scale NaOCl machine for killing spores on wheat grain destined for the People's Republic of China is envisioned for Portland-area grain export facilities. This machine must be capable of economically treating more than 1,000 tons of grain per hour. The anticipated benefit of this project is to solve international quarantine restrictions imposed by TCK spores so that Pacific Northwest wheat grain can again be made available to these markets.

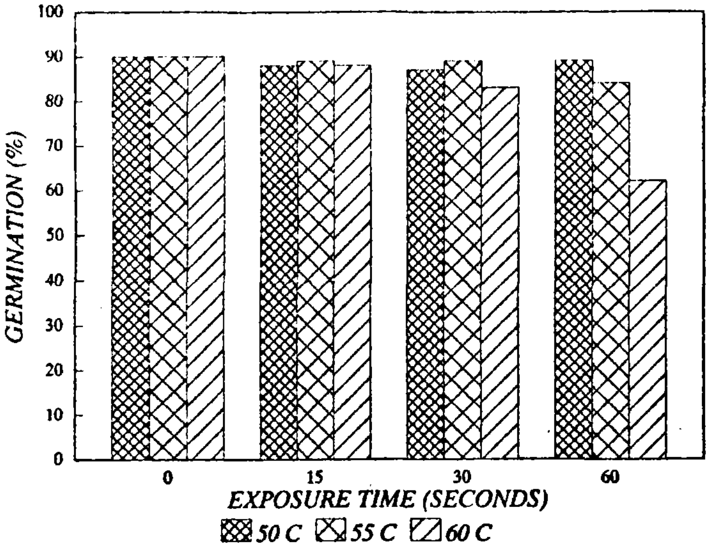

Figure 1. Effect of high temperature NaOCl treatment temperature and exposure time on Stephens wheat seed germination.

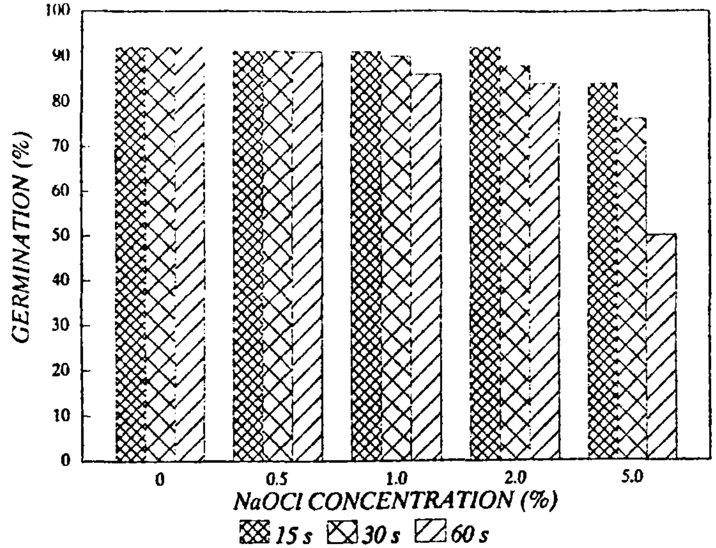

Figure 2. Influence of NaCOl concentration and exposure time on Daws wheat seed germination at 50°C. 15 s = 15 seconds, 30 s - 30 seconds, and 60 s = 60 seconds.

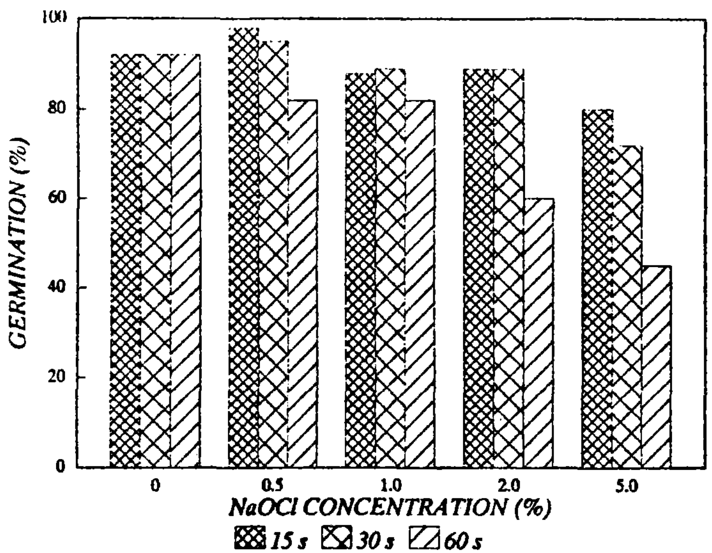

Figure 3. Influence of NaOCl concentration and exposure time on Daws wheat seed germination at 55°C.

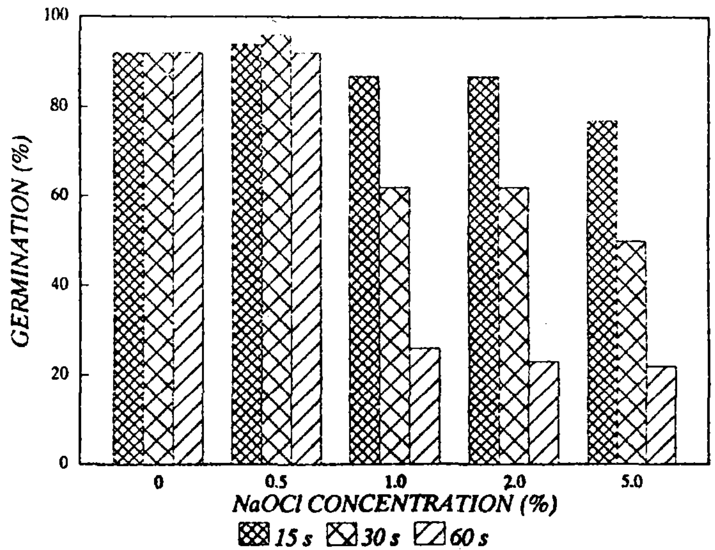

Figure 4. Influence of NaOCl concentration and exposure time on Daws wheat seed germination at 60°C.

PRACTICAL APPLICATIONS OF BARLEY GENE MAPPING

Patrick M. Hayes[1]

BACKGROUND

Over the past 100 years, tremendous progress has been made in barley improvement. Breeders have laboriously assembled the genetic puzzle leading to the level of yield, disease resistance, malting quality, and so forth that producers and industry demand. However, this process has not been one of explicit "breeding by design".

While not exactly hit or miss, conventional plant breeding procedures that have given today's barley varieties depend on painstaking selection based on the performance of thousands of cross progeny evaluated in hundreds of experiments. Plant breeding endeavors will always require extensive field testing, but overall efficiency can be enhanced by advancing only cross progeny that stand a reasonable probability of carrying desired combinations of genes. Knowing where genes are located will allow for "breeding by design".

I'll use the example of crossing two U.S. spring barley cultivars, Steptoe and Morex, to illustrate how two techniques - doubled haploid production and quantitative trait locus mapping - can assist breeders in designing selection programs that should lead to higher probabilities of recovering barley varieties.

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STEPTOE X MOREX: A CASE STUDY

Steptoe, the dominant feed barley in the Pacific Northwest of the US, has no malting quality. Morex, is the Industry 6-row quality standard. Steptoe is widely adapted and a very "stable" variety, meaning it produces above average yields in very diverse environments. In the Pacific Northwest, it is grown under irrigated and non-irrigated conditions, and it is both spring- and fall-planted. In 1989, there were even 120,000 hectares of fall-planted Steptoe in Spain. Morex does not have the yield potential of Steptoe, nor is it as widely adapted. For purposes of comparison, Morex and Steptoe quality and yield data are given in Table 1. It might seem reasonable to cross these two varieties and select new genotypes among the cross progeny that would have the yield potential of Steptoe and the malting quality of Morex. It may have been attempted, but no barley breeder I know has admitted to doing it. The reason that a breeder of malting barley would not attempt the cross of Steptoe X Morex is a function of two factors: linkage and gene action.

Table 1. Comparison of quality and agronomic traits in Morex and Steptoe

Variety	Yield† (MT/HA)	Malt‡ Protein (%)	Malt Extract (%)	Diastatic Power (Deg)	Alpha amylase (20 Deg)
Steptoe	5.09	14.7	70.1	75	23.3
Morex	4.10	15.8	75.6	168	47.8

† Yield data based on 19 locations of 1989 Western Spring Barley Nursery

‡ Quality data based on 1987 Nursery, St. Paul, MN. Analyses courtesy of Cereal Crops Research Unit (USDA), Madison, WI.

Linkage is the association in inheritance of certain genes due to their being localized on the same chromosome. The closer genes are together, the more closely they are linked. Over cycles of selection, breeders have built up "linkage blocks", sections of chromosomes carrying genes that confer desired characteristics. Let's consider a hypothetical example of four genes in a linear array: two extract genes lie between two yield genes. In the case of Steptoe, where the primary selection criterion was yield, alleles responsible for low malt extract may have been inadvertently selected with the two alleles for yield. Likewise, in Morex, where the primary selection criterion was malting quality, alleles for low yield may have inadvertently been carried along during selection for the high extract alleles. From a feed barley breeder's perspective, Steptoe would have a favorable linkage block for yield; from a malting barley breeder's perspective, Morex would have a favorable linkage block for extract. The breeder crossing Steptoe and Morex would hope to select a recombinant line with the positive alleles at all loci. The probability of recovering such a plant is a function of 1) how tightly the genes are linked, and 2) how well the breeder can measure gene action. Even in the face of very tight linkage, recombinant genotypes can be recovered, given enough opportunities for recombination and large population sizes.

However, actually identifying the desired recombinant lines, based on their expression of yield and extract, is problematic for two reasons. In the first place, meaningful measurement of yield and extract (quantitative traits) requires multiple-environment field performance data. Quantitative traits do not show discrete inheritance patterns, as do qualitative traits (i.e. 2-row vs. 6-row spike), and of necessity have been studied with the tools of statistics rather than those of Mendelian analysis. Secondly, because barley is a self-pollinated crop, much of the gene action expressed in generations immediately following a cross (dominance and non-additive epistasis) is transient and cannot be exploited. Doubled haploids and quantitative trait locus mapping offer a resolution to these complications.

DOUBLED HAPLOIDS: A TOOL FOR ACCELERATED BREEDING AND GENETIC ANALYSIS:

A doubled haploid plant is derived from male or female gametic cells and/or tissues. When plants are regenerated from the gametes of a heterozygous donor (i.e. the F1 of Steptoe X Morex) an array of completely inbred doubled haploid (DH) lines is produced. This array is, for all practical purposes, equivalent to that which would be obtained after an infinite number of generations of self-pollination. These DH lines can then be evaluated in as many replicated field trials as seed supply and research budgets allow. The problem of non-additive gene action is circumvented, and the requirement of replicated evaluation is met.

Returning to the hypothetical example of the extract and yield genes in Steptoe and Morex, a breeder would theoretically be able to identify a recombinant doubled haploid line carrying both the Steptoe yield genes and the Morex extract genes, but the cost would be high. Nonetheless, if the breeder used conventional generation advance, the probability of selecting the desired genotype would be infinitesimally small and the cost prohibitive. Combining quantitative trait locus mapping (discussed in the next section) and doubled haploid production should allow for cost-effective selection of desired genotypes. At this point, a brief review of doubled haploid techniques is in order.

