1996 COLUMBIA BASIN AGRICULTURAL RESEARCH ANNUAL REPORT

Special Report 961
Agricultural Experiment Station • Oregon State University
in cooperation with Agricultural Research Service • USDA

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Oregon State University

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Columbia Plateau Conservation Research Center
USDA-Agricultural Research Service

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INTRODUCTION

Staffs of the Columbia Basin Agricultural Research Center (CBARC-Oregon State University, 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. Changes in staffing, programming, and facilities at these centers during the past year are summarized below.

PROMOTIONS AND AWARDS

Two OSU staff received awards from the College of Agricultural Sciences. Richard Smiley received the Briskey Award for Faculty Excellence, and Bob Correa received the Classified Employee of the Year Award. Don Wysocki received a merit award from the National Association of Wheat Growers for his leadership in publishing a manual, *Best Management Practices for Wheat* and he was also recognized as a Berg Fellow by the Soil and Water Conservation Society. Dan Ball was elected President of the Oregon Society of Weed Science.

Within the USDA staff, Roger Goller, and Katherine Skirvin received promotions. Certificates of Merit with cash awards were given to Dale Wilkins, Phil Dailey, and Betty Klepper. Dr. Betty Klepper was elected President-Elect of Crop Science Society of America and will become President in November, 1996.

STAFF CHANGES

Kathy Ward resigned as faculty research assistant in the OSU soil science research program, and Pamela Zwer and Teresa Walenta left the OSU wheat breeding program.

John Williams, hydrologist, joined the ARS staff, first as a post-doctoral research associate and, later in the year, as a permanent addition to the scientific staff. Amy Baker, R. T. Erskine, and Mark Schaefer were employed in temporary positions during the year. Pendleton participated in three special summer employment programs funded by the ARS Area Office. These included a College Summer Internship filled by Jill Huntsman, a Teacher Fellowship filled by Paul Merana, and a Research Apprenticeship filled by Melissa Hedman. Other temporary employees during summer and school vacations included Erin Bailey, Collette Coiner, Matt Harsch, Jennifer Kirby, Holli Krumbein, Kimberly Miller, Samantha Morrow, Jodi Neil, and Robin Straughan.

NEW PROJECTS

For the OSU staff, Dan Ball was the recipient of an Oregon Department of Agriculture Grant on management of downy brome for optimum rotation opportunities.

For the ARS staff, Steve Albrecht, Clyde Douglas, and Paul Rasmussen started a new soil quality project to evaluate the contribution of organic matter to soil quality and to quantify the organic matter in various soil fractions. This project is in collaboration with the Rothamsted Experiment Station, England and is supported in part by a grant from the USDA, Foreign Agricultural Service, International Cooperation and Development, Research and Scientific Exchanges Division. John Williams and Dale Wilkins, working with Don McCool of Pullman, designed, constructed and tested a new rainfall simulator for use under wintertime frozen-soil erosion conditions on Pacific Northwest slopes. Dale Wilkins developed a special project to train Mr. Hebing Liu, Gansu Agricultural Academy of Science, Landzhou, People's Republic of China, in the use of erosion prediction equations used in the United States for research purposes.

FACILITIES

Electronic communications moved solidly forward with the connection of all OSU and ARS offices to the OSU computer network and worldwide web. The OSU office was also renovated to complement efficiencies realized by the new communication system. An experimental plot swather was the only OSU equipment purchased during the year.

The USDA office building upgrades included repair and sealing of the parking lot, improvements to the microbiology lab including a new walk-in cooler, an equipment storage room, and heating and cooling repairs and renovations.

TRAINING

Oregon State University staff continued to maintain requirements for pesticide application licenses, first aid, and cardio-pulmonary resuscitation and worker protection programs. Gloria Eidam received additional training in OSU's on-line electronic financial information system.

On the USDA staff, all pesticide applicators completed training to maintain licensing; all staff received updates on CPR and first aid where needed; and safety officers received specialized training on "Agricultural Health and Safety." Steve Albrecht, Ron Rickman, and Sue Waldman took a Blue Mountain Community College (BMCC) course in the object-oriented computer language C++. Training in administrative rules and regulations on travel was taken by Jacque Grandbois and Sharron Wart, and training on management of Imprest Funds was taken by Jacque Grandbois. Betty Klepper participated in a one-day session on organizing files and records. Jacque Grandbois took courses called "The Internet" (at BMCC), "The Indispensable Assistant" (along with Daryl Haasch), and "Confidence, Composure, and Competence" (along with Sharron Wart). Dale Wilkins took a course called, "Handling Negativity." John Williams attended the ARS New Scientist workshop at the Pacific West Area Office, and a short course on Management Problems of the Technical Person in a Leadership Role.

VISITORS

Distinguished visitors hosted by staff at the center included Phyllis Johnson, Associate Area Director, and Brad Baugh, Area Health and Safety Officer, ARS Pacific West Area; John Laflen, Director, USDA-ARS National Soil Erosion Laboratory, West Lafayette, Indiana; Hebing Liu, Gansu Agricultural Academy of Science, People's Republic of China; Bruce Andrews, Director, Oregon Dept. of Agriculture; Thayne Dutson, Mike Burke, Kelvin Koong, and Bruce Sorte, OSU College of Agricultural Sciences; Sheldon Ladd and Stella Coakley, Chairs of OSU Departments of Crop and

Soil Sciences, and Botany and Plant Pathology.

SEMINARS

The seminar series at the center was coordinated by Don Wysocki. Seminars included the following speakers: John Tanaka, Executive Director, Blue Mountain Natural Resources Institute, La Grande, OR; Chi-Hua Huang, Soil Scientist, USDA-ARS, National Soil Erosion Laboratory, West Lafayette, IN; Don Horneck, Manager, Agri-Check Soil Testing Laboratory, Umatilla, OR; Jeff Lee, Research Environmental Scientist, United States Environmental Protection Agency, Corvallis, OR; John Laflen, Director, USDA-ARS, National Soil Erosion Laboratory, West Lafayette, IN; and Luise Langheinrich, Coordinator Umatilla Basin Watershed Council, Pendleton, OR.

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 of the Director of the Oregon Agricultural Experiment Station and also, at Pendleton, by the Area 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 chairs 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 Gary Burt (Walla Walla: 509-529-6787), met on May 3, 1995 and February 2, 1996. The Sherman Station Liaison Committee, led by Chairman Ernie Moore (Moro: 541-565-3202), met on December 19, 1995, June 14, 1995, and March 23, 1996. Both committees participated in a review of research and research needs, hosted by the Oregon Wheat Commission on February 26, 1996.

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 1995-96. The Oregon Wheat Commission continued to provide the critical support upon which the center's OSU projects are founded. Thanks are also given to those who donated equipment (Jeff Shaw, Ted Gilliland), funds, seed, soil, and/or chemicals (American Cyanamid, BASF Corporation, Bayer Corporation, CIBA Crop Protection, E.I. duPont, FMC, Hungnong Seed America, InterMountain Canola, Lewiston Grain Growers, Mid Columbia Producers, Miller Chemical & Fertilizer, Monsanto, Pendleton Grain Growers, Rhone Poulenc, Russell Karow, Sandoz Agro, SeedTec International, Frank Tubbs, Wilbur-Ellis Co.,) or loaned equipment or facilities (USDA-ARS Pullman, OSU Dept. of Crop and Soil Sciences, and Hermiston Agricultural Research and Extension Center). Collaborators from the Natural Resources Conservation Service (NRCS) included Harry Riehle (WA), Ralph Fisher (ID), Tom Gohlke (OR), Bob Adelman (Pendleton), Kate Danks (Pendleton), Steve

Jaeger (Pendleton), Jay Gibbs (Condon), and Dusty Eddy (The Dalles).

We also acknowledge those who donated labor, supplies, equipment, or funding for the Pendleton Field Day: American Cyanamid, BASF Corporation, Bayer Corporation, CIBA Crop Protection, DowElanco, E.I. duPont, Farm Credit Services, Farm Equipment Headquarters, First Interstate Bank, FMC Corporation, Gustafson, Huntington-Price, Inland Chemical Service, Inland Empire Bank, InterMountain Canola, McGregor, Main Street Cowboys, Monsanto, Pendleton Bus Company, Pendleton Flour Mills, Pendleton Grain Growers, Pioneer Implement Corp., Sandoz Agro, Les Schwab Tire Center, SeedTec International, Smith Frozen Foods, Steele's Bar and Grill, Tri-River Chemical, Umatilla County Wheat Growers League, U.S. Bank, Walla Walla Farmer's Co-op, Western Farm Service, Western States Equipment, Wheatland Insurance, and Wilbur-Ellis.

We also thank donors who provided buses, meals, and other services for the Moro Field Day: Cargill, Cascade Ranchers, First Interstate Bank, Gustafson, Lean To Catering, Mid-Columbia Bus, Mid-Columbia Producers, Monsanto, Morrow County Grain Growers (Lexington and Wasco), M & S Farm & Home Supply, Northwest Chemical, Richelderfer Air Service, Sherman Aviation, Sherman County School District, Sherman Farm Chemicals, The Halton Company, Western Tillage Equipment, Wheatacres Irrigation, and Wilbur-Ellis.

Cooperative research plots at the center were operated by Warren Kronstad, Patrick Hayes, Chris Mundt, Russ Karow,and Jack Brown. Additionally, we are very and Tom Darnell), Union/Baker/Wallowa Counties (Gordon Cook) and Sherman /Wasco Counties (Sandy MacNab) in Oregon, and from Columbia County thankful for the ever-present assistance from the Extension Service personnel in all counties of the region, and especially from Umatilla County (Mike Stoltz, Phil Hamm and Tom Darnell), Union/Baker/Wallowa Counties (Gordon Cook) and Sherman/Wasco Counties (Sandy MacNab) in Oregon, and from Columbia County (Roland Schirman), Adams/Lincoln Counties (Bill Schillinger), and Walla Walla County (Walt Gary) in Washington.