There are several techniques for producing DH lines in barley. We are currently using a doubled haploid system known as Hordeum bulbosum - mediated chromosome elimination. The technique is based on the elimination of H. bulbosum chromosomes from H. vulgare X H. bulbosum crosses and was first reported by Kasha and Kao (1970). Since no endosperm is formed, the haploid embryo must be rescued and cultured on nutrient media for plant regeneration. The chromosome number of haploid plants is doubled by a colchicine treatment. As this technique uses barley female gametes, it is a gynogenetic haploid system.

Of the haploid techniques currently available in barley, the Hordeum bulbosum method, as it bypasses the callus phase putatively responsible for somaclonal variation, is arguably the most appropriate for capitalizing upon sexual, as opposed to culture-induced, variation. Haploid production efficiency (HPE) with the bulbosum method is influenced by a number of factors and their complex interactions, including genotypic effects of H. vulgare (Pickering, 1983), the interaction of H. vulgare and H. bulbosum (Simpson et al., 1980), and culture environment (Jensen, 1977). In general, HPE can be expressed as

HPE = (seeds/florets)(embryos/seeds)(plants/embryos)

We have developed an in vitro floret culture technique that considerably increases the efficiency of H. bulbosum-mediated haploid production and allows for DH production from diverse germplasm arrays. (Chen and Hayes, 1989; Hayes and Chen, 1989). Our overall HPE is now near 50 percent; HPE's from an array of winter and facultative barley are presented in Table 2.

As a barley plant produces more pollen than eggs, androgenetic haploid systems (using male gametes) are potentially much more efficient that gynogenetic systems. However, gametophytic selection and/or somaclonal variation attributable to extended callus phases are limitations to androgenetic DH production imposed by current technology.

F1-derived DH lines are of particular utility in quantitative trait locus (QTL) mapping, because they provide an immortal reference population allowing for simultaneous linkage map construction and trait evaluation. I'll continue with the Steptoe X Morex case study, as we have produced over 300 DH lines from the cross of Steptoe and Morex, forming one of two populations used by the North American Barley Genome Mapping Project (NABGMP).

QUANTITATIVE TRAIT LOCUS MAPPING:

Assuming that quantitative traits (i.e. yield and extract) do have a genetic basis, it should be possible to map these genes in relation to marker loci that show Mendelian inheritance. Given a tight enough linkage between marker and QTL, the QTL can then be subjected to Mendelian analysis.

In theory, linkages between quantitative traits and morphological traits (i.e. 2-row vs. 6-row spike habit) could be established. Unfortunately, there are not sufficient morphological traits to identify all such possible linkages, and many morphological trait "markers" have undesirable side effects on quantitative trait expression. Protein markers (i.e. isozymes) would theoretically provide a bit more genome coverage, but unfortunately there is not enough isozyme polymorphism in barley to make them very useful in a QTL mapping context. DNA markers, notably restriction fragment length polymorphism (RFLPs), have allowed for potentially unlimited genome coverage. DNA marker technology is rapidly coming to a level of economy and simplicity appropriate for breeders/geneticists with a practical bent. Whether the linkage of quantitative trait effects with be major genes, isozymes, or RFLPs (Lander and Botstein, 1989), the intent is to reduce the complexity of quantitative characters to the simplicity of Mendelian analysis.

One hundred and fifty Steptoe X Morex F1-derived DH lines will be used by the North American Barley Genome Mapping Project, a multi-institution, collaborative endeavor involving virtually every barley breeding and genetics group in the U.S. and Canada. The NABGMP is supported by a consortium of grower organizations, industry groups, and public agencies. A principal objective of the NABGMP is to map genes responsible for agronomic and quality characteristics of economic importance, and Steptoe X Morex is one of two populations that will be used for this purpose.

The first requirement for QTL mapping is that the parents show an acceptable level of polymorphism. That is, the parents must have different DNA sequences throughout enough of the genome for the marker technique to work. Polymorphism can be maximized by making a very wide cross like wild barley (Hordeum spontaneum) X Hordeum vulgare, var. Steptoe. However, this cross would be of limited agronomic interest. A population derived from two elite 6-row malting lines, (e.g. Morex X Robust) would be of great interest from a breeding standpoint, but probably would not be satisfactory in terms of resolving polymorphism, with current levels of technology. Steptoe and Morex is a good compromise. The two cultivars are sufficiently diverse in ancestry that they are polymorphic, and both are within the realm of agronomic utility.

Once a sufficient number of polymorphic DNA markers have been identified - ideally 140 markers spaced approximately every 10 centimorgans - the DH population is mapped. That is, the allelic constitution of each DH line at each of the 140 marker loci is determined. These data are then used for map construction, which is straightforward using available mapping software (i.e. MAPMAKER; Lander et al.,1987), and further streamlined by the completely inbred nature of the DH lines. This software constructs a linkage map, based on the amount of recombination of markers in the progeny. The use of cytogenetic stocks (i.e. wheat/barley addition lines) allows for the unequivocal assignment of loci to chromosomes. The resulting map is nothing more than a series of seven lines, one representing each barley chromosome, populated with a series of locus identifiers. The challenge and utility of the map lies in establishing linkages between marker loci and quantitative traits.

The next step is to evaluate the entire population of Steptoe X Morex DH lines in field trials in as many representative environments as possible. The field data are then subjected to statistical analyses and, ultimately, the expression of trait performance is reconciled with the genetic map. QTLs are identified through a synthesis of the linkage map and field performance data. Knapp et al. (1990) have presented a flanking marker genetic model for DH progeny. The model is a function of the means of quantitative trait locus genotypes and recombination frequencies between marker and quantitative trait loci. A key component of the NABGMP is extension of this model to investigate QTL locus effects in different environments. Thus, contrasts can be specified for estimating additive effects, additive x additive effects, and the interactions of these effects with environments. The populations of DH lines provide a vehicle for actually exploring the genetic basis of genotype x environment interaction.

Simply stated, a relationship is established between the expression of a particular quantitative trait and the occurrence of a particular marker. When other than random associations of marker and quantitative trait expression are detected, the linkage of the marker to the QTL locus can be measured. In this fashion, the location of quantitative trait loci (i.e. those contributing to yield, malting quality characters, disease resistance, etc.) can be superimposed on the linkage map of DNA markers.

Returning one last time to the hypothetical yield and extract genes in Steptoe and Morex, linkages will be established between markers and the yield and extract loci through the QTL mapping process. Selection of recombinant DH lines with a high probability of carrying Steptoe yield genes and Morex extract genes will first be based on the presence of markers, and then on field performance. Only lines that have a high probability of carrying the desired combinations of genes are advanced to field testing. This is breeding by design.

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TILLING FROZEN SOIL TO CONTROL WATER EROSION

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In agronomic zones 3, 4, and 5 in the Pacific Northwest (Douglas et al., 1990) soil loss from water erosion occurs most frequently between December and March in fields seeded to cereals with frozen soil (Zuzel and Pikul, 1990 and Zuzel et al., 1982). Low infiltration rates in frozen soils are a major contributor to erosion in this region. Infiltration rate can be increased by creating a channel through the frozen soil layer with tillage. Pikul et al., 1989 showed that there was no water infiltration into soil that was frozen 5 in. deep, but fall tillage of the same soil 8 in. deep with a 2 in. wide chisel resulted in water infiltration of 1 in/hr when the soil was frozen 5 in. deep.

Field tests conducted in 1988 to evaluate the technique of forming tillage slots at the time of seeding for improved infiltration when the soil was frozen were not successful. Early rains prior to soil freezing resulted in silting that closed the tillage channels near the soil surface. This sealing of large macropore channels eliminated the possibility of improved infiltration rate (Pikul, Ramig, Zuzel and Wilkins, unpublished, Columbia Plateau Conservation Research Center, Pendleton, OR). One possible solution to maintaining the integrity of the tillage channels for improved infiltration is to till the soil when it is frozen. This concept of tilling when the soil is frozen in fields seeded to cereals is being investigated by researchers at the Columbia Plateau Conservation Research Center. One portion of this research was to develop a tool to till frozen soil.

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DESIGN CRITERIA

The tillage tool was designed to meet six functional requirements. These requirements are to:

1. Create tillage slots or macropore channels for conducting water from the soil surface to below the frozen layer (assumed to be less than 8 in. thick). It is critical that the integrity of the slots or channels connecting the soil surface to below the frozen layer be maintained throughout the frozen soil period. For experimental work, one tillage slot per pass was required.

2. Cause minimum soil disturbance. Tillage conducted after wheat seedlings are established results in fracturing, and exposing roots to the atmosphere, covering plants with soil, and dislodging plants. This tillage reduces plant stands and increases the incidence of soil borne diseases. Minimum soil disturbance is necessary to reduce plant damage.

3. Maintain access to slots and channels for surface water. The tillage operation must leave the up slope soil surface in a condition that promotes water flow into the slots and channels. Any build up of a soil berm should be on the down slope side of the tillage mark.

4. Provide depth control and adjustment. A manual adjustment for setting and maintaining tillage depth from 8 to 14 in. was required.

5. Assume penetration through frozen soil. The combination of implement weight and tillage tool suction force needed to cause the tillage tool to penetrate 4 to 6 in. of frozen soil.

6. Operate with a three-point hitch (ASAE, 1987). For ease in transporting the tillage implement to field sites, and maneuverability in small plot areas a category II three-point hitch implement was desirable.

TILLAGE TOOL

Figure 1 shows the tool designed for tilling frozen soil. The tillage implement consists of a tool bar frame, shank and spider. The total weight of the implement including two 60 lb removable weights is 1700 lbs. The tool bar is a 4 by 4 in. square bar with a wall thickness of 0.25 in. and 8 ft long. The tool bar was rigidly fastened to a three-point hitch configuration which conformed to dimensions for category II implements (ASAE, 1987). The top link from the tractor to the implement on the three-point hitch is used to adjust the angle of attack of the tillage tool. Downward force from reaction of soil on the tool increases as the angle of attack increases. This downward force in addition to the weight of the implement provides the penetration force. Adjustable gauge wheels with 18 in. diameter by 5.5 in. wide pneumatic tires were mounted on the tool bar to control the operating depth of the tillage shank.

A single shank 22 in. long and 3/4 in. thick was attached with two bolts to a clamp mounted in the center of the tool bar. The frontmost shank mounting bolt was a 3/8 in. diameter grade 5 bolt which acted as a safety shear pin in case the tillage tool struck an immovable object.

A spider wheel from a Calkins model SR-3-00 rotary subsoiler was mounted directly behind the tillage shank. This spider had five, 2 in. wide by 1.5 in. thick

Figure 1. Tillage for tilling frozen soil.

soil engaging spuds that extended radially 14 in. from the spider hub. The radial distance to the tips of the spuds was 32 in. The spider shaft was attached approximately 50 in. behind the tillage shank by a hinged linkage and a hydraulic cylinder that controlled the vertical position of the spider relative to the tool bar. This hinged linkage and the attachment of the hydraulic cylinder were designed so that the implement could be operated with either or both the tillage shank and subsoiler spider engaged. Mounting brackets were attached to the spider hinge linkage for adding weight to improved spud penetration. Figure 1 shows two weights added to the implement.

OPERATION

This tillage implement was attached to a 42 Hp John Deere model 350 crawler type tractor. Field tests were conducted on slopes of 15 to 25 % in December 1989 and 1990 and January 1991. With a 4 in. layer of frozen soil and tilling from 10 to 12 in. deep at 1.5 mph, this implement functioned satisfactory. The rotary subsoiler spider made pock marks in the tillage channel every three ft. which provided easy access for surface water to enter the tillage channel. Soil lifted the by the shank and spider moved to the down slope side of the shank mark forming a small berm and leaving the up slope side open for water to flow into the pock marks and tillage channel. The 42 hp tractor pulled the implement at 1.5 mph and had excess power.