We also wish to thank over 200 farmers who have allowed us to work on their property during the past year, and who have assisted by performing field operations, loaning equipment, donating chemicals, and adjusting their practices to accommodate our plots. The locations of the principal outlying sites are shown on the map that follows.

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

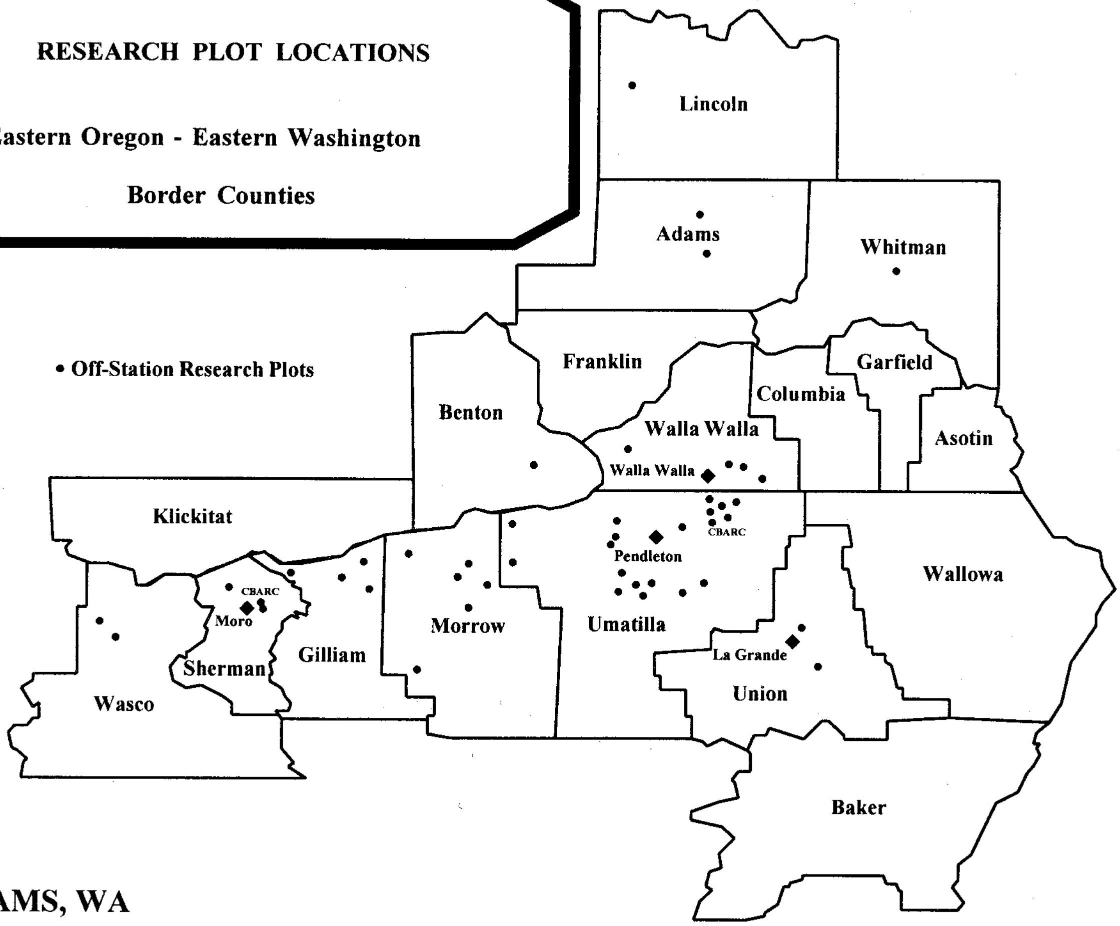
Richard Smiley
Superintendent
OSU-CBARC

Betty Klepper
Research Leader
USDA-ARS-CPCRC

RESEARCH PLOT LOCATIONS

Eastern Oregon - Eastern Washington

Border Counties



ADAMS, WA
Harold Clinesmith
Curtis Hennings

BENTON, WA
Greg Smith

GILLIAM, OR
Steve Anderson
Tim Holtz
Jim Rucker
Harold Walsh

LINCOLN, WA
Bob Zimmerman
Don Zimmerman

MORROW, OR
Eric Anderson
Charlie Anderson
Bill Jepson
Frank Mader
Harold Rietman
Chris Raush

UMATILLA, OR
Dave Casper
Berk Davis
Pat Davis
Jim Duff
Ted Gilliland
Bob Hale
Maurice Johns
Robert Johns
Mac Levy
Larry Lorenzen
Dennis Rea
Tremayne Rea
Clint Reeder
Paul Reeder
Leon Reese
Sherman Reese
Jeff Shaw
Jerry Simpson
Hermiston Exp. Station
Pendleton Exp. Station
Mack Temple
Jim Whittaker

SHERMAN, OR
Chris Kaseberg
Bruce Pinkerton
Dave Pinkerton
Sherman County Exp. Station

UNION, OR
Pat Brogoitti
John Cuthbert

WALLA WALLA, WA
Bob Buchanan
Don Meiners
Jay Nowogroski
Bart Owsley

WASCO, OR
David Brewer
Jack Hay

WHITMAN, WA
USDA-ARS Palouse Conservation Farm

RESEARCH CENTER PUBLICATIONS

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NEW VARIETIES ON THE HORIZON

Mary Verhoeven, Mike Moore, and Warren Kronstad

The goal of the wheat breeding program at OSU/CBARC is to provide the Oregon producer with the highest yielding, most disease and stress resistant cultivars possible in a variety of market classes. To do this a variety of testing sites are utilized: Corvallis, Moro, Pendleton-CBARC, Pendleton-Rugg, Ontario, Klamath Falls, Medford, La Grande, and Hermiston. These sites are analogous to laboratories with different areas of specialization. Corvallis is an excellent laboratory for cool, moisture-loving fungal diseases like *Septoria tritici, Septoria nodorum*, powdery mildew, and stripe rust; in Ontario cultivars can be tested for genetic yield potential; at Moro drought tolerance, shattering, and emergence can be assessed; at both the Pendleton sites bunt and RWA screening, as well as yield potential, are being tested. The Rugg's site has a higher rainfall pattern and pre-irrigation is available to insure a good stand going into the winter. Each location/lab provides information on a different part of the puzzle in piecing together a new variety. One puzzle piece that is often missing, the laboratory results that aren't always reliable, is that of a winter hardiness location. This year a winter hardiness nursery was seeded near Helix, and a good differential response to cold temperatures has been observed at this site.

Varieties being developed by the wheat breeding program involving winter types include: soft white, club, hard white, and durum, and for spring cultivars: hard white, soft white, and hard red wheats. They are listed in approximate order of effort in the breeding program.

SOFT WHITE WINTER

Three lines that have emerged from the pack for yield, quality, or both are: OR870012, OR870831, and OR880525. OR870012 is a fairly tall, late line. In five years of testing it has outperformed Stephens at Pendleton and Corvallis (Table 1). The quality is similar to Stephens. It has better resistance to leaf and stripe rust and *Septoria tritici* than Stephens (Table 2). OR870831 is an early, short, disease resistant line with good yield potential. It has outyielded Stephens at both Pendleton and Corvallis and equaled Madsen at both locations. Quality has been variable. Flour yield is less than Stephens, but in some instances cookie diameter and sponge cake volume have been superior. OR880525 is between Madsen and Stephens in height, with maturity similar to Madsen. In four years of testing it has been better in yield than Stephens at Corvallis and equaled its yield at Pendleton (Table 3). Its major attribute is its superior milling properties and test weight.

Table 1. Yield (bu/acre) of Soft White Winter Wheats Compared with Stephens and Madsen 1991-95.

Cultivar	Yrs. Tested	Pendleton	Corvallis	Moro
Stephens	5	108.6	90.1	82.9
Madsen	5	120.2	114.8	77.5
OR870012	5	114.8	124.0	76.6
OR870831	5	117.4	115.7	79.8

CLUB WHEAT

The Club Wheat Breeding portion of the project is discussed in a separate section of this report.

Table 2. Agronomic Data on Selected Soft White Winter Wheat Cultivars 1991-95. Disease and winterhardiness data reported is worst case over all locations.

Cultivar	Heading Julian date	Height inches	Leaf Rust	Stripe Rust	Septoria* Tritici	Winter-hardiness**
Stephens	135	43.0	60S	40MR	90	1.9
Madsen	141	46.5	--	--	60	2.5
OR870012	140	48.0	20MS	10MR	70	3.5
OR870831	129	42.5	--	1R	70	2.8
OR880525	141	45.0	60S	20MR	83	2.1

* Septoria tritici scale: 0-99% of leaf area covered

** Winterhardiness scale: 1-5, with 1 as full stand, no damage, and 5 as dead

Table 3. Yield (bu/acre) of OR880525 Compared with Stephens and Madsen 1992-95.

Cultivar	Yrs. Tested	Pendleton	Corvallis	Moro
OR880525	4	98.3	106.0	83.4
Stephens	4	99.8	82.6	86.6
Madsen	4	115.5	112.9	79.7

HARD WHITE WINTER WHEAT

The Asian noodle market, the target area for the hard whites, is like the proverbial elephant and the blind men. It is vast and varied, and every place you touch it, it seems like a different creature. The overriding quality characteristics needed for Asian noodles are intermediate protein levels, good starch quality, and color stability. If these three characteristics can be put into a good agronomic package, many types of Asian noodles can be made, from trunk to tail.