The impact of this tillage on soil erosion and wheat disease and yield are being evaluated during the 1991 crop year. Future research on this concept will include additional field evaluation on erosion, crop production and tool performance. Some questions that need to be addressed are : What are the power requirements for different field conditions? What is the optimum tillage shank geometry? Would a coulter in front of the shank reduce soil disturbance? What is the optimum spacing of tillage slots for effective soil erosion control for different slopes and soil characteristics?

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PACIFIC NORTHWEST WINTER AND SPRING WHEAT CULTIVAR DESCRIPTIONS

P.K. Zwer, D.L. Sutherland, and K.J. Morrow[1]

INTRODUCTION

A regional yield testing program is conducted in northcentral and northeastern Oregon by the Club Wheat Breeding Program. Disease reactions, numerous agronomic characteristics, yield, test weight, and quality characteristics, such as flour protein and hardness are evaluated for varieties and advanced breeding lines at six on-farm locations as well as the Pendleton and Sherman Experiment Stations. Information gathered from this program as well as other sources is compiled and presented to assist in the selection of winter and spring wheat and triticale cultivars for northcentral and northeastern Oregon as well as southeastern Washington.

MATERIALS AND METHODS

Winter grain, advanced club, and spring grain yield trials, each composed of 30 entries and three replications, were sown at eight locations. Varieties and advanced breeding lines of club, hard red, hard white, and soft white wheat represent the different classes of wheat examined. Winter and spring triticale varieties are also included in the experiments. Additional preliminary and advanced club yield tests as well as the Western Regional Soft White and HardRed Yield Trials were conducted at the Pendleton and Sherman Experiment Stations. The experiments were planted with a Hege small plot drill at a seeding rate of 20 to 22 seeds ft^2. The drill was modified for deep furrow sowing. The plots, composed of five rows with 12 inch centers, measured 80 ft^2.

The winter grain experiments were sprayed for weed control in March with metribuzin, bromoxynil, and MCPA (each .25 lb. ai/acre) with the exception of trials at LaGrande where bromoxynil and MCPA (each .38 lb. ai/acre) were used and at Pendleton where metribuzin, bromoxynil (each .25 lb. ai/acre) and dicamba (.06 lb. ai/acre) were sprayed on the plots. Spring grain weed control consisted of bromoxynil and MCPA (each .38 lb. ai/acre) in April.

Data were collected throughout the growing season and at harvest. The plots were harvested with a Hege 140 small plot combine. The grain was weighed, cleaned, and test weights determined. Data were collected on a hand-held computer and transferred onto the main computer for analysis. Seed samples were submitted to the Western Wheat Quality Laboratory for quality characterization except for the Athena winter and LaGrande spring grain yield trials.

RESULTS AND DISCUSSION

Sowing and harvesting dates for winter and spring grain yield trials are presented in Table 1. Seed was planted into moisture at all sites except the Arlington winter yield trials. Gopher damage and Russian wheat aphid infestation reduced the spring wheat yields at Lexington.

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Plant height, grain yield, test weight, and flour protein data are presented in Tables 2 and 3 for the 1989-1990 winter grain entries. Flour protein is 1 to 1.5 percent lower than grain protein. The entries represent cultivars from three wheat market classes, hard red, soft white, and club, as well as triticale. Three advanced breeding lines, presently being increased for new variety releases, OR830801, FW75336 (soft common), and OR855 (club) are also included. Long term yield averages are shown in Table 4. Agronomic characterisitics and disease reactions are summarized in Tables 5 and 6, respectively.

The advanced club yield trials assessed 21 promising advanced club selections, five club varieties, and three varietal mixtures. Tables 7 and 8 summarize the data for the club mixtures and varieties.

Spring grain yield, test weight, and flour protein for the 1989-1990 growing season are presented in Tables 9 and 10. Three wheat market classes (hard red, hard white, and soft white) and triticale were included as entries in the yield trial. Long term yield averages for the spring grain entries are summarized in Table 11. Agronomic characteristics and disease reactions are presented in Tables 12 and 13, respectively.

Table 1. Sowing and harvest dates for the winter and spring grain yield trials, 1989-90. Columbia Basin Research Center, OR.

Location	Winter trials		Winter trials	
	Sown	Harvested	Sown	Harvested
Arlington	September 28	July 16	March 12	July 16
Athena	September 22	August 8	March 9	August 8
Helix	September 20	July 17	March 6	August 3
Heppner	September 26	July 31	March 12	July 31
LaGrande	September 29	August 15	March 30	August 15
Lexington	September 26	July 13	March 12	August 2
Moro	September 28	July 19	March 14	July 19
Pendleton	September 25	July 25	March 9	August 1

Table 2. Oregon winter grain yield trial data for the 1989-90 crop year at four locations in Morrow, Gilliam, and Sherman Counties, OR.

Line or Cultivar	Location: Arlington Ht[1]	Arlington Test[2] wt	Arlington Yld[3]	Arlington Flour[4] prot	Heppner Ht	Heppner Test wt	Heppner Yld	Heppner Flour prot	Lexington Ht	Lexington Test wt	Lexington Yld	Lexington Flour prot	Moro Ht	Moro Test wt	Moro Yld	Moro Flour prot	Ave. yield[6]
	common wheat																
HARD RED																	
Andrews	24	61	28	11.4	37	61	49	9.6	32	61	45	6.8	27	61	42	11.3	41
Batum	27	59	33	9.1	37	59	60	9.2	30	61	56	9.1	30	59	47	9.9	49
ORCR8313	28	61	29	13.8	40	61	49	14.7	33	62	40	7.0	32	62	38	10.8	39
Wanser	27	61	30	11.4	44	62	44	10.8	35	62	40	6.2	34	62	32	10.7	37
SOFT WHITE																	
Daws	25	58	26	10.7	37	60	62	9.6	31	60	49	7.7	30	59	40	11.4	44
Dusty	24	59	32	11.7	35	59	64	11.3	28	60	31	7.2	28	60	42	10.3	42
FW75336	25	60	32	11.6	36	62	63	11.4	31	60	53	7.7	30	60	51	11.4	50
Hill 81	27	59	29	13.4	39	59	57	12.8	30	60	42	8.0	33	59	44	12.0	43
Lewjain	24	60	32	11.6	34	59	62	12.8	29	61	41	8.6	28	60	44	9.1	45
Madsen	26	60	32	11.1	38	60	68	11.2	32	59	46	7.7	29	59	45	11.3	48
Malcolm	25	59	31	11.5	35	60	59	11.6	31	61	43	7.6	31	60	51	10.4	46
OR830081	25	60	40	11.3	34	59	64	10.5	29	60	65	7.3	30	59	50	10.8	55
Oveson	24	59	33	11.8	36	60	59	9.8	32	60	44	7.5	31	59	42	11.1	44
Stephens	24	58	34	12.6	35	60	64	14.1	29	60	57	7.5	29	60	47	12.2	51
	club wheat																
Hyak	23	59	29	11.8	38	59	65	11.8	28	59	48	6.9	26	58	34	12.4	44
OR855	23	62	36	11.2	35	61	61	13.3	30	60	43	7.8	27	62	46	10.6	47
Tres	26	58	24	11.2	38	60	60	9.9	31	59	52	7.6	26	59	31	11.8	42
	triticale[5]																
Flora	29	46	29	12.8	39	44	57	12.8	29	52	54	6.9	32	47	51	9.6	48
Whitman	32	51	29	10.6	49	49	55	11.9	38	55	52	5.7	37	51	46	10.5	46
Nursery ave.	26	59	31	11.6	38	59	59	11.5	31	60	47	7.4	30	59	43	10.9	--

[1] Ht = height expressed in inches.

[2] Test wt =test weight expressed in pounds/bushel.

[3] Yld = grain yield expressed in bushels/acre.

[4] Flour prot = flour protein expressed as a percentage.

[5] Triticale yields were determined using 60 pounds/bushel.

[6] Average yield across all locations.

Table 3. Oregon winter grain yield trial data for the 1989-90 crop year at four locations in Umatilla and Union Counties, OR.

Line or Cultivar	Athena Ht[1]	Athena Test[2] wt	Athena Yld[3]	Athena Flour[4] prot	Helix Ht	Helix Test wt	Helix Yld	Helix Flour prot	LaGrande Ht	LaGrande Test wt	LaGrande Yld	LaGrande Flour prot	Pendleton Ht	Pendleton Test wt	Pendleton Yld	Pendleton Flour prot	Ave. yield[6]
common wheat																	
HARD RED																	
Andrews	42	61	74	ND[7]	38	63	62	10.3	37	60	109	12.9	40	61	83	13.0	82
Batum	41	56	81	ND	40	61	85	9.0	43	59	106	12.3	44	56	87	12.2	90
ORCR8313	46	62	67	ND	41	63	65	12.0	43	62	109	12.8	45	63	84	11.5	81
Wanser	47	61	49	ND	45	64	56	10.0	49	60	86	12.5	49	61	43	13.5	59
SOFT WHITE																	
Daws	41	61	75	ND	42	63	90	10.4	39	60	113	10.7	44	61	93	12.1	93
Dusty	41	59	79	ND	38	63	81	9.4	39	58	108	11.2	41	62	94	11.0	91
FW75336	41	59	96	ND	37	63	81	10.5	38	57	128	12.1	41	61	96	11.8	100
Hill 81	43	61	92	ND	41	63	82	10.2	43	60	123	12.6	45	62	104	11.8	100
Lewjain	40	61	86	ND	35	62	73	8.8	39	60	116	11.1	41	60	91	11.0	92
Madsen	41	60	93	ND	39	63	80	10.6	40	59	122	13.2	43	62	93	12.6	97
Malcolm	39	60	96	ND	37	63	93	9.2	36	60	116	10.6	41	61	104	11.8	102
OR830081	37	60	97	ND	37	62	78	11.2	36	59	109	11.4	39	60	101	11.5	96
Oveson	42	58	79	ND	38	63	81	9.8	39	58	120	11.1	43	60	99	10.9	95
Stephens	36	60	94	ND	36	63	81	10.1	38	60	128	10.7	39	61	101	11.9	101
club wheat																	
Hyak	43	58	81	ND	39	62	82	10.1	44	59	119	10.9	43	61	93	11.1	94
OR855	41	60	70	ND	39	64	67	9.5	40	61	120	12.5	43	63	86	12.1	86
Tres	47	59	71	ND	42	63	72	9.8	44	61	113	10.8	45	62	84	11.4	85
triticale[5]																	
Flora	41	44	87	ND	39	51	99	8.3	39	45	115	10.3	36	44	85	10.2	97
Whitman	51	52	73	ND	46	56	98	9.4	51	52	116	11.2	49	53	110	10.0	99
Nursery ave.	42	58	80	ND	39	62	79	9.9	41	58	115	11.6	43	60	91	11.6	ND

[1] Ht = height expressed in inches.

[2] Test wt =test weight expressed in pounds/bushel.

[3] Yld = grain yield expressed in bushels/acre.

[4] Flour prot = flour protein expressed as a percentage.

[5] Triticale yields were determined using 60 pounds/bushel.

[6] Average yield across all locations.

[7] ND = not determined.

Table 4. Yield averages for winter grain grown from 1985-90 in northcentral and northeastern Oregon.