Two advanced hard white winter lines that look promising are OR850513 and OR889176. OR850513, after many years of yield testing, has equaled Stephens at Pendleton and outperformed both Stephens and Madsen at Corvallis (Tables 4 & 5). It is earlier and shorter than either cultivar (Table 6). It is better on *Septoria*, leaf rust, and stripe rust than Stephens. Though a hard white wheat, it often has an intermediate hardness score that could be a classification problem. It is not a good bread wheat, but it has good color stability, intermediate protein levels, and in three years of regional testing it had the highest

Table 4. Yield (bu/acre) of Hard White Winter Wheat Compared with Stephens 1990-95.

Cultivar	Yrs. Tested	Pendleton	Corvallis	Moro
Stephens	6	101.8	95.9	81.5
OR850513	6	100.5	116.8	77.7

Table 5. Yield (bu/acre) of Hard White Winter Wheat Compared with Stephens and Madsen 1991-95.

Cultivar	Yrs. Tested	Pendleton	Corvallis	Moro
Stephens	4	96.0	86.9	82.3
Madsen	4	107.2	113.1	72.5
OR850513	4	96.8	115.6	80.4
OR889176	4	107.4	107.2	75.1

Table 6. Agronomic Data Comparing Stephens and OR850513 from Three Years of Western Regional Data 1992-94.

Cultivar	Station[1] Years	Heading	Height (in.)
Stephens	18	153	33.8
OR850513	18	150	32.8

[1] 6 locations X 3 years = 18 station years.

RVA score of the hard whites every year. RVA score is a measure of starch quality. Though the RVA is high, there is a question as to whether it is high enough to satisfy the noodle market. OR889176, in four years of testing, has outperformed Stephens at both Pendleton and Corvallis, and has equaled the yield of Madsen at Pendleton (Table 5). This line is shorter and earlier than Stephens and Madsen and is awnletted. Its major drawback could be winterhardiness, as it is the progeny of a spring x winter single cross (Table 7). It has been evaluated for quality for eight years. It is a good milling line, but its RVA score has not been the most promising. It also has some problems with color stability. On the plus side it has made excellent pancakes, and in that niche shows promise in the domestic market.

Table 7. Agronomic Data Comparing Stephens and OR889176 from 1994 Western Regional Nurseries.

Cultivar	Heading	Height (in.)	Winter Hardiness
Stephens	156.4	32.5	6.5
OR889176	154.0	31.2	6.0

WINTER DURUM

There are three winter durums on seed increase this year: OR3920036-A, OR3920036-B, and OR936723. These lines have been bred for the Pendleton area. The yields of these three lines are 100, 91, and 87 percent of Stephens over a two-year period. All of these lines have acceptable quality characteristics for the local market -- good gluten strength and good yellow color. Winterhardiness could be a problem. Most of the durum lines have been crossed with spring types to get the quality characteristics necessary for the market. This confounds an already tender crop. Another problem encountered is yellow berry. This 'softens' the kernel, making it unacceptable. There is an ongoing agronomic study to determine what fertility level is necessary to alleviate this grain quality problem.

SPRING WHEAT

The spring wheat aspect of the program works on hard red, hard white, soft white and durums. The majority of the germplasm comes from our international connection with the International Wheat and Maize Improvement Center (CIMMYT). Early generation material is available to us for selection under growing conditions in Oregon. We also obtain the CIMMYT international nurseries, which include primarily F5 lines. From this vast pool of genetic material, one hard white wheat line has been selected for pre-release. OR4895181 has a very good yield record. Over six years it has outyielded Klasic by five bushels/acre at Pendleton. At Klamath Falls in four years of testing it has outperformed Klasic by 11 bushels. (Table 8) It is in its third year of regional testing. In 1994, the only year from which summarized regional nursery data are available, it was the top yielding hard white spring line in the nursery (11 locations) and was among the top five lines overall.

Table 8. Spring Hard White Cultivars Yield in Bushels/Acre.

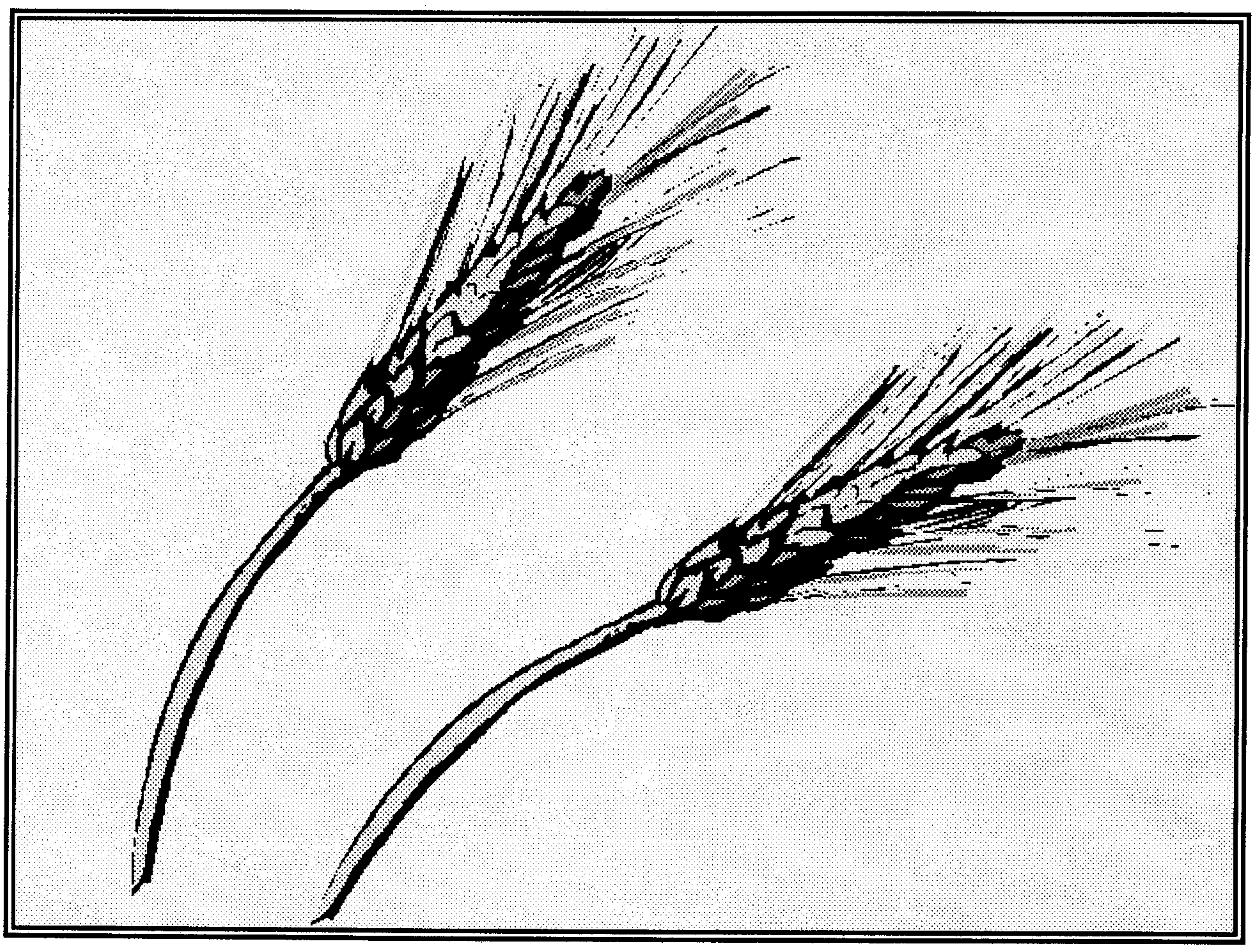
Location	# of Years	Klasic	4895181
Pendleton	6 (90-95)	80.3	85.8
Klamath Falls	4 (92-95)	72.4	83.2

Agronomically, OR895181 has a heading date equal to the soft white spring wheat Penawawa and it is five days later than Klasic. In height it is equal to Penawawa and is, on the average, 7 inches taller than Klasic. Its maturity is also similar to Penawawa. Table 9 presents data comparing OR895181 with the new Idaho hard white spring line, ID377s, and the new soft white spring from Washington, Alpowa.

OR895181 has been evaluated for quality for six years. During this time it has had good RVA scores (over 190 in four out of four years tested), but it has had some problems with low test weights and low milling scores. Its bread making capabilities appear to be adequate.

Table 9. Agronomic Data on Klasic, ID377s and OR4895181 taken from the Western Regional Spring Wheat Nurseries (WRSWN) in 1994.

Variety	Heading (Days from Jan. 1)	Height (inches)
Klasic	169.5	22.8
ID377s	172.4	30.0
OR4895181	174.1	29.8
Penewawa	174.6	30.0
Alpowa	174.8	32.7



STATE-WIDE CEREAL VARIETY TESTING PROGRAM TRIALS

Russ Karow, Helle Ruddenklau and Mike Moore

INTRODUCTION

This article reports results from cereal variety trials conducted across Oregon in 1995. Data specific to the Columbia Basin are included in tables and discussed in the text. These trials were conducted as part of a testing program initiated in 1992 to provide growers with local data on cereal variety performance. This program is coordinated by Russ Karow, OSU Extension cereals specialist, and Helle Ruddenklau, OSU Department of Crop and Soil Science research assistant. Seed is packaged in Corvallis and distributed to trial coordinators across the state. Coordinators plant, manage, and harvest trials, in some instances in cooperation with growers. Information on trial locations, coordinators, and grower cooperators is given in Table 1. Russ Karow's research team processes harvested grain, analyzes results, and provides summary data to extension agents, seed dealers, field men, and growers across the state and region.

Winter and spring barleys, triticales and wheats of several market classes were tested at the 12 sites in the testing network. Grain yield, test weight, protein, and lodging were determined for all varieties at all sites. Heading date, height, disease reactions, and other quality factors were determined as time, labor, and equipment allowed.

MATERIALS AND METHODS

Dryland plots (5 x 17 feet) at Heppner, Pendleton, and Moro were seeded at 20 seeds per square foot. Irrigated plots at LaGrande (5 x 17 feet), Hermiston (5 x 20 feet), and all other locations were seeded at 30 seeds per square foot. Seeding rates for dryland plots ranged from 46 to 112 pounds per acre, depending on variety, to attain the desired 20 seeds per square foot seeding rate. Irrigated plot seeding rates ranged from 69 to 168 pounds per acre. All trials were laid out as randomized complete block designs with three replications. Plots were seeded using small plot drills. Seeding, harvest, and production practices were typical for each location. Harvested grain was cleaned with a Pelz rub-bar cleaner. Plot yield, test weight, protein, and moisture were all determined on cleaned grain samples. Cleaned barley samples had few awns, hence test weights were atypically high, but variety to variety comparisons are valid. Yields are reported on a 10 percent moisture basis, and in 60 pound bushels for wheats and triticales, and in pounds per acre for barleys. Proteins are reported on a 12 percent moisture basis and were determined using a Tecator Infratec 1225 Whole Grain Analyzer purchased for OSU by the Oregon Wheat Commission.

In addition to small-plot variety tests, large-scale winter wheat drill strip trials have been conducted across the state the last three years. Cooperating growers were provided with 50 to 80 pounds of seed of each variety to be tested. Seed for 1995 trials was donated by Eric and Marnie Anderson, Pendleton Grain Growers, and Madsen Grain. Cooperators, often with assistance of local county agents, established single-replicate drill strip plots on their farms. These drill strips were managed and harvested by the cooperating grower with standard field equipment. Weigh wagons or weigh pads were used to obtain yield data. Two-quart grain samples were saved from some plots and used for test weight and protein analyses. Table 2 lists sites, grower cooperators, and background information about 1995 winter wheat drill strip test plots.

RESULTS AND DISCUSSION

Both winter and spring trials were planted at Hermiston, but an early July hail storm destroyed all trials. Winter grain data for other sites are presented in Tables 3-8. Data for spring grains are presented in Tables 9-15. Data from winter wheat drill strip plots are presented in Table 16. While over-site averages are provided for all data types, you will also find values labeled "percent of average" associated with most yield data. Percent of average data are generated by dividing a variety's yield by the trial average yield. A variety with a calculated value greater than one has performed better than average, while a variety with a value less than one is below average. Calculating yield performance in this manner allows easy variety comparison across diverse environments and over years. Multi-year, percent of average yield data are presented in Tables 5-6 for winter grains and 12-13 for spring grains.

Winter Wheats and Triticales. Over the three year period 1993-95 across eight environments, Stephens, Malcolm, and Gene exhibited the highest yield levels (Table 5). Note however that differences among varieties are not statistically different at the 5 or 10 percent probability level. The yield range for the 12 winter wheats and triticales shown in Table 5 is only 12 percent or roughly 11 bushels per acre. A similar trend is seen in the two-year averages shown in Table 6, and in the 1995 data shown in Table 4. There is a less than 10 percent yield spread among commonly grown and recently released varieties. Given that the yield potential of these varieties appears to be similar, variety selection can be based on other criteria such as disease resistance, lodging potential, plant maturity, etc.

Average test weight was near or above 60 pounds per bushel at all sites but Madras and Morrow (Table 7). All grain trials at Madras, winter and spring, were flatted by a thunderstorm at the soft dough stage and lodging was severe. Lodging led to shrunken grain and low test weights. Lodging was not observed at Morrow, but disease stress resulted in shrunken grain. As expected, the hard red winter wheat Hoff had highest test weights across sites while Parma and Whitman triticales shared low test weight honors. Celia triticale has had test weights nearly equivalent to wheat in years past, but had significantly lower test weights at some sites in 1995.

Protein levels were low at several sites (less than 9 percent; Table 8) indicating that plots may have been under-fertilized. Given higher-than-normal precipitation levels during the cropping season and resultant high yields, under-fertilization and low protein levels were not unexpected. Lodging resulted in high protein levels at Madras. The LaGrande site has consistently had high protein levels in all years of testing.

Drill strip test data are presented in Table 16. Six varieties were included in the 1995 standard set; Gene, MacVicar, Madsen, Rod, Rohde and Stephens. As in 1994, Rod had the highest yield averaged across sites and was also the highest yielding variety in 9 of the 16 tests. Rod has shown only average performance in the past two year's small-plot tests. Rohde club wheat has shown excellent yield potential across environments, even under high rainfall and irrigated conditions.

Winter Barleys. Winter barley data are given in the bottom sections of Tables 3-8. Of the released varieties, Kold stands out in both yield and agronomic performance. This is heartening as Kold is the only winter barley currently available in the Pacific Northwest that has resistance to barley stripe rust. Hundred has also yielded well over years (Tables 5-6), but test weights have been low (Table 7). Steptoe, Hesk, and Scio, traditionally grown winter barleys, show average performance.

Spring Wheats and Triticales. Spring grain data are presented in Tables 9-15. Alpowa (a new soft white wheat released by Washington State University), ID377S (the hard white released to the Idaho Wheat Commission by University of Idaho breeder Ed Sonza), and Treasure were the highest yielding varieties across sites in 1995 (Table 11), and over years (Table 13). Centennial has also shown consistent, above average performance, but growers have reported that this variety is hard to thresh and can have high dockage levels. Seed supplies for Alpowa are limited at this time but will expand over the next two years. ID377S is being grown under contract with the Idaho Wheat Commission. Four hundred acres of ID377S are slated to be grown in Oregon in 1996. Acreage may expand slowly in subsequent years if crop quality can be maintained and marketing efforts are successful. Treasure has not been grown extensively in Oregon, but trial data suggest that experimentation with this variety is warranted. Wawawai is a Wakanz replacement. Both have Hessian fly resistance. While Wawawai has exhibited erratic yields over sites, performance in the Pendleton area has been good. This variety should be considered for use where Hessian fly has been a problem in recent years.

Spring Barleys. Spring barley data are presented in the bottom sections of Tables 9-15. As has been the case for the past two years, Baronesse two row feed barley exhibited exceptional yield across environments and years (Tables 11-13). Test weights also continue to be a strength of Baronesse. Several lines tested in 1995 may be of future interest. BSR45 is a barley stripe rust resistant line that has been tentatively named "Icaro." Icaro was developed by Dr. Pat Hayes, OSU barley breeder, in cooperation with co-workers at ICARDA - the International Center for Agricultural Research in Dry Areas. Icaro has been approved for initial breeders seed increase. Agronomic performance was near average at four locations in 1995. If barley stripe rust becomes a serious problem in Oregon, Icaro may serve as a short-term solution. WPB-BZ4899-74 is a hulless, waxy barley developed bv Western Plant Breeders. It was included in trials simply to get a better idea of hulless barley performance across environments. Percent of average yield across the 10 test environments was 93 percent; better than expected.

CONCLUSIONS

Data for 1995 once again show that there are few statistical differences among winter or spring grain varieties. Whether tested in small or large plots, newer varieties show a similar yield potential. It appears that factors such as available moisture, disease, and insect stress are capping yields in each environment, not the genetic yield potential of varieties per se. Our data suggest that growers should carefully assess those environmental factors that limit yield in each of their fields and grow newer varieties with tolerance or resistance to those stresses. The yield potential is there; we need to allow for expression.

FOR MORE INFORMATION

Use more than one year's data to make variety selection decisions. For more information, contact your local OSU Extension Service office and ask for a copy of Special Report 755, "Winter Cereal Varieties for 1996," or Crop Science Report 105, "Spring Grain Varieties for 1996." These publications contain current year and historic variety performance data for wheats, barleys, triticales, oats, and even cereal rye. Your county agent may have other data as well.

The state-wide variety testing program is a grower-driven program. If you have ideas about varieties to be included in your area or have suggestions for program improvement, contact Russ Karow OSU Extension cereals specialist (503-737-5857).

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Table 1.—1995 state-wide cereal variety testing program locations, site coordinators and grower cooperators.

Trial name	Trial type	Trial location	Trial coordinator	Grower cooperator
Corvallis	all grains - dryland	Hyslop Farm	Russ Karow, Helle Ruddenklau	
Morrow Co. (Heppner)	all grains - dryland	Anderson Farm	Mike Moore	Charlie Anderson
Hermiston	all grains - irrigated	Hermiston Expt. Station	Mike Moore	
Klamath Falls	all grains - irrigated	Klamath Expt. Station	Randy Dovel	
LaGrande	all grains - irrigated	Cuthbert Farm	Mike Moore	John Cuthbert
Madras	all grains - irrigated	Central OR Expt. Station	Steve James, Mylen Bohle	
Medford	all grains - dryland	Southern OR Expt. Station	Rich Roseberg	
Moro	all grains - dryland	Sherman Expt. Station	Mike Moore	
North Valley (Cornelius)	winter grains - dryland	Goetze Farm	Russ Karow, Helle Ruddenklau	Norm Goetze
North Valley (Sheridan)	spring grains - dryland	Moritz Farm	Russ Karow, Helle Ruddenklau	Sandy & Mike Moritz
Ontario	all grains - irrigated	Malheur Expt. Station	Mike Barnum, Clint Shock	
Pendleton	all grains - dryland	Pendleton Expt. Station	Mike Moore	

Table 2.—Growers, locations, and cooperating county agents for 1995 winter wheat drill strip test plots in Oregon and Washington.