	Location															
	Arlington		Athena		Helix		Heppner		LaGrande		Lexington		Moro		Pendleton	
Line or Cultivar	Avg[1]	Yrs[2]	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs
	---common wheat---															
HARD RED																
Andrews	29	3	73	3	49	2	44	3	104	3	45	3	48	3	67	3
Batum	33	3	75	3	68	2	45	3	104	3	51	3	53	5	73	4
Hatton	34	2	69	2	47	1	39	2	98	2	42	2	46	3	59	3
ORCR8313	33	3	74	3	55	1	45	3	112	3	46	3	46	5	72	5
Wanser	29	3	60	3	50	1	38	3	90	3	40	3	39	4	52	5
SOFT WHITE																
Basin	33	2	76	2	43	2	43	2	113	2	48	2	60	3	74	2
Cashup	21	2	80	2	39	1	37	2	119	2	47	2	63	3	72	2
Daws	34	6	79	4	69	3	42	6	97	6	50	6	50	6	75	5
Dusty	36	6	77	4	71	3	45	6	97	6	47	6	54	6	81	4
Hill 81	35	6	83	4	72	3	43	6	99	6	50	6	50	6	79	5
Lewjain	45	6	81	4	66	3	45	5	102	5	50	5	52	5	81	4
Madsen	33	3	84	3	61	2	50	3	113	3	47	3	52	5	77	5
Malcolm	35	6	86	4	75	3	44	6	97	6	53	6	54	6	80	6
OR830801	40	1	97	1	78	1	64	1	109	1	65	1	64	3	76	3
Oveson	34	6	81	4	72	3	39	6	94	6	50	6	48	6	75	6
Stephens	38	6	83	4	71	3	47	6	93	6	58	6	53	6	77	6
	---club wheat---															
Crew	34	5	74	3	65	2	34	5	89	5	48	5	51	5	71	4
Hyak	31	3	76	3	64	2	49	3	114	3	48	3	47	5	72	5
Hyak-OR855	29	1	77	1	81	1	62	1	119	1	45	1	39	1	81	1
Hyak-OR855-Tres	30	1	77	1	75	1	60	1	112	1	54	1	36	1	79	1
Hyak-Tres	26	1	88	1	73	1	65	1	112	1	53	1	37	1	78	1
OR855	39	4	79	4	65	3	47	4	109	4	49	4	52	5	80	4
Tres	34	6	79	4	69	3	39	6	95	6	51	6	49	6	74	6
	---triticale[3]---															
Flora	33	3	81	3	77	2	43	3	110	3	50	3	63	3	77	2
Whitman	27	2	76	2	98	1	41	2	117	2	43	2	49	2	89	2

[1] Expressed in bushels/acre.

[2] Number of years tested.

[3] Triticale yields were determined using 60 pounds/bushel.

Table 5. Agronomic characteristics of selected winter cultivars in Oregon.[1]

Cultivar	Released Year	Released State[2]	Emergence[3] index	Winter-[3] hardiness	Maturity	Height[4]	Lodging[5] resistance	Test[3] weight	Chaff[6] color	Head type
					common wheat					
HARD RED										
Andrews	1987	WA	5	7	Early	SD-M	R	7	W	Awned
Batum	1985	WA	5	7	Mid-late	SD-SM	R	6	W	Awned
Hatton	1979	WA	6	9	Mid-late	MT	MR	8	W	Awned
Wanser	1965	WA	6	9	Midseason	M	MS	8	B	Awned
Weston	1978	ID	6	8	Early-mid	MT	R	8	-	Awned
SOFT WHITE										
Basin[7]	1985	Pr	6	6	Midseason	SD-M	R	8	W	Awned
Cashup[7]	1985	Pr	7	8	Midseason	SD-M	R	8	W	Awned
Daws	1976	WA	4	8	Midseason	SD-M	R	6	W	Awned
Dusty	1984	WA	5	5	Mid-late	SD-M	MR	7	W	Awned
Hill 81	1981	OR	5	5	Midseason	SD-MT	R	7	W	Awned
John	1984	WA	6	7	Midseason	SD-M	R	7	W	Awned
Lewjain	1982	WA	6	6	Late	SD-M	MR	7	W	Awned
Madsen	1988	WA	5	4	Midseason	SD-MT	R	7	W	Awned
Malcolm	1987	OR	5	4	Early-mid	SD-M	R	7	W	Awned
Nugaines	1961	WA	5	7	Midseason	SD-M	R	8	W	Awned
Oveson	1987	OR	5	4	Mid-late	SD-MT	MR	7	W	Awned
Sprague	1973	WA	6	7	Early-mid	SD-M	MS	7	W-B	Awned
Stephens	1977	OR	5	4	Early-mid	SD-M	R	7	W	Awned
Yamhill	1969	OR	7	4	Midseason	MT-T	MR	7	W	Awnletted
					club wheat					
Crew	1981	WA	6	5	Midseason	SD-MT	MR	6	W-B	Awnless
Faro	1976	OR	6	5	Early-mid	SD-MT	R	5	B	Awnless
Hyak	1988	WA	5	5	Early-mid	SD-MT	MR	6	W	Awnletted
Jacmar	1978	Pr	5	7	Early-mid	SD-M	R	5	B	Awnletted
Moro	1965	OR	8	5	Early-mid	MT	MS	5	B	Awnless
Tres	1984	WA	5	5	Midseason	SD-M	R	7	W	Awnletted
Tyee	1979	WA	5	6	Midseason	SD-MT	R	5	W	Awnless

[1] Table compiled by R. Karow, Extension Cereal Specialist, OSU.

[2] WA = Washington, OR = Oregon, ID = Idaho, Pr = Private.

[3] Scale of 1 to 10, poor to excellent.

[4] SD = semidwarf, SM = short-medium, M = medium, MT = medium-tall, T = tall.

[5] R = resistant, MR = moderately resistant, MS = moderately susceptible.

[6] W = white, B = bronze.

[7] Information provided by developer, Columbia Basin Seeds.

Table 6. Disease reactions for commonly grown winter wheats in Oregon.[1]

Cultivar	Rust		Bunt		Flag	Cephalosporium[3]	Septoria	Foot[4]	Take	Snow
	Stripe	Leaf	Common	Dwarf	smut			rot	all	mold
					common wheat					
HARD RED										
Andrews	MR[2]	S	R	MR	--	S	--	S	--	MR
Batum	R	MS	R	S	MS	MS	--	S	S	S
Hatton	MR	S	R	MS	--	--	--	S	--	S
Wanser	T	S	R	MR	--	--	--	--	--	MS
Weston	MS	MS	--	--	--	--	--	--	--	--
SOFT WHITE										
Basin[5]	R	R	R	MR	R	MR	--	--	--	--
Cashup[5]	R	R	R	S	R	MR	--	--	--	--
Daws	MR	MS	R	S	MS	MS	MS	MS	S	S
Dusty	MR	MS	R	S	MS	MS	--	S	S	S
Hill 81	MR	MR	R	S	S	MR	MT	S	S	--
John	MS	S	S	S	--	--	--	--	S	R
Lewjain	R	MS	R	MR	MS	MR	MT	T	S	--
Madsen	R	R	S	S	--	MS	--	R	--	--
Malcolm	MR	MR	R	S	--	MS	MS	MS	S	S
Nugaines	MR	S	R	S	MR	MR	MS	MS	S	S
Oveson	R	S	MR	S	--	MR	--	MS	S	S
Sprague	S	S	S	S	S	S	--	S	S	R
Stephens	MR	MS	R	S	MS	S	MS	MR	S	S
Yamhill	MS	MR	S	S	MR	MS	MS	T	S	--
					club wheat					
Crew[6]	MR-S	MR	R	S	MS	S	--	S	S	--
Faro	S	S	MR	S	MS	S	MS	MS	S	--
Hyak	R	R	S	S	--	S	--	R	--	--
Jacmar	S	S	MR	MR	MS	MS	MT	T	S	--
Moro	MS	S	MR	R	MR	MR	--	MS	S	--
Tres[7]	MR-S	MR	MR	S	S	S	--	MS	S	--
Tyee	S	S	MR	S	S	MR	--	T	S	--

[1] Table compiled by R. Karow, Extension Cereal Specialist, OSU.

[2] R = resistant, MR = moderately resistant, MS = moderately susceptible, S = Susceptible, T = tolerant, MT = moderately tolerant, -- = reaction unknown.

[3] Resistance to cephalosporium stripe seems to vary with environment. Resistance may be due to morphological growth patterns rather than true genetic resistance.

[4] Pseudocercosporella foot rot.

[5] Information provided by developer, Columbia Basin Seeds.

[6] Crew is a multiline variety composed of ten separate lines, some of which are rust susceptible.

[7] Tres is moderately resistant to powdery mildew. A stripe rust race in parts of eastern Oregon and Washington has overcome Tres' stripe rust resistance.

Table 7. Oregon club wheat yield data for the 1989-90 crop year at four locations in Morrow, Gilliam, and Sherman Counties, OR.

Line or Cultivar	Arlington Ht[1]	Arlington Test[2] wt	Arlington Yld[3]	Arlington Flour[4] prot	Heppner Ht	Heppner Test wt	Heppner Yld	Heppner Flour prot	Lexington Ht	Lexington Test wt	Lexington Yld	Lexington Flour prot	Moro Ht	Moro Test wt	Moro Yld	Moro Flour prot	Ave.[5] yield
Elgin	25	59	27	11.8	45	61	50	9.6	33	60	43	8.7	29	58	30	10.9	38
Hyak	22	60	26	10.9	36	60	61	8.5	29	61	48	9.0	27	55	27	10.4	41
Hyak-OR855 Mix	24	61	29	10.0	35	61	62	9.1	28	60	45	8.2	26	60	39	9.7	44
Hyak-OR855-Tres	23	60	30	11.6	35	60	60	11.9	29	60	54	8.1	25	59	36	9.7	45
Hyak-Tres Mix	22	59	26	10.9	37	60	65	9.5	30	59	53	7.9	28	58	37	9.7	45
Moro	26	59	30	10.2	46	58	59	8.8	32	58	40	7.4	31	57	34	9.3	41
OR855	23	60	30	11.2	35	62	66	10.6	29	61	50	8.2	27	60	43	10.3	47
Tres	21	58	26	10.6	37	61	58	9.9	29	58	52	8.4	25	57	32	11.2	42
Nursery ave.	23	60	28	9.5	37	60	58	9.7	30	60	46	8.2	26	58	37	10.2	42

[1] Ht = height expressed in inches.

[2] Test wt = test weight expressed in pounds/bushel.

[3] Yld = yield expressed in bushels/acre.

[4] Flour prot = flour protein expressed as a percentage.

[5] Average yield across all locations.

Table 8. Oregon club wheat yield data for the 1989-90 crop year at four locations in Umatilla and Union Counties.

Line or Cultivar	Athena Ht[1]	Athena Test[2] wt	Athena Yld[3]	Athena Flour[4] prot	Helix Ht	Helix Test wt	Helix Yld	Helix Flour prot	LaGrande Ht	LaGrande Test wt	LaGrande Yld	LaGrande Flour prot	Pendleton Ht	Pendleton Test wt	Pendleton Yld	Pendleton Flour prot	Ave. yield[5]
Elgin	51	58	49	11.4	48	62	54	10.7	51	60	76	10.2	48	61	45	10.1	56
Hyak	44	60	81	9.5	38	63	80	9.3	43	59	104	9.9	41	63	75	9.1	85
Hyak-OR855 Mix	44	60	77	9.8	39	63	81	10.5	42	61	119	11.1	44	61	81	9.4	90
Hyak-OR855-Tres	47	61	77	9.3	41	63	75	9.9	47	61	112	10.7	44	61	79	9.7	86
Hyak-Tres Mix	44	59	88	9.2	41	63	73	10.1	44	61	112	10.8	46	61	78	9.3	88
Moro	46	55	49	11.7	43	61	59	10.4	49	59	71	11.9	47	57	47	10.5	57
OR855	43	59	66	11.3	40	64	70	10.8	43	61	120	12.0	45	63	81	10.4	84
Tres	46	59	69	9.1	41	64	70	10.0	46	59	113	12.0	47	62	77	9.0	82
Nursery ave.	44	59	69	10.2	40	63	72	10.2	43	60	105	11.1	44	61	71	9.7	79

[1] Ht = height expressed in inches.

[2] Test wt = test weight expressed in pounds/bushel.

[3] Yld = yield expressed in bushels/acre.

[4] Flour prot = flour protein expressed as a percentage.

[5] Average yield across all locations.

Table 9. Oregon spring grain yield trial data for the 1989-90 crop year at four locations in Morrow, Gilliam, and Sherman Counties, OR.

Line or Cultivar	Arlington				Heppner				Lexington				Moro				Ave. yield[6]
	Ht[1]	Test[2] wt	Yld[3]	Flour[4] prot	Ht	Test wt	Yld	Flour prot	Ht	Test wt	Yld	Flour prot	Ht	Test wt	Yld	Flour prot	
common wheat																	
HARD RED																	
Bronze Chief	27	56	25	17.6	30	51	31	17.7	19	55	16	17.8	27	58	26	14.8	25
McKay	29	59	34	15.7	25	51	30	15.5	18	56	14	15.8	27	59	30	14.2	27
OR4870355	27	57	32	17.6	30	57	37	15.6	18	55	11	17.6	27	59	29	15.0	27
OR4870400	27	60	35	17.0	30	54	32	16.8	15	59	8	17.0	27	59	30	14.9	26
OR4870456	25	60	32	16.3	30	56	37	14.9	17	55	16	16.6	25	61	32	13.1	29
OR4870462	29	58	35	16.4	30	51	29	17.2	19	57	15	17.7	26	59	29	15.1	27
OR4870475	22	61	34	17.4	31	53	30	16.7	16	58	15	17.7	22	60	31	13.8	28
ORS8510	26	59	28	15.8	37	51	32	16.6	20	55	17	16.2	26	61	31	13.9	27
Wampum	29	57	27	16.1	32	50	37	15.5	23	53	16	16.2	29	56	27	14.1	27
Westbred 906R	26	60	27	17.2	31	52	34	17.0	23	59	22	15.9	27	60	30	14.7	28
Yecoro Rojo	21	61	33	15.9	32	56	27	17.0	15	58	17	15.3	22	62	31	14.0	27
SOFT WHITE																	
Dirkwin	29	56	40	14.9	30	53	28	15.4	22	53	13	15.2	27	56	29	12.7	28
Edwall	26	58	34	14.4	27	49	32	15.4	20	53	15	13.4	25	56	31	12.5	28
OR4870316	24	58	27	15.5	28	52	30	15.4	21	54	15	15.2	27	58	29	15.3	25
OR4870503	26	58	31	15.7	33	50	36	16.9	22	56	16	13.9	28	58	33	13.3	29
OR4870570	26	57	29	15.4	30	54	30	15.9	22	57	22	13.8	28	58	32	14.0	28
ORS8427	28	59	23	15.4	34	48	29	17.5	22	54	14	16.0	28	56	26	14.0	23
Owens	28	58	34	14.9	30	51	38	14.8	23	54	18	14.5	27	56	20	14.2	28
Penawawa	27	57	35	14.6	30	50	36	15.7	21	54	16	13.6	27	57	32	12.7	30
Twin	28	55	33	15.5	29	50	35	15.8	17	53	6	16.5	28	57	28	13.2	26
Wakanz	28	57	41	14.1	31	50	37	15.4	20	55	20	13.7	25	58	31	12.9	32
Waverly	27	57	33	14.8	29	51	31	14.7	21	54	24	12.7	28	58	32	13.1	30
HARD WHITE																	
Klasic	21	60	30	16.2	28	57	27	15.6	18	59	23	15.2	21	62	28	15.3	27
ORS8413	25	60	31	15.6	31	48	26	15.9	22	55	20	15.4	27	58	32	15.3	27
Wadual	29	58	33	15.7	26	51	30	15.8	24	56	15	14.6	30	59	28	13.7	27
triticale[5]																	
Juan	38	52	34	12.3	34	43	27	14.3	26	48	22	13.6	37	47	27	12.5	28
Karl	27	51	29	13.7	29	43	33	14.6	20	46	25	13.7	28	49	26	12.9	28
durum																	
OR4880059	24	59	28	16.1	31	54	35	15.6	18	57	16	17.3	25	59	27	16.1	27
OR4880068	21	59	17	16.8	28	53	34	16.9	17	58	12	16.9	23	58	21	15.6	21
OR4880121	22	61	29	16.6	32	56	34	14.8	16	58	13	17.4	22	61	27	14.8	26
Nursery ave.	26	58	31	15.7	30	52	32	15.9	20	55	16	15.5	27	58	29	14.1	27

[1] Ht = height expressed in inches.

[2] Test wt = test weight expressed in pounds/bushel.

[3] Yld = yeild expressed in bushels/acre.

[4] Flour prot = Flour protein expressed as a percentage.

[5] Triticale yields were determined using 60 pounds/bushel.

[6] Average yield across all locations.

Table 10. Oregon spring grain yield trial data for the 1989-90 crop year at four locations in Umatilla and Union Counties, OR.

	Location																
	Athena				Helix				LaGrande				Pendleton				
Line or Cultivar	Ht[1]	Test[2] wt	Yld[3]	Flour[4] prot	Ht	Test wt	Yld	Flour prot	Ht	Test wt	Yld	Flour prot	Ht	Test wt	Yld	Flour prot	Ave. yield[6]
	common wheat																
HARD RED																	
Bronze Chief	34	55	50	16.3	32	58	47	15.4	32	59	56	15.3	34	56	42	15.4	49
McKay	38	54	54	14.3	35	57	58	14.7	35	57	62	14.7	36	56	55	13.8	57
OR4870355	40	55	57	16.0	35	59	54	15.1	36	60	68	15.0	35	58	49	15.0	57
OR4870400	36	55	58	15.2	35	59	66	14.1	35	57	68	14.2	36	58	57	14.1	62
OR4870456	36	57	60	14.6	33	60	60	14.2	31	60	73	14.2	33	58	45	14.3	60
OR4870462	35	55	62	16.0	34	57	65	15.2	34	58	73	15.1	35	56	54	16.4	64
OR4870475	30	57	63	15.0	28	58	62	15.3	28	58	69	15.0	30	56	59	14.8	63
ORS8510	36	56	58	14.6	33	58	54	14.5	34	61	56	14.0	34	56	55	15.1	56
Wampum	40	53	47	14.0	38	55	53	13.8	39	58	62	12.8	40	55	56	13.5	55
Westbred 906R	38	58	60	15.3	34	60	58	15.1	34	60	70	15.2	36	58	60	16.2	62
Yecoro Rojo	29	60	61	14.9	27	61	60	14.5	27	62	69	14.5	26	59	58	15.3	62
SOFT WHITE																	
Dirkwin	40	52	52	13.2	38	55	57	12.5	37	51	71	14.1	37	53	54	13.4	59
Edwall	38	50	53	13.9	35	56	60	13.0	35	55	67	12.7	36	55	57	13.0	59
OR4870316	34	54	60	14.1	32	58	63	13.8	32	53	58	13.9	32	57	56	13.1	59
OR4870503	38	53	57	14.6	35	59	64	13.2	38	52	61	14.9	37	58	66	13.8	62
OR4870570	37	53	56	14.9	35	58	72	13.2	37	54	75	13.9	35	57	61	14.0	66
ORS8427	36	56	55	13.2	37	56	47	13.4	35	60	58	13.3	34	54	42	14.2	51
Owens	40	53	59	13.8	36	56	63	12.7	36	56	76	13.1	40	53	52	13.5	63
Penawawa	37	52	53	14.2	36	56	57	12.5	37	52	55	14.0	39	56	62	12.7	57
Twin	38	51	51	13.9	36	54	58	13.4	36	54	66	13.5	36	54	52	13.8	57
Wakanz	36	53	56	14.1	33	58	61	12.2	36	56	66	13.0	34	54	53	12.6	59
Waverly	38	52	54	14.1	35	55	61	13.3	37	53	56	14.0	37	52	58	13.4	57
HARD WHITE																	
Klasic	28	62	63	14.8	27	62	58	15.1	27	64	65	15.3	27	61	61	16.4	62
ORS8413	35	54	60	13.5	34	56	59	13.1	34	56	71	14.1	31	54	50	14.1	60
Wadual	40	56	59	13.7	38	58	57	13.6	39	56	63	14.4	39	56	48	13.6	57
	triticale[5]																
Juan	50	44	53	13.6	45	49	60	14.6	49	48	73	12.7	46	48	65	12.4	63
Karl	41	46	60	14.4	35	52	63	13.0	37	50	61	13.1	36	49	56	13.4	60
	durum																
OR4880059	31	56	45	14.7	31	59	49	15.6	31	59	55	14.4	31	57	51	14.9	50
OR4880068	28	58	51	15.0	27	59	47	15.4	27	60	60	14.5	28	56	50	16.1	52
OR4880121	28	58	43	14.3	27	60	51	13.8	26	60	55	14.7	27	58	52	15.5	50
Nursery ave.	36	54	56	14.5	34	57	58	14.0	34	57	65	14.1	35	56	55	14.3	59

[1] Ht = height expressed in inches.

[2] Test wt = test weight expressed in pounds/bushel.

[3] Yld = yield expressed in bushels/acre.

[4] Flour prot = flour protein expressed as a percentage.

[5] Triticale yields were determined using 60 pounds/bushel.

[6] Average yield across all locations.

Table 11. Yield averages for spring grain grown from 1985-90 in northcentral and northeastern Oregon.

	Location															
	Arlington		Athena		Helix		Heppner		LaGrande		Lexington		Moro		Pendleton	
Line or Cultivar	Avg[1]	Yrs[2]	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs	Avg	Yrs
---common wheat---																
HARD RED																
Bronze Chief	27	3	56	3	40	3	28	3	63	3	27	3	43	3	39	2
Kodiac	34	2	59	2	30	2	30	2	65	2	30	2	51	2	35	1
McKay	27	6	60	4	46	3	27	4	56	6	29	6	39	6	47	5
Wampum	22	5	56	3	45	2	26	3	55	5	28	2	30	5	50	5
Westbred 906R	29	4	61	4	45	3	31	4	70	4	34	4	36	6	49	5
Yecoro Rojo	27	6	61	4	42	3	30	4	69	4	32	6	35	6	44	5
SOFT WHITE																
Dirkwin	29	6	60	4	49	2	25	4	64	6	34	6	39	6	52	5
Edwall	24	2	59	3	50	2	27	2	55	5	29	5	36	5	50	5
Owens	29	6	62	4	51	3	30	4	65	6	33	6	37	6	51	5
Penawawa	27	4	62	3	47	2	26	2	61	5	30	4	36	2	53	5
Twin	27	6	61	4	51	3	29	4	66	6	31	6	41	6	52	5
Wakanz	32	2	65	2	54	2	30	2	69	2	28	2	36	5	55	5
Waverly	25	5	62	3	52	2	23	3	55	5	32	5	37	5	54	5
HARD WHITE																
Klasic	26	2	70	2	45	2	23	2	68	2	26	2	42	2	52	2
Wadual	28	2	61	2	47	2	24	2	64	2	21	2	39	2	52	2
---triticale[3]---																
Grace	27	2	46	2	48	2	21	2	49	2	34	2	46	2	59	1
Juan	34	3	59	3	60	3	29	3	71	3	32	3	47	3	57	2
Karl	31	3	63	3	50	3	30	3	69	3	34	3	45	3	54	2
Nutricale	27	2	43	2	44	2	20	2	47	2	31	2	41	2	43	1

[1] Expressed in bushels/acre.