Grower	City	County	Irrigation	County Agent
Bob Johns	Athena	Umatilla	No	Mike Stoltz
Bob Barnes	Salem	Marion	No	Gale Gingrich
Bruce and Helle Ruddenklau	Amity	Yamhill	No	Susan Aldrich-Markham
Alan Klages	Joseph	Wallowa	Yes	Gordon Cook
Mark Hale	Pendleton	Umatilla	No	Mike Stoltz
Dennis Glaser	Tangent	Linn	No	Mark Mellbye
Bill Miller	Dufur	Wasco	No	Sandy Macnab
Bob Newston	Pendleton	Umatilla	No	Mike Stoltz
Dean Nichols	Dayton, WA	Columbia, WA	No	Roland Sherman
Sandy Macnab/Erling Jacobsen	Moro Expt. Station	Sherman	No	Sandy Macnab
John Rietmann	Ione	Morrow	No	Phil Nesse
Mike Weimer	Arlington	Gilliam	No	Phil Nesse
Russ Erickson	Condon	Gilliam	No	Phil Nesse
Gary Brown	Wasco	Sherman	No	Sandy Macnab
Olin Reser	Condon	Gilliam	No	Phil Nesse
Lyle Peck	Heppner	Morrow	No	Phil Nesse

Table 3.—1995 state-wide variety testing program winter grain Julian heading dates, heights and lodging across locations in Oregon.

Variety/ line	Market class	Corvallis	Madras	Ontario	Corvallis	Madras	Moro	Morrow	North Valley	Ontario	Pendleton	Madras	Ontario
		Julian heading date			Plant height (inches)							Lodging percent	Lodging score*
Winter wheats and triticales													
Cashup	SW	147	162		39	40	28	30	39		39	100	--
Celia	Triticale	144	158	144	43	44	33	35	41	37	42	63	--
Daws	SW	145	160	144	41	40	30	29	42	36	39	98	--
Gene	SW	132	155	142	37	33	25	28	33	33	33	100	--
Hill 81	SW	148	161	146	43	42	26	34	44	37	44	93	--
Hoff	HR	140	154	142	44	38	28	34	44	36	40	98	--
Hyak	Club	138	159		45	40	27	32	44		44	98	--
Kmor	SW	148	163		41	40	26	27	39		40	100	--
Lambert	SW	142	157		45	42	29	38	43		42	67	--
Lewjain	SW	150	165		39	40	26	29	39		37	100	--
Mac 1	SW	145	156	144	45	42	30	37	45	41		100	--
MacVicar	SW	144	158	143	41	39	30	32	38	37	39	65	--
Madsen	SW	144	162	146	42	39	30	34	39	33	40	77	--
Malcolm	SW	144	156	143	44	40	29	31	41	38	38	83	--
Parma	Triticale	147	163	144	45	47	35	44	49	42	48	100	--
Rely	Club	149	160		43	44	29	33	40		37	97	--
Rod	SW	147	162		40	42	29	30	39			100	--
Rohde	Club	145	160	146	43	41	25	31	45	34		99	--
Rulo	Club	149	162		42	43	26	34	42		41	98	--
Stephens	SW	142	156	142	41	39	28	34	40	35	40	99	--
W301	SW	143	154	144	43	39	29	33	37	37	41	100	--
Whitman	Triticale	129	151	139	53	52	39	47	54	44	52	100	--
Yamhill	SW	144	163		47	42	27	39	47			98	--
Trial average		143	159	144	42	41	21	34	41	36	41	93	--
PLSD (5%)		1	3	1	4	4	--	--	3	2	--	NS	--
PLSD (10%)		1	2	1	3	3	--	--	3	2	--	NS	--
CV		1	1	1	5	6	--	--	5	3	--	26	--
Winter barleys													
AB-812	6RF			137						35			3.3
Gwen	6RF	126	141		39	41	--	--	46		42	22	
Hesk	6RF	143	150	142	33	42	--	--	42	34	39	73	1.7
Hoody	6R hooded	141	152		39	46	--	--	50		39	72	
Hundred	6RF	141	150	142	34	38	--	--	40	36	42	43	4.7
Kamiak	6RF	124	141		42	39	--	--	52		52	77	
Kold	6RF	140	150	142	31	39	--	--	40	35	37	68	1.7
ORW6	6RF/M	130	146	137	34	39	--	--	42	33	39	72	3.7
ORW7	6RF/M	141	151	141	35	43	--	--	41	39	43	28	2.0
Scio	6RF	136	150		35	40	--	--	43		41	72	
Showin	6RF	137	150	140	31	31	--	--	30	29	32	73	5.0
Steptoe	6RF	135	150	138	42	45	--	--	52	35	46	88	4.3
SDM204	6RF		154			36	--	--				70	
SDM208	6RF		150	139		39	--	--		34		82	1.0
Trial average		136	149	140	36	40	--	--	44	34	41	65	3.2
PLSD (5%)		3	2	1	5	5	--	--	3	3	--	NS	2.1
PLSD (10%)		3	2	1	4	4	--	--	4	2	--	NS	1.7
CV		1	1	1	8	7	--	--	7	5	--	43	39

Grain did not lodge at other locations.

*Lodging score: 1=none, 2=1-20%, 3=21-40%, 4=41-60%, 5=61-80%, 6=>80%

Table 4.—1995 state-wide variety testing program winter grain yield data across nine locations in Oregon.

Variety/ line	Market class	Corvallis	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	8 site average*	8 site percent of average*
Winter wheats and triticales						Yield (bu/a; 60 lb bu; 10% moisture)						
Cashup	SW	84	92	100	113	42	45	107		101	85	1.02
Celia	Triticale	76	83	99	96	54	40	105	133	108	83	1.00
Daws	SW	75	102	114	112	56	46	118	140	81	88	1.06
Gene	SW	109	96	89	114	56	50	105	143	93	89	1.09
Hill 81	SW	74	91	113	101	49	41	115	135	87	84	1.00
Hoff	HR	65	91	118	120	51	47	97	137	61	81	0.97
Hyak	Club	71	80	73	117	52	36	119		82	79	0.94
Kmor	SW	85	76	84	105	53	38	108		80	79	0.95
Lambert	SW	69	90	107	124	53	47	99		82	84	1.01
Lewjain	SW	74	64	93	109	49	33	107		84	77	0.91
Mac 1	SW	88	87	100	131	55	41	105	149	51	82	0.98
MacVicar	SW	81	79	104	124	49	34	96	150	85	81	0.96
Madsen	SW	86	75	98	105	53	56	103	137	94	84	1.03
Malcolm	SW	90	105	113	129	57	53	117	150	80	93	1.12
Parma	Triticale	62	87	89	106	55	49	92	127	100	80	0.98
Rely	Club	56	85	93	123	56	41	84		74	76	0.92
Rod	SW	79	88	115	115	58	48	99		76	85	1.03
Rohde	Club	70	84	105	133	54	47	123	131	70	86	1.02
Rulo	Club	56	82	100	127	51	42	102		72	79	0.94
Stephens	SW	88	77	105	106	56	47	102	128	96	85	1.03
W301	SW	84	89	97	97	55	49	76	146	88	79	0.98
Whitman	Triticale	62	96	100	107	51	37	108	118	79	80	0.95
Yamhill	SW	79	68	74	90	53	44	113		63	73	0.89
Trial average		78	85	103	114	52	44	105	142	84	82	82
PLSD (5%)		13	NS	21	19	8	9	NS	19	15	NS	0.12
PLSD (10%)		11	17	18	16	6	7	NS	16	13	14	0.10
CV		11	15	13	12	8	13	18	8	11	12	12
Winter barleys											7 site average*	7 site percent of average*
						Yield (lb/a; 10% moisture)						
AB-812	6RF								8669			
Gwen	6RF	2845	4182	2889	3994	--	3373	4290		3463	3577	0.89
Hesk	6RF	2608	5616	4078	3347	--	3174	5344	8001	3338	3929	0.96
Hoody	6R hooded	1778	2162	3040	2194	--	1247	3575		1400	2199	0.54
Hundred	6RF	3109	4862	3860	4678	--	3017	4956	7669	4448	4133	1.01
Kamiak	6RF	2814	4045	4077	4961	--	3622	4271		2655	3778	0.93
Kold	6RF	3106	5204	4215	5497	--	3470	5998	6637	5416	4701	1.15
ORW6	6RF/M	3966	5187	4984	5407	--	3868	5928	8535	5331	4953	1.23
ORW7	6RF/M	3819	5959	1945	4920	--	4082	4896	5786	4187	4258	1.06
Scio	6RF	3188	3025	3650	5269	--	4226	5196		4531	4155	1.04
Showin	6RF	2907	5433	5258	3105	--	3264	4516	6455	4457	4134	1.02
Steptoe	6RF	3743	5659	3932	3239	--	3132	5404	7454	4104	4173	1.02
SDM204	6RF			6257		--						
SDM208	6RF			4692		--			8255			
Trial average		3080	4667	4067	4408	--	3316	4943	7489	3939	4060	4060
PLSD (5%)		608	1100	1534	1237	--	735	1062	1240	1053	752	0.18
PLSD (10%)		503	910	1272	1030	--	608	878	1023	871	629	0.15
CV		12	14	22	20	--	13	13	10	16	18	17

* does not include Ontario

Table 5.—1993-95 winter grain yields across Oregon locations expressed as a percent of trial average.