[2] Number of years tested.

[3] Triticale yields were determined using 60 pounds/bushel.

Table 12. Agronomic characteristics of selected spring wheat cultivars in Oregon.[1]

Cultivar	Released Year	Released State[2]	Maturity	Height[3]	Lodging[4] resistance	Test[5] weight	Chaff[6] color	Head type
				common wheat				
HARD RED								
Bronze Chief	1985	Pr	Early	SD-M	R	8	B	Awned
Kodiak	1985	Pr	Early	SD-S	R	6	W	Awned
McKay	1981	ID	Midseason	SD-M	R	8	W	Awned
Spillman	1989	WA	Midseason	SD-M	R	8	W	Awned
Westbred 906R	1982	Pr	Early-mid	SD-M	R	8	W	Awned
Westbred 926	1987	Pr	Early-mid	SD-M	R	8	W	Awned
Yecoro Rojo	1975	CA	Early	SD-S	R	8	W	Awned
SOFT WHITE								
Dirkwin	1978	ID	Early-mid	SD-M	MR	6	W	Awnless
Edwall	1984	WA	Early-mid	SD-M	R	7	W	Awned
Owens	1981	ID	Midseason	SD-M	R	8	W	Awned
Penawawa	1985	WA	Midseason	SD-M	R	8	W	Awned
Twin	1971	ID	Mid-late	SD-M	-	5	W	Awnless
Wakanz	1988	WA	Midseason	SD-M	R	8	W	Awned
Waverly	1982	WA	Midseason	SD-M	R	7	W	Awned
HARD WHITE								
Klasic	1987	Pr	Early	S	R	-	W	Awned
Wadual	1988	WA	Midseason	SD-M	R	9	W	Awned

[1] Data obtained from C. R. Rohde and Washington State Crop Improvement Assn.

[2] CA = California, ID = Idaho, OR = Oregon, WA = Washington, Pr = Private.

[3] SD = semidwarf, S = short, SM = short-medium, M = medium, MT = medium-tall, T = tall.

[4] R = resistant, MR = moderately resistant, MS = moderately susceptible.

[5] Scale of 1 to 10, poor to excellent.

[6] W = white, B = bronze.

Table 13. Disease reactions for selected spring wheat cultivars in Oregon and Washington.[1]

Cultivar	Rust[2]		
	Stripe	Leaf	Stem
SOFT WHITE			
Dirkwin	R	VS	R
Edwall	MR	MR	R
Owens	R	S	R
Penawawa	MR	MR	R
Twin	R	S	ND
Wadual	MR	MR	MR
Wakanz	MR	MR	MR
HARD RED			
Bronze Chief	MR	MS	R
Kodiak	MS	MS	MS
McKay	R	R	R
Spillman	R	R	R
Westbred 906R	R	R	ND
Westbred 926	R	R	ND
Yecoro Rojo	S	R	R

[1] Data collected from C. R. Rohde and Washington State Crop Improvement Association.

[2] R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible, and ND = not determined.

CLUB WHEAT BREEDING PROGRAM

P.K. Zwer, D.L. Sutherland, and K.J. Morrow

The two primary goals of the club wheat improvement program are to develop excellent quality, high yielding disease and pest resistant club wheat cultivars and to provide data for cultivars and advanced breeding lines grown in diverse agronomic zones throughout northcentral and northeastern Oregon. Several projects were initiated and maintained to address research components important to these overall goals.

DISEASE AND PEST RESISTANCE

Program resources were directed toward characterizing advanced breeding lines and genetic resources for resistance or tolerance to stripe rust, strawbreaker foot rot, Rhizoctonia root rot, and the Russian wheat aphid.

Early and late generation populations were inoculated with a mixture of Puccinia striiformis pathotypes commonly isolated in northeastern Oregon. Notes were taken for 278 F_1 plants, 190 F_2 and 167 F_4 populations, 1670 F_5 headrows and 1891 F_8-F_{10} headrows. Information was also collected for the crossing block, introductions, and yield trials. An additional 36 entries, selected from the advanced headrows based on stripe rust reaction and agronomic characteristics, were advanced into the preliminary yield trial.

The strawbreaker foot rot evaluation nursery, composed of 463 advanced breeding lines and parental materials, was sown in two replications. The nursery was inoculated with Pseudocercosporella herpotrichoides in November 1989. Notes were collected in July by recording a 0 to 10 score where 0 reflected no lodging and 10 was completely lodged. The lodging notes correlated well with the expected reactions of susceptible and resistant cultivars. Resistant cultivars, Hyak, Madsen, and Cerco possessed mean values of 1.5, 1.0, and 1.0, respectively, whereas the susceptible cultivars, Elgin and Omar expressed values of 8.0. Parental materials from several European sources, particularly England, exhibited little or no lodging. Cultivars such as Maris Huntsman, Mega, Maris Hobbit, Brigand, Bounty, and Kinsman were assigned values between 0 and 1.5. The resistant genotypes will be used in the crossing program.

The experiment, designed to assess the genetic variability for tolerance to Rhizoctonia root rot, consisted of 30 entries and five replications. The plot area was inoculated with Rhizoctonia solani to provide a uniform infection in the plot area. Unfortunately the inoculum did not provide sufficient infection for differences to be ascertained between the non-inoculated and inoculated plots. The experiment was replanted in September at the Pendleton and Sherman Research Stations.

The Russian wheat aphid evaluation program progress was limited in early 1990, however a strong program was reinstated in

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October. Populations generated with the tolerant RWA genetic resources and adapted club parents are in the F_1 (58 crosses) and F_2 (10 crosses) generations. Several F_1 plants generated from crosses between the tolerant genotypes, PI137739, PI294994, and PI262660 and adapted club genotypes, were evaluated and found to possess levels of tolerance similar to the parental lines. Data were collected and distributed for the 2nd Uniform RWA Seedling Test, a cooperative effort between eight western states in the United States and one province in Canada. Several new sources of tolerance/resistance were identified in this study. Evaluations to characterize seedling reactions to RWA infestation were conducted for several hundred durum, club, and common wheat genetic resources and advanced breeding lines. Several lines were identified with tolerance. A genetic study in cooperation with the University of Idaho was initiated. The objective of the research is to determine the number of genes for tolerance in PI47545 and PI48650 and characterize allelic relationships to the previously described lines, PI294992, PI137739, and PI262660. Crosses were made in the 1990 greenhouse crossing program, however additional crosses are required in the 1991 greenhouse crossing. A genetic study to describe the number of genes for resistance in PI294994 and PI137739 in the seedling and adult-plant stage was initiated for a graduate student's masters thesis problem. The adult plant study will be conducted in the field. A study was initiated to characterize the effect of RWA infestation on shoot and root development in seventeen genotypes possessing varying levels of tolerance and susceptiblity. Dr. Moussa Mosaad, visiting scientist from Egypt, cooperated with this study.

BREEDING PROGRAM

The greenhouse crossing program resulted in 394 single and three-way crosses. The primary emphasis was to introduce diverse seedling and adult-plant resistance genes from unadapted genetic resources into the club wheat background. Additional crossing strategies involved crosses to improve milling and baking quality, yield potential, RWA tolerance, and to develop a spring club with RWA tolerance. The field crossing block, sown at three different planting dates and composed of 540 entries, provided information such as heading date, stripe rust reaction, lodging, and furnished a pure seed supply. Extensive notes were recorded for stripe rust reaction, agronomic characteristics, as well as seed plumpness and softness in 3,800 headrows. Heads were selected from 720 rows, resulting in 2,160 F_6 and advanced generation headrows. Single head selections were also harvested from F_2 and F_4 populations, resulting in 22,680 F_3 and F_5 headrows. A greater number of heads was selected in the field, however only heads possessing cloudy, plump, white seed were retained and sown. Selected bulks for F_2 and F_3 segregating populations totaled 899 plots. Additional nurseries to assess strawbreaker foot rot, flagsmut, and stripe-rust contain 2,185 entries.

Preliminary and advanced club wheat yield trials, comprised of 75 entries and three replications, were sown at Pendleton and Moro. A regional advanced club yield test, composed of 30 entries, was sown at eight locations. Table 1 presents yield data and plant height for promising club lines as well as club variety mixtures. The Western Regional Soft White and Hard Red Yield Trials, containing 75 entries and four replications were sown at Pendleton. Breeders seed of the advanced club selection, OR855, was sown in September to produce Foundation seed in 1991. OR855 was a selection from the cross Paha/Sel72//Daws. The selection is a bronze-glumed, awned club wheat. Yield data, test weight and flour protein data are summarized in the article concerning variety descriptions.

QUALITY

All material harvested was cleaned and a seed sample sent to the Western Wheat Quality Laboratory for quality characterization. Flour protein, kernel hardness, and alkaline water retention capacity were determined for the early generation lines and genetic resources as well as the entries in the regional winter grain, advanced club, and spring grain yield trials grown at the on-farm locations. The complete array of milling and baking tests were performed for the yield trials grown at Pendleton and Moro. The information will be utilized in the selection of rows and entries in the breeding program. The flour protein data will be provided to growers along with yield information.

COMPUTERIZED FIELD BOOK SYSTEM

A computerized field book system was developed to improve the accuracy and efficiency of record keeping. All documentation for field experiments is now generated from the computer records. The hand-held computer was utilized to record grain weight and test weight for the yield trials. The information was automatically transferred onto the main computer where the statisical analysis was performed.

Table 1. Agronomic data for advanced club wheat breeding lines, 1989 and 1990. Columbia Basin Agriculutral Research Center, OR.

	Location																		
	Arlington			Helix			Heppner			Lexington			Moro			Pendleton			Location
Selection	Ht[1]	Test[2] wt	Yld[3]	Ht	Test wt	Yld	Ht	Test wt	Yld	Ht	Test wt	Yld	Ht	Test wt	Yld	Ht	Test wt	Yld	Avg yld
86-315	24	60	30	37	63	69	30	61	44	30	60	47	27	61	53	41	62	90	56
86-636	23	61	31	39	64	68	31	61	43	30	60	46	27	61	56	38	63	88	55
87-955	21	61	34	39	64	80	33	61	52	27	61	45	26	62	48	41	63	96	59
87-1028	21	57	24	39	61	85	35	59	63	30	59	50	25	55	60	41	60	95	63
85HR6962	21	57	24	36	62	71	33	59	51	28	58	43	28	59	52	39	61	84	54

[1]Height expressed as inches.

[2]Test weight expressed as pounds per bushel.

[3]Yield expressed as bushels per acre.

DRYLAND CANOLA PRODUCTION IN EASTERN OREGON

Don Wysocki, Michael Stoltz, Tom Chastain, and Karl Rhinhart[1]

Rapeseed *(Brassica napus or Brassica campestris)* is a cool season oilseed crop that is receiving increased attention as an alternate crop or a rotation crop with wheat. There are two types of rapeseed, edible rapeseed and industrial rapeseed. Because the two types can cross-pollinate and produce a product unsuitable for either purpose, eastern Oregon has grown exclusively the edible type. Canola (double low rapeseed) is an edible type that has both low erucic acid content in the oil and has meal (byproduct of oil processing) that is low in glucosinolate content. This meal has a market in the Pacific Northwest as a high protein source for animal feeds. Although there are both winter and spring varieties, our work has been focused on winter varieties. Canola is a relatively new crop in eastern Oregon, however, it has an established market and a worldwide acreage. The 1990 Farm Bill will likely encourage expansion of canola production in eastern Oregon. This paper summarizes our production results with canola for the past few years and provides some of our recommendations for production in eastern Oregon.