Variety/line	Market class	Corvallis	LaGrande	Madras	Medford	Moro	Morrow county	North Valley	Ontario	Pendleton	8-site average
Winter wheats and triticales						Yield as a percent of trial average					
Celia	Triticale	1.00	0.99	1.01	--	1.08	1.10	0.91	0.99	1.20	1.04
Daws	SW	0.94	1.08	0.97	--	0.99	0.99	1.04	0.96	0.92	0.99
Gene	SW	1.19	0.95	0.96	--	1.07	1.14	0.99	0.96	1.10	1.05
Hoff	HR	0.79	1.03	1.09	--	1.02	0.91	0.93	0.97	0.87	0.95
MacVicar	SW	1.07	0.93	1.06	--	0.99	0.95	0.99	1.11	1.04	1.02
Madsen	SW	1.09	1.02	0.99	--	0.98	1.07	0.94	1.01	1.06	1.02
Malcolm	SW	1.16	1.05	1.03	--	0.98	1.11	1.07	1.06	1.03	1.06
Rod	SW	0.98	1.14	1.04	--	1.13	1.11	1.02	0.69	0.96	1.01
Rohde	Club	0.84	0.96	0.98	--	1.14	0.97	1.07	0.97	1.01	0.99
Stephens	SW	1.05	1.00	1.03	--	1.07	1.19	1.00	1.01	1.17	1.07
W301	SW	1.03	0.93	1.04	--	1.05	1.15	0.96	1.08	1.10	1.04
Whitman	Triticale	1.08	1.09	0.97	--	1.08	0.95	1.02	0.91	1.14	1.03
PLSD (5%)											NS
PLSD (10%)											NS
1993-95 average yield (bu/a)		89	89	108	--	55	56	118	146	74	92
Winter barleys					Yield as a percent of trial average						5-site ave
AB-812	6RF					--		--	1.10		
Gwen	6RF	0.95	0.90	0.97	0.91	--	0.90	--		0.90	0.92
Hesk	6RF	0.92	1.12	1.03	0.98	--	1.11	--	1.07	1.05	1.04
Hundred	6RF	0.94	1.12	1.05	1.18	--	1.06	--	1.06	1.17	1.07
Kamiak	6RF	0.98	0.77	0.84		--	0.91	--		0.77	0.85
Kold	6RF	1.16	1.11	1.06	1.23	--	1.03	--	0.93	1.17	1.11
Showin	6RF	0.63	1.08	1.25		--	1.00	--	1.01	1.11	1.01
Steptoe	6RF	1.09	1.15	0.88		--	1.02	--	1.01	0.98	1.03
PLSD (5%)											0.16
PLSD (10%)											0.13
1993-95 average yield (lb/a)		4535	4298	4454	4066	--	3436	--	7552	4320	4209

Table 6.—1994-95 winter grain yields across Oregon locations expressed as a percent of trial average.

Variety/ line	Market class	Corvallis	LaGrande	Madras	Medford	Moro	Morrow County	North Valley	Ontario	Pendleton	8-site average
Winter wheats and triticales					Yield as a percent of trial average						
Cashup	SW	1.21	1.06	1.03	0.99	0.91	1.01	0.99		1.06	1.03
Celia	Triticale	1.09	0.99	1.00	0.80	1.18	1.02	0.97	0.99	1.26	1.04
Daws	SW	1.07	1.12	0.97	0.96	1.03	0.96	1.07	1.00	1.00	1.02
Gene	SW	1.22	1.06	0.91	1.09	1.07	1.17	1.03	1.00	1.12	1.08
Hill 81	SW	1.11	1.04	1.05	0.91	0.97	1.01	1.07	0.99	1.04	1.02
Hoff	HR	0.73	1.04	1.14	1.16	1.08	0.98	0.98	0.97	0.83	0.99
Hyak	Club	0.91	0.92	0.83	0.98	1.04	0.92	0.57		1.05	0.90
Kmore	SW	1.03	0.96	0.90	0.91	0.87	0.96	0.51		0.99	0.89
Lambert	SW	0.91		1.01	1.12	0.82	1.06	0.95		0.94	
Lewjain	SW	0.85	0.80	0.93	0.88	1.02	0.85	0.51		0.99	0.85
MacVicar	SW	1.06	0.97	1.04	1.04	0.96	0.96	0.98	1.11	1.05	1.01
Madsen	SW	1.16	1.00	0.93	0.95	1.00	1.17	0.89	0.99	1.07	1.02
Malcolm	SW	1.12	1.09	1.10	1.05	1.02	1.24	1.02	1.10	1.03	1.08
Rely	Club	0.76	0.95	0.91	0.99	1.04	0.89	0.40		0.93	0.86
Rod	SW	0.89	1.06	1.04	0.98	1.17	1.05	0.95		0.91	1.00
Rohde	Club	0.75	1.02	1.01	1.14	1.16	1.01	1.12	0.97	0.92	1.02
Stephens	SW	1.08	0.93	1.05	0.95	1.06	1.18	1.01	1.02	1.15	1.05
W301	SW	1.01	1.02	1.00	0.86	1.06	1.17	0.90	1.11	1.11	1.02
Whitman	Triticale	1.13	1.07	0.97	0.96	1.11	0.96	1.04	0.90	1.10	1.04
Yamhill	SW	0.87	0.91	0.83	0.91	0.86	1.00	0.99		0.76	0.89
PLSD (5%)											0.11
PLSD (10%)											0.09
1994-95 average yield (bu/a)		87	88	107	102	45	54	117	142	80	85
Winter barleys					Yield as a percent of trial average						6-site average
AB-812	6RF					--		--	1.19		
Gwen	6RF	0.97	0.85	0.89	0.89	--	0.98	--		0.91	0.91
Hesk	6RF	0.87	1.18	1.05	1.03	--	1.10	--	1.09	1.08	1.05
Hoody	6RF	0.72	0.63	0.71	0.58	--	0.62	--		0.49	0.62
Hundred	6RF	1.01	1.10	1.10	1.24	--	1.07	--	1.08	1.20	1.12
Kamiak	6RF	0.93	0.80	0.80	0.93	--	0.86	--		0.67	0.83
Kold	6RF	1.10	1.10	1.05	1.28	--	1.07	--	0.92	1.23	1.14
Showin	6RF	0.94	1.15	1.29	0.90	--	1.03	--	0.99	1.15	1.08
Steptoe	6RF	1.16	1.17	0.92	0.65	--	0.93	--	0.98	0.99	0.97
PLSD (5%)											0.14
PLSD (10%)											0.12
1994-95 average yield (lb/a)		4556	4418	4036	4107	--	3658	--	7477	4436	4202

Table 7.—1995 state-wide variety testing program winter grain test weights across nine locations in Oregon.

Variety/ line	Market class	Corvallis	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	8 site average*
Winter wheats and triticales						Test weight (lb/bu)					
Cashup	SW	61.0	61.3	57.4	60.9	62.1	58.7	59.6		61.6	60.3
Celia	Triticale	58.6	54.7	51.1	57.4	59.0	54.0	58.3	57.6	59.4	56.6
Daws	SW	60.7	62.4	58.6	61.0	60.8	58.8	62.2	62.8	61.4	60.7
Gene	SW	58.5	57.5	56.1	56.7	58.8	53.7	59.3	61.4	61.3	57.7
Hill 81	SW	59.7	62.3	59.0	61.7	61.3	57.8	61.6	61.5	61.3	60.6
Hoff	HR	62.4	64.0	60.0	63.0	63.3	59.8	63.7	63.9	64.7	62.6
Hyak	Club	57.0	60.3	55.5	58.3	59.5	55.5	60.5		60.8	58.4
Kmor	SW	59.6	61.1	54.6	59.2	59.7	57.3	60.1		60.9	59.1
Lambert	SW	60.4	59.5	56.3	60.8	61.2	55.8	61.1		61.5	59.6
Lewjain	SW	59.2	62.6	55.3	61.3	61.3	58.2	61.4		61.3	60.1
Mac 1	SW	60.4	62.3	58.2	62.6	61.7	58.4	59.9	63.4	61.8	60.6
MacVicar	SW	61.0	60.1	58.3	61.7	61.0	57.4	61.0	62.1	61.9	60.3
Madsen	SW	59.6	61.1	59.5	59.9	60.9	58.9	61.7	61.3	61.6	60.4
Malcolm	SW	61.2	61.3	57.3	61.2	61.4	58.6	62.4	62.2	61.8	60.6
Parma	Triticale	53.9	53.0	50.7	54.0	55.1	50.3	52.1	56.6	56.7	53.2
Rely	Club	58.5	59.2	56.6	60.7	59.5	58.1	56.3		60.1	58.6
Rod	SW	60.0	59.6	57.0	60.0	59.2	58.1	60.0		60.7	59.3
Rohde	Club	61.3	64.4	58.7	62.6	62.1	60.1	63.1	61.3	61.7	61.7
Rulo	Club	57.8	60.1	54.9	60.1	59.8	56.4	59.0		60.4	58.6
Stephens	SW	60.5	60.6	57.9	60.6	60.5	58.1	60.7	60.9	62.1	60.1
W301	SW	61.4	60.2	58.6	60.6	61.1	57.0	58.3	61.4	62.4	60.0
Whitman	Triticale	54.7	54.4	51.8	56.3	54.4	49.8	56.5	56.1	56.9	54.3
Yamhill	SW	58.8	59.7	57.7	58.3	58.9	56.6	58.7		59.5	58.5
Trial average		59.6	60.2	56.6	60.1	60.0	56.7	60.2	60.9	61.0	59.3
PLSD (5%)		0.9	2.4	2.4	1.3	1.3	2.1	2.3	0.9	1.0	1.0
PLSD (10%)		0.8	2.0	2.0	0.9	0.9	1.8	1.9	0.7	0.8	0.8
CV		1	2.00	3	1	1	2	2	1	1	2
											7 site average*
Winter barleys						Test weight (lb/bu)					
AB-812	6RF								48.9		
Gwen	6RF	50.3	53.5	52.8	51.3	--	54.0	53.3		52.4	52.5
Hesk	6RF	45.7	51.8	50.1	45.7	--	48.8	51.3	48.8	50.0	49.1
Hoody	6R hooded	42.0	48.2	47.8	46.2	--	42.2	49.9		45.7	46.0
Hundred	6RF	45.1	49.3	49.9	47.8	--	43.8	50.0	48.0	50.0	48.0
Kamiak	6RF	49.0	53.2	49.9	50.9	--	54.0	51.9		52.3	51.6
Kold	6RF	46.0	52.0	52.4	50.3	--	50.8	52.2	50.5	51.5	50.7
ORW6	6RF/M	47.4	51.8	50.4	47.5	--	50.6	49.7	49.1	49.9	49.6
ORW7	6RF/M	48.8	48.7	50.6	50.6	--	54.5	52.3	50.5	53.1	51.2
Scio	6RF	47.1	50.9	50.9	48.6	--	49.9	50.8		50.5	49.8
Showin	6RF	45.3	51.6	52.0	43.2	--	48.3	48.8	48.6	47.8	48.2
Steptoe	6RF	49.0	54.6	50.4	49.4	--	50.8	53.0	50.1	50.9	51.2
SDM204	6RF			48.8		--					
SDM208	6RF			50.8		--			50.3		
Trial average		46.9	51.4	50.5	48.8	--	49.8	51.2	49.5	50.4	49.8
PLSD (5%)		1.3	1.6	2.0	1.7	--	2.5	2.1	0.6	0.8	1.7
PLSD (10%)		1.1	1.4	1.7	1.4	--	2.0	2.1	0.5	0.7	1.4
CV		2	2	2	2	--	3	3	1	1	1