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CANOLA TRIAL RESULTS

We have grown canola at several locations in Umatilla county for the past few years (Table 1). These experiments have had mixed results. The most significant factor contributing to poor results has been difficulty with stand establishment. Lack of consistent plant emergence was a problem during the autumns of 1987 and 1988 due to seedbed conditions that were extremely dry. Two experiments were discontinued in 1987 and 1988 because of poor emergence, poor soil moisture, poor seed placement, and loss of seed zone water.

<u>1986-87</u> Cascade winter canola was seeded into fallow in August and September of 1986 in five test strips that were 24 X 90 ft. or greater. Bloom occurred about March 27, 1987. Variation in yield among the plots was partly due to differences in stand establishment. The lowest yielding plot was affected by a runoff event, from a 1-inch rainfall one day after planting.

Two replicated variety trials were seeded in the fall of 1986. The first was planted August 21 at Pilot Rock (Table 1) using an IH 10-inch spacing shovel drill. The field received 37 lb/acre N as anhydrous ammonia in June. Seed was placed 2 inches deep, just into moisture, but emergence was spotty on September 2nd. Plots were harvested with the grower's combine and the yields are shown in Table 3. There were differences in seed zone water content within the experiment, so one replication had substantially poorer emergence and yield than the others. Viking was the poorest performing variety. The second trial was seeded October 21 at a location east of Adams on land previously cropped in winter wheat. The site was prepared by discing the stubble twice. Soil water in the seed zone was suitable for germination and plants emerged well, but were small throughout the winter. Yields were lower than expected (Table 3). The lateness of this seeding may have contributed to the low yields. There was no statistical differences among varieties.

1987-1988 An experiment with three varieties, two seeding dates, and four seeding depths was established on fallow at a site near Cayuse (Table 1). Seeding dates were September 4 and September 16. Seeding depths were 1/2 inch (dusted in), 2 inches (on moist soil), 3 inches (1 inch into moist soil), and 4 inches (2 inches into moist soil). Seed zone water was good on September 4, but marginal on September 16. A John Deere HZ drill equipped with Garrison openers to place fertilizer below the seed was used to plant the plots. Soil cover over the seed was 1/2 inch on the shallow depth and about 1.5 inches on the others. Total rainfall for September and October was 0.04 inches. Emergence on the September 4 planting was poor and the September 16 planting was a failure. Some plants that emerged on the September 4 seeding died from heat stress. Maximum 1-inch soil temperatures exceeded 105°F for 9 consecutive days after the September 4 planting date. The hot, dry weather excessively lowered seed zone water content between September 4 and 16. Garrison openers disturb soil beneath the seed row, this may also induce seed zone water loss. Yield data for the September 4 seeding is shown in Table 4. The plots were not replicated, so data can not be statistically evaluated.

A similar experiment was conducted in South Cold Springs Canyon (Table 1). Seeding depths were 1 inch, 3.5 inches, and 6 inches. Seed zone water was marginal at 4 inches, but was adequate at 6 inches. There was no germination at the 1 and 3.5-inch depths, whereas germination occurred at the 6-inch depth. Hypocotyls (stem) of plants at the 6-inch depth extended to the soil surface but the plants never emerged. The hypocotyls had extended 4 to 5 inches, but the seedlings ran out of energy prior to emergence. We feel that this is the upper limit for canola hypocotyl extension and that the seed should not be planted this deep.

1988-1989 A variety and seeding date experiment was conducted near Cayuse (Table 1) on fallow in the fall of 1988. Total rainfall during the months of August, September, and October was 0.48 inches. Canola was seeded 3.5 inches deep (1 inch into marginal soil moisture) into a cloddy seedbed on September 10. Since germination and emergence was poor, the experiment was not continued.

1989-1990 Variety trials with a nitrogen fertility topdressing treatment were established in fallow at two sites in the fall of 1989 (Table 1). August rainfall was 1.19 inches at the Pendleton Research Center, with 0.85 inches falling between August 20-25. Five varieties were seeded 1-inch deep in a replicated trial on August 28 using a John Deere HZ 14-inch deep furrow drill with split packer wheels. Seed zone water content was excellent at 1/2 inch and deeper, consequently, emergence at both sites was excellent. Crop rows were observed 10 days after seeding. Anhydrous ammonia was applied at 60 lbs. nitrogen per acre into the fallow in June. Variety plots were split and half of each plot received an additional 30 pounds nitrogen per acre as top dressed NH_4NO_3 on March 6. Yield results for these two sites are presented in Table 5. There was no significant yield difference among varieties at either site. There was, however, a significant response to top dressing at both sites. Overall there was a 159 lb/acre yield response to the top dressed nitrogen. This amounts to a net profit of about $7.00 per acre, if the price of canola is $0.10/lb, nitrogen is $0.20/lb and application costs are $2.00/acre.

PRODUCTION RECOMMENDATIONS

We feel that growing dryland canola is feasible in eastern Oregon. Several factors must be evaluated when considering canola as a alternate or rotation crop. The optimum seeding window in eastern Oregon occurs between mid-August and mid-September depending on elevation and annual precipitation of your location. Later seeding dates have not consistently shown good results.

The most important production constraint that we have encountered is stand establishment. In most years, canola will need to be seeded into summer fallow, recropping canola after wheat is risky. Seed should be placed into moist soil with no more than 3 inches of cover. We have observed emergence through 4-5 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 fine-seeded crop, finding the seed to determine seeding depth can be difficult. Also, depth of seed placement within the row can be quite variable compared to larger-seeded crops. We are currently experimenting with methods to improve consistentcy of placement. Check seed placement carefully for consistent depth. Seeding rates of 6-10 lb/acre are recommended. Use the higher seeding rate for later seedings or rough seedbeds. All 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 topdressing of nitrogen. A healthy, well established stand of canola planted during the optimum seeding window will outcompete 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 as well.

Harvesting canola is slower and more difficult than small grains. Because canola is an indeterminent crop we have not collected data on plant height, but this may be a consideration for harvest. We have observed that the variety Cascade is shorter that most varieties. It may have an advantage for ease of combining. Seed shatter before harvest can be a problem. Canola is ready to harvest at 8-10 percent moisture and is typically ready before wheat. Once the seed reaches this water content, harvest cannot be delayed. Applying Spodnam can lower 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. We have also observed that canola has a favorable impact on wheat crops which 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 which can have a positive effect on wheat yield.

Table 1. Summary of canola experimental sites in Umatilla County, Oregon, 1986-1991.

Experiment Type	Location	Year	Soil Type	Annual Precipitation
				-- inches --
Demonstration Strip	Base of Cabbage Hill	1986-87	McKay silt loam	19
Variety trial	Pilot Rock	1986-87	Pilot Rock silt loam	14
Seeding Date Variety Trial	East of Adams	1986-87	Adams silt loam	17
Seeding Date Seeding Depth Variety Test Strips	Cayuse	1987-88	Gurdane silty clay loam	18
Seeding Date Variety Test Strips	South Cold Springs	1988-89	Hermiston silt loam	10
Seeding Date Variety Trial	Cayuse	1988-89	Gurdane silty clay loam	18
Variety Trial	Pendleton Airport	1989-90	Walla Walla silt loam	13
Variety Trial	Base of Cabbage Hill	1989-90	McKay silt loam	19

Table 2. Summary of Cascade winter canola demonstrations, Umatilla County, Oregon, 1986-87.

Experimental Variable	Strip 1	Strip 2	Strip 3	Strip 4	Strip 5
Seeding Date	Aug. 25	Sept. 18	Sept. 18	Sept. 18	Sept. 18
Seeding Depth[1] (in)	3	1/2	1	1	1
Seeding Rate (lb/acre)	10	10	10	10	10
Nitrogen (lb/acre)	65	65	65	65	65
Yield (lb/acre)	2874	2385	3633	1634	2195

[1] Rainfall of 1.5 and 1.0 inches were received on September 15 and 19, respectively

Table 3. Yields of winter canola varieties, Umatilla county, Oregon, 1986-87.

Location	Variety	Yield lb/acre
Pilot Rock		
	Cascade	1658
	Glacier	1433
	Lindora	1785
	Viking	1024
	LSD (5%)	614
East of Adams		
	Cascade	939
	Glacier	1475
	Lindora	1326
	Liradonna	1322
	Santana	1223
	Viking	1024
	LSD (5%)	NS

Table 4. Yields of winter canola varieties, Cayuse, Oregon, 1987-88.

Variety	Seeding Depth			
	1/2 inch	2 inches	3 inches	4 inches
	yield lb/acre			
Cascade	1298	2037	1491	1883
Glacier	458	992	955	1016
Liradonna	1446	1786	1491	1883

Table 5. Yields of winter canola varieties, Umatilla County, Oregon, 1989-90.

Location	Variety	Spring Nitrogen Application		
		Topdress	No-topdress	
		-- Yield lb/acre --		
Pendleton Airport				
	Arabella	2264	2237	
	Cascade	2236	2540	
	Ceres	2170	2073	
	Liradonna	2222	2063	
	Onyx	2405	1977	
				Location Mean 2219
Base of Cabbage Hill				
	Arabella	1728	1821	
	Cascade	1682	1278	
	Ceres	1899	1523	
	Liradonna	1826	1502	
	Onyx	1819	1651	
	Topdress Mean	2025	1866	
				Location mean 1673
LSD (5%)				
Location NS Topdress 130 Variety NS				

WHEN DO WE STORE WATER WITH FALLOW?

Robert E. Ramig and Leslie G. Ekin[1]

Fallow is an important water conservation practice in the semiarid portions of the northwestern United States. Yet soil management practices for a fallow-wheat (F-W) rotation are much debated as farmers seek to increase water conservation and storage efficiency while reducing costs. The main reasons for fallow are storage of water in the soil, weed control, and release of plant nutrients. Acreage controls of national farm programs and necessity for stable yields from year to year also result in the use of fallow. With the development and use of herbicides and commercial fertilizers, the foremost reason for fallow is conservation and storage of water. Water limits crop production in most dry-farmed regions. Drought contributes to approximately 70 percent of wheat crop failures in Oregon (Carlson, 1987).

The objectives of this research were to: 1) determine when water is stored or lost in a F-W rotation in two precipitation zones of the winter rainfall climate in the semiarid region of eastern Oregon and Washington, and 2) determine the effect of wheat stubble management and tillage for fallow on water conservation in these precipitation zones.

MATERIALS AND METHODS

The experiment was conducted on a Walla Walla silt loam near Moro and Pendleton, Oregon from 1978 through 1984. Soils were 7 feet or greater in depth to underlying basalt rock. Slope at each location varied between 3 and 5 percent. There were two adjacent sites in a F-W rotation at each location; one in fallow, one in winter wheat each year. Long term mean crop-year (September 1 - August 31) precipitation at Moro and Pendleton is 11.54 and 16.38 inches, respectively. Approximately 63 percent of the crop year precipitation at Moro occurs from November through March; 56 percent at Pendleton. Daily maximum air temperature during July and August range from 90 to 110 °F at Moro and 84 to 115°F at Pendleton. Class A pan evaporation for April through October is 50.6 inches at Moro; 54.1 inches at Pendleton.