*does not include Ontario

Table 8.—1995 state-wide variety testing program winter grain protein percents across nine locations in Oregon.

Variety/ line	Market class	Corvallis	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	8 site average*
Winter wheats and triticales					Protein percent (12% moisture basis)						
Cashup	SW	7.0	11.2	11.8	8.5	8.2	8.0	8.1		8.6	8.9
Celia	Triticale	6.8	12.0	12.0	9.6	7.7	7.7	8.0	10.2	7.5	8.9
Daws	SW	7.7	11.1	11.7	9.1	7.5	9.4	7.9	9.8	8.1	9.0
Gene	SW	8.1	12.3	11.9	9.9	8.4	10.8	9.6	10.6	9.3	10.0
Hill 81	SW	7.8	12.0	12.2	9.4	8.4	9.0	8.5	9.5	8.4	9.4
Hoff	HR	8.1	11.3	12.0	9.6	8.7	8.7	8.8	10.3	10.0	9.6
Hyak	Club	7.3	12.3	12.3	8.5	8.2	10.0	7.9		8.5	9.4
Kmor	SW	7.6	12.3	12.3	9.0	7.3	9.2	8.5		8.7	9.4
Lambert	SW	7.9	12.2	12.0	9.1	8.2	8.9	8.4		8.6	9.4
Lewjain	SW	7.5	11.5	13.0	9.3	7.7	9.5	8.6		8.8	9.5
Mac 1	SW	7.8	11.5	11.9	9.1	8.6	9.1	9.1	11.1	9.6	9.6
MacVicar	SW	7.4	11.9	11.2	8.5	8.9	9.6	8.8	10.1	8.6	9.4
Madsen	SW	7.6	12.9	11.7	9.1	8.4	9.5	9.1	9.6	9.3	9.7
Malcolm	SW	7.7	11.7	11.5	8.7	8.5	9.6	8.7	9.6	8.0	9.3
Parma	Triticale	8.1	13.0	12.2	9.6	7.6	8.5	9.0	8.7	7.7	9.5
Rely	Club	7.6	11.4	12.2	8.6	7.2	9.1	8.8		8.7	9.2
Rod	SW	7.3	10.9	12.1	8.7	7.6	8.0	8.5		8.1	8.9
Rohde	Club	8.0	10.7	11.7	8.6	7.1	8.2	8.5	9.3	9.0	9.0
Rulo	Club	8.2	11.6	12.6	8.9	7.9	9.4	8.2		9.1	9.5
Stephens	SW	8.2	12.5	11.8	9.2	8.9	9.3	9.3	9.4	8.9	9.8
W301	SW	8.1	12.4	11.5	9.3	8.1	9.0	9.5	9.6	8.8	9.6
Whitman	Triticale	8.6	10.6	11.2	8.8	8.4	9.3	8.8	9.6	8.6	9.3
Yamhill	SW	7.7	12.1	11.7	9.3	8.7	9.6	8.8		9.0	9.6
Trial average		7.8	11.9	11.8	9.1	8.1	9.3	8.7	9.7	8.7	9.4
PLSD (5%)		0.5	1.1	0.7	0.6	0.9	NS	0.7	1.0	0.7	0.5
PLSD (10%)		0.4	0.9	0.6	0.5	0.6	1.4	0.5	0.8	0.5	0.4
CV		4	5	4	1	6	11	4	6	5	5
Winter barleys					Protein percent (12% moisture basis)						
AB-812	6RF								9.5		
Gwen	6RF	8.7	11.4	10.1	10	--	8.2	9.8		9.3	9.6
Hesk	6RF	8.7	10.6	9.5	9.9	--	7.8	8.5	9.9	9.2	9.2
Hoody	6R hooded	10.1	13.4	10.9	1.5	--	11.1	11.0		9.8	9.7
Hundred	6RF	8.7	11.7	9.6	10.1	--	9.0	9.0	10.2	8.1	9.5
Kamiak	6RF	8.2	11.9	11.1	10.3	--	6.7	9.2		8.1	9.3
Kold	6RF	8.5	11.2	9.3	9.9	--	7.6	9.0	10.5	8.6	9.2
ORW6	6RF/M	8.5	11.1	10.1	9.4	--	7.5	9.1	9.5	7.9	9.1
ORW7	6RF/M	8.3	10.7	9.0	9.6	--	7.3	8.4	9.8	7.9	8.7
Scio	6RF	8.3	11.6	9.6	9.8	--	7.0	8.5		8.2	9.0
Showin	6RF	8.6	10.4	9.0	11	--	8.3	9.7	10.5	9.5	9.5
Steptoe	6RF	8.3	10.5	9.9	9.2	--	7.5	8.7	9.8	8.0	8.9
SDM204	6RF			8.4		--					
SDM208	6RF			10.3		--			10.1		
Trial average		8.6	11.3	9.7	10	--	8.0	9.2	10	8.6	9.2
PLSD (5%)		0.4	0.7	NS	0.7	--	1.2	1.0	0.6	0.9	NS
PLSD (10%)		0.4	0.6	1.3	0.5	--	1.0	0.6	0.5	0.7	NS
CV		3	4	10	5	--	9	4	3	6	14

*does not include Ontario

Table 9.—1995 state-wide variety testing program spring grain Julian heading dates and lodging across five sites in Oregon.

Variety/ line	Market class	Corvallis	Klamath	Madras	Ontario	Pendleton	5-site average	Madras	Medford	Ontario
Spring wheats and triticales		Julian heading date						Lodging percent	Lodging percent	Lodging score*
Alpowa	SW	151	202	177	153	150	167	70		1.7
Anza	HR				153					1.0
Calorwa	Club	146	194	176	153	147	163	95		2.0
Centennial	SW	149	194	176	151	147	163	93		1.0
Dirkwin	SW	153	199	179	155	147	167	58		1.0
Fieldwin	SW									
ID377S	HW	150	192	177	153	150	164	92		1.0
ID448	SW	155	198	181	155	150	168	57		1.0
ID471	SW	150	194	175	152	147	163	93		1.3
Juan	Triticale	155	199	177	154	150	167	33		1.0
Klasic	HW	147	189	168	150	148	160	100		1.0
Owens	SW	149	192	179	152	149	164	93		1.3
Penawawa	SW	150	196	177	154	150	165	65		1.0
Treasure	SW	152	196	180	155	151	167	63		1.0
Trical 2700	Triticale					149				
Trical Victoria	Triticale	150	200	175	153	149	166	73		1.0
Westbred Vanna	SW		197	180	154			62		1.0
Westbred 881	Durum					148				
Westbred 906R	HR			172				37		
Westbred 926R	HR	148	191	173	150	146	161	30		1.0
Westbred 936R	HR		191	174	151			42		1.0
Wakanz	SW	153	203	178		149		65		
Wawawai	SW	150	193	175	153	151	164	98		2.3
Yecora Rojo	HR	145	190	169	150	148	160	64		1.0
Yolo	HR				153					1.0
Trial average		151	195	176	153	149	164	69		1.2
PLSD (5%)		2	3	3	2	--	--	NS		0.7
PLSD (10%)		1	2	2	2	--	--	NS		0.6
CV		1	2	1	1	--	--	53		35
Spring barleys										
78Ab10274	2RF/M	149	197	172	153	141	162	67	100	6.0
82Ab23222 (Payette)	6RF	150	200	176	154	135	163	92	38	1.3
BSR 41	2RF/M	141	188		146	142				6.0
BSR 45	2RF/M	144			147	140				2.3
Baronesse	2RF	151	194	173	152	140	162	75	15	3.0
Colter	6RF	144	189	168	150	141	158	57	80	1.0
Columbia	6RF		199	177	154			80		1.7
Crest	2RM	151	198	171	153	140	163	85	100	5.7
Crystal	2RM	151			153				60	3.7
Gus	6RF		192							
Gustoe	6RF		195						0	
Harrington	2RM				153					3.7
Maranna	6RF	151	198	171	154	140	163	80	50	1.0
Russell	6RM	144	191	164	148	141	158	60	0	1.0
Stander	6RM		194							
Steptoe	6RF	148	189	171	151	138	160	73	48	1.3
WA 11045-87	6R awnless	159								
WPB-BZ489-74	6R hulless	153	201	176	153	144	165	95	50	3.0
WPB-Sissy	6RF		194	176	153			57		1.7
Trial average		149	194	172	151	140	161	76	45	2.7
PLSD (5%)		1	2	3	2	--	--	NS	NS	1.6
PLSD (10%)		1	2	3	1	--	--	25.0	NS	1.3
CV		1	1	1	1	--	--	24	88	35

Grain did not lodge at other locations.
*Lodging score: 1 = none; 2 = 1-20%; 3 = 21-40%; 4 = 41-60%; 5 = 61-80%; 6 = >81%

Table 10.—1995 state-wide variety testing program spring grain heights across nine sites in Oregon.

Variety/ line	Market class	Corvallis	Klamath	LaGrande	Madras	Medford	Morrow	North Valley	Ontario	Pendleton	8-site average
Spring wheats and triticales						Height (inches)					
Alpowa	SW	36	31	35	35	34		23	34	36	33
Anza	HR								32		
Calorwa	Club	33	28	32	34	34		18	30	31	30
Centennial	SW	36	25	34	35	35		21	33	34	32
Dirkwin	SW	38	30	37	33	34		22	33	38	33
Fieldwin	SW					30					
ID377S	HW	39	30	36	35	35		24	37	38	34
ID448	SW	37	30	32	34	31		23	34	36	32
ID471	SW	38	27	35	33	36		22	33	31	32
Juan	Triticale	47	36	48	46	44		29	41	44	42
Klasic	HW	29	20	25	29	26		19	25	25	25
Owens	SW	38	30	39	34	38		23	35	38	34
Penawawa	SW	33	27	35	34	34		21	34	35	31
Treasure	SW	35	29	33	35	30		23	33	37	32
Trical 2700	Triticale									61	
Trical Victoria	Triticale	40	33	38	41	38		28	36	39	37
Westbred Vanna	SW		29		33				34		
Westbred 881	Durum			31						35	
Westbred 906R	HR				31						
Westbred 926R	HR	35	28	34	32	32		22	33	35	31
Westbred 936R	HR		25		32				33		
Wakanz	SW	36	31	35	33	30		23		36	
Wawawai	SW	42	31	43	38	40		28	38	41	38
Yecora Rojo	HR	27	19	27	28	27		17	24	29	25
Yolo	HR								32		
Trial average		36	28	35	34	34		23	33	37	33
PLSD (5%)		4	3	3	3	--		2	2	--	--
PLSD (10%)		3	2	3	3	--		2	2	--	--
CV		6	2	5	6	--		6	3	--	--
Spring barleys						Height (inches)					
78Ab10274	2RF/M	35	30	35	35	35	27	22	31	37	32
82Ab23222 (Payette)	6RF	30	26	32	40	32	23	18	29	28	28
BSR 41	2RF/M	37	28				37		29	35	
BSR 45	2RF/M	38					33		32	36	
Baronesse	2RF	34	27	31	35	30	26	20	29	31	29
Colter	6RF	38	25	30	43	39	29	21	33	38	32
Columbia	6RF		25	29	36				29		
Crest	2RM	34	27	32	31		27	20	29	36	29
Crystal	2RM	35				34			32		
Gus	6RF		22								
Gustoe	6RF		21			22					
Harrington	2RM								31		
Maranna	6RF	27	26	31	38		22	17	25	27	27
Russell	6RM	38	30	34	39	31	31	23	34	32	33
Stander	6RM		31								
Steptoe	6RF	40	29	33	37	32	31	20	32	34	32
WA 11045-87	6R awnless	34									
WPB-BZ489-74	6R hulless	32	27	33	38		26	21	28	35	30
WPB-Sissy	6RF		26		34				28		
Trial average		35	27	32	37	32	28	20	30	34	19
PLSD (5%)		3	2	NS	4	--	--	3	2	--	--
PLSD (10%)		2	2	NS	4	--	--	3	2	--	--
CV		5	1	15	7	--	--	9	4	--	--

Table 11.—1995 state-wide variety testing program spring grain yields across ten sites in Oregon.

Variety/ line	Market class	Corvallis	Klamath	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	10-site average	Percent of trial average
Spring wheats and triticales							Yield (bu/a; 10% moisture)						
Alpowa	SW	72	83	62	99	95	50	40	56	113	67	74	1.11
Anza	HR									99			
Calorwa	Club	75	58	56	73	108	49	40	46	105	55	66	1.00
Centennial	SW	77	69	58	85	106	52	38	52	108	54	70	1.05
Dirkwin	SW	68	74	60	79	81	51	40	49	91	52	65	0.99
Fieldwin	SW					78							
ID377S	HW	72	84	63	90	108	52	39	50	110	61	73	1.09
ID448	SW	66	89	47	86	71	59	34	52	108	64	68	1.02
ID471	SW	73	79	59	86	99	60	33	53	111	58	71	1.07
Juan	Triticale	61	76	44	91	89	36	19	46	101	32	59	0.85
Klasic	HW	74	50	49	97	99	49	38	47	108	39	65	0.96
Owens	SW	71	71	56	78	95	53	27	46	98	50	65	0.96
Penawawa	SW	74	77	59	82	96	49	34	50	116	58	69	1.03
Treasure	SW	79	91	57	86	100	51	31	54	111	68	73	1.09
Trical 2700	Triticale										73		
Trical Victoria	Triticale	61	63	50	92	89	49	28	51	86	59	63	0.94
Westbred Vanna	SW		53		86					108			
Westbred 881	Durum			44				29			27		
Westbred 906R	HR				80								
Westbred 926R	HR	62	55	51	79	90	47	38	50	91	52	61	0.93
Westbred 936R	HR		48		99					102			
Wakanz	SW	59	78	53	94	77	57	36	46		68		
Wawawai	SW	70	65	69	72	87	51	38	55	129	65	70	1.05
Yecora Rojo	HR	64	48	52	94	75	52	41	49	101	56	63	0.96
Yolo	HR										111		
Trial average		68	68	55	86	91	51	35	50	105	56	67	1.00
PLSD (5%)		9	17	NS	14	16	11	11	NS	12	12	7	0.10
PLSD (10%)		8	14	NS	12	13	9	9	NS	10	10	6	0.08
CV		8	10	24	10	13	13	19	10	7	13	11	11
Spring barleys							Yield (lb/a; 10% moisture)						
78Ab10274	2RF/M	3942	4937	3547	4725	2389	3606	3016	2835	5187	5158	3934	1.03
82Ab23222 (Payette)	6RF	3121	4006	4439	4473	4334	3065	2315	2099	5298	3463	3661	0.94
BSR 41	2RF/M	3726	4295				3667	2480		6047	4444		
BSR 45	2RF/M	3736					2911	2877		5207	4706		
Baronesse	2RF	4382	5151	4274	4002	4712	4198	2984	2676	5608	5079	4307	1.12
Colter	6RF	4153	4609	3730	4733	2869	3758	2542	2253	6250	5262	4016	1.03
Columbia	6RF		4779	3336	4513					5943			
Crest	2RM	3883	4241	3869	4697	4098	3631	2563	2469	5290	4593	3933	1.02
Crystal	2RM	3421				3632				5165			
Gus	6RF		4497										
Gustoe	6RF		4225			5563							
Harrington	2RM									5130			
Maranna	6RF	3478	4735	2992	4524	4850	3580	2241	2137	5425	3654	3762	0.96
Russell	6RM	3408	3809	3670	3685	4612	3204	2770	2566	4572	3707	3600	0.95
Stander	6RM		4181										
Steptoe	6RF	4412	4711	3468	5661	3011	3778	2682	2243	5752	5061	4078	1.04
WA 11045-87	6R awnless	3085											
WPB-BZ489-74	6R hulless	3586	3480	3896	3710	4583	2989	2203	2288	5380	3889	3600	0.93
WPB-Sissy	6RF		4606		3766					4674			
Trial average		3718	4406	3722	4409	4116	3490	2607	2440	5457	4456	3877	1.00
PLSD (5%)		423	583	NS	1016	1543	503	430	469	NS	710	463	0.11
PLSD (10%)		350	485	NS	841	1283	416	355	387	900	587	386	0.09
CV		7	8	20	14	26	8	10	11	12	9	13	13

Table 12.—1993-95 spring grain yields across Oregon locations expressed as a percent of trial average.

Variety/line	Market class	Corvallis	Klamath	LaGrande	Madras	Moro	Morrow	North Valley	Ontario	Pendleton	Average
Spring wheats and triticales				1993-95 average yield expressed as a percent of trial average							
Calorwa	Club	0.94	0.90	1.05	0.95	0.94	0.95	0.83	0.90	0.88	0.93
Centennial	SW