Six treatments were established on wheat stubble land: 1) stubble left standing over winter, plowed in the spring (conventional tillage), 2) fall flail stubble with a rotary flail, 3) fall burn stubble (simulate harvest or post harvest fires), 4) fall disk stubble 2 to 4 inches deep, 5) fall chisel 14 to 16 inches deep with chisels spaced 24 inches, and 6) stubble left standing overwinter, swept in the spring (conservation tillage). Each treatment was replicated three times in a randomized complete block arrangement. Plot size was 150 by 300 feet. Fall treatments were performed in early September. All treatments were sprayed with Roundup® in late February to kill weeds and volunteer wheat. Treatment 1 was moldboard plowed 6 to 7 inches deep in early March at Moro and early April at Pendleton. The remaining treatments were subsurface tilled at a depth of 4 to 5 inches the same day using 14-inch sweeps. Conventional rodweeding 3 to 4 inches deep was used as necessary during the summer to control

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weeds on all treatments and maintain a surface soil mulch. One or 2 rodweedings were required at Moro; 2 or 3 at Pendleton. Winter wheat was seeded in late September or early October using a deep furrow drill with 12-inch row spacing.

Soil water contents were measured periodically with a neutron moisture meter at 1-foot increments to a depth of 7 feet. Measurements were made at approximately monthly intervals during the winter recharge season and at biweekly intervals after February 1 in the seeded crop. Precipitation was measured at each location with a standard National Weather Service rain gauge. Maximum rainfall intensity was 0.2 inch/hr (Brown et al., 1983) and infiltration complete when soils are not frozen. Data were analyzed using analyses of variance and treatment means separated using the protected least significant difference. Treatments were considered significantly different if the probability level was 0.05 or lower.

Soils at both locations after harvest were dry to the permanent wilting point to a depth of 6 feet. Little available water remained in the 7th foot. Water gains or losses in the 7-foot soil profiles were expressed as percentage of the precipitation that occurred during the sub-intervals and the 18-month water storage interval. This procedure gave a clearer presentation of water conservation or loss by sub-intervals and minimized annual variations of water conservation or loss caused by annual differences in quantity and distribution of precipitation and other climatic factors.

RESULTS AND DISCUSSION

Percentage cumulative precipitation and mean water storage for the six treatments for the first 18 months of the F-W cycle are presented in Figure 1 for the Moro location. The 18-month interval readily separated into three water storage or loss sub-intervals: fallow winter (W1), fallow summer (S1), and crop winter (W2). Water was stored during fallow winter and crop winter, but not during fallow summer.

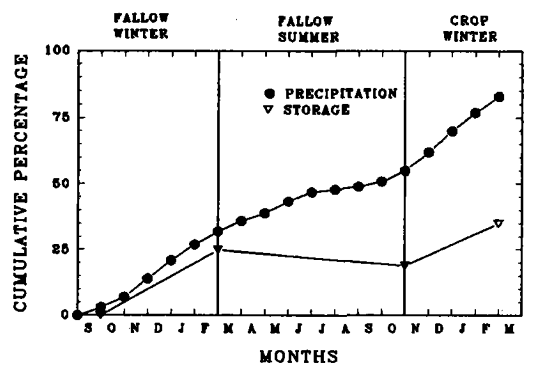

Figure 1. Mean cumulative precipitation and soil water storage during 18-month water storage period in a fallow-wheat sequence at Moro, OR 1980-1984.

Water recharge of the soil profiles began when rains greater than 0.30 inch occurred after wheat harvest and recharge continued for 6 months through the fallow winter until approximately March 1 at Moro, and for 7 months until April 1 at Pendleton. Water storage efficiencies during fallow winter at the two locations are evident from the treatment means in Tables 1 and 2, and from Figure 1. Significantly less water was stored at both locations where the stubble had been burned. Mean water storage for all treatments at Moro was 75 percent and at Pendleton 65 percent of fallow winter precipitation. The average for the two locations was 70 percent.

No water was stored during fallow summer (8 months at Moro; 7 months at

Table 1. Range and mean percentage precipitation stored in six fallow tillage treatments during the 6-month (Sept 1 - Feb 28) fallow winter (W1) at Moro, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Initial Fallow Tillage[1]	Range	Mean
1. Spring plow	68-86	78
2. Fall Flail	73-85	77
3. Fall burn	44-84	65
4. Fall disk	66-89	79
5. Fall chisel	71-82	74
6. Spring sweep	67-90	79
LSD, .05	----	8
Precipitation, inches	4.62-12.19	9.48

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same trt. 1 was plowed.

Table 2. Range and mean percentage precipitation stored in six fallow tillage treatments during the 7-month (Sept 1 - March 31) fallow winter (W1) at Pendleton, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Fallow Tillage[1]	Range	Mean
1. Spring plow	64-79	69
2. Fall flail	58-83	65
3. Fall burn	50-78	58
4. Fall disk	57-81	65
5. Fall chisel	53-78	63
6. Spring sweep	60-77	68
LSD, .05	----	6
Precipitation, inches	8.85-16.07	12.23

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same day trt. 1 was plowed.

Pendleton) even though rainfall ranged from 5.35 to 10.12 inches. Scanty rains of less than 0.30 inch, high air temperatures (90-110°F), and low relative humidity (10-60 percent) contributed to evaporation of all precipitation plus previously stored water from the upper 8 inches of the soil profile. The mulch of fine soil where the stubble had been burned the previous fall significantly reduced the water loss by evaporation from the soil at the low rainfall location at Moro (Table 3). There were no significant differences among treatments during fallow summer at Pendleton (losses ranged from -16 to 28 percent of precipitation and are not presented). Water losses by runoff, deep percolation, and transpiration by weed growth were negligible at both locations.

Water storage occurred again during the 4-month crop winter sub-interval (Fig. 1 and Table 4). Differences in water storage among treatments at Moro and ranged from 51 to 59 percent of crop winter precipitation. At Pendleton differences among treatments were not significant, ranged from 38 to 42 percent of the precipitation, and the data are not presented. Crop winter was from mid-October, after the wheat crop had been seeded, to early March when evapotranspiration precluded additional water storage at both locations.

Water conservation and storage during crop winter was less efficient than during fallow winter. Fallow tillage had flattened and buried some of the crop residues, exposing the soil surface to drying winds and deep soil freezing (Pikul et al., 1986). Tillage also destroyed macroporosity at the soil surface thereby reducing the infiltration rate.

Table 3. Range and mean percentage precipitation stored in six fallow tillage treatments during the 8-month (March 1 - Oct 31) fallow summer (S1) at Moro, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Fallow Tillage[1]	Range	Mean
1. Spring Plow	-49 to -4[2]	-23[2]
2. Fall flail	-67 to 4	-20
3. Fall burn	-14 to 4	- 6
4. Fall disk	-46 to -1	-24
5. Fall disk	-46 to 13	-17
6. Spring sweep	-42 to 2	-22
LSD, .05	----	10
Precipitation, inches	5.35-8.04	7.07

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same day trt. 1 was plowed.

[2] Negative values mean none of the precipitation for the period was stored and the equivalent of the negative percentage of the precipitation evaporated from the soil profile.

Table 4. Range and mean percentage precipitation stored in six fallow tillage treatments during the 4-month (Nov 1 - Feb 28) crop winter (W2) at Moro, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Fallow Tillage[1]	Range	Mean
1. Spring plow	37-76	56
2. Fall flail	34-81	55
3. Fall burn	23-83	54
4. Fall disk	16-80	51
5. Fall chisel	42-71	59
6. Spring sweep	17-69	51
LSD, .05		NS
Precipitation, inches	4.67-8.16	6.53

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same day trt. 1 was plowed.

Table 5. Range and mean percentage precipitation stored in six fallow tillage treatments during the 18-month (Sept 1 - Feb 28) fallow plus crop winter at Moro, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Fallow Tillage[1]	Range	Mean
1. Spring plow	38-47	41
2. Fall flail	32-46	41
3. Fall burn	30-49	39
4. Fall disk	25-48	38
5. Fall chisel	39-47	43
6. Spring sweep	36-44	41
LSD, .05		NS
Precipitation, inches	20.32-24.56	23.08

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same day trt. 1 was plowed.

Table 6. Range and mean percentage precipitation stored in six fallow tillage treatments during the 18-month (Sept 1 - Feb 28) fallow plus crop winter at Pendleton, OR. Figures are average of 15 (5 years x 3 replications) measurements.

Fallow Tillage[1]	Range	Mean
1. Spring plow	27-43	35
2. Fall flail	24-42	32
3. Fall burn	23-41	31
4. Fall disk	25-44	33
5. Fall chisel	23-44	34
6. Spring sweep	25-43	34
LSD, .05	----	2
Precipitation, inches	23.96-35.58	28.42

[1] Fall operations in late August. All treatments sprayed with Round-up® in late February. Spring tillage in early March. Treatments 2 through 6 were swept same day trt. 1 was plowed.

Water storage for the three sub-intervals (fallow winter, fallow summer, and crop winter) were added up and expressed as percentage of the precipitation for the 18-month water storage interval (Tables 5 and 6). Mean water conservation among treatments for the 18-month interval ranged from 38 to 43 percent of precipitation at Moro (Table 6) but differences due to treatment were not statistically significant at P = .05 Mean water conservation among treatments for the 18-month interval ranged from 31 to 35 percent of precipitation at Pendleton (Table 6). Water conservation and storage as a percentage of precipitation was greater at Moro (low rainfall) than at Pendleton (high rainfall). However, differences in storage among treatments at Moro were significant in three of five intervals, but not as a mean of five intervals.

SUMMARY

The 18-month water conservation and storage interval in F-W rotations in two winter rainfall zones at Moro and Pendleton, OR divided into three sub-intervals: 6 or 7-month fallow winter, 8 or 7-month fallow summer, and a 4-month crop winter. Respective percentage storage of precipitation in these three sub-intervals averaged 75, -19, and 54 percent. Total water storage for the 18-month interval averaged 37 percent of precipitation.

Significantly less water was stored during the fallow winter in both rainfall zones where the wheat stubble had been burned in the fall. Differences in water conservation and storage among the other five treatments were not significant at both locations. At Pendleton, respective percentage storage of precipitation for the three sub-intervals were 65, -20, and 41 percent. Total water storage for the 18-month interval averaged 33 percent of precipitation.

All fallow summer precipitation plus previously stored soil water equivalent to 19 percent of the fallow summer precipitation was lost by evaporation when averaged over six tillage and stubble management systems for five F-W cycles. Significantly less water was lost during fallow summer at the low rainfall site where the stubble had been burned in the fall when compared to the other tillage systems.

The best opportunity to improve water conservation and storage in this winter rainfall climate appears to be during the crop winter when only 54 and 41 percent of the precipitation was stored at Moro and Pendleton. Dr. Dale Wilkins and staff are studying the effect of contour chiseling after seeding and light soil frost as a means to increase water conservation during the crop winter.

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PRECIPITATION SUMMARY - PENDLETON

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

Crop Yr	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
61 Year Average	.75	1.33	1.96	2.10	1.92	1.52	1.72	1.51	1.41	1.23	.34	.48	16.28
1970-71	1.02	1.40	2.22	1.02	1.44	.77	1.28	1.65	1.66	3.14	.63	.33	16.56
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						
20 Year Average	.94	1.20	2.31	2.14	1.82	1.58	1.94	1.63	1.50	1.01	.40	.81	17.29

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
81 Year Average	.61	.90	1.70	1.67	1.63	1.15	.98	.76	.83	.69	.21	.29	11.44
1970-71	.13	.68	2.36	1.21	1.63	.12	1.28	.84	.93	.81	.20	.09	10.28
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						
20 Year Average	.59	.70	1.67	1.67	1.52	1.02	1.15	.80	.83	.62	.31	.49	11.36

CUMULATIVE
GROWING DEGREE DAYS
(Base = 0°C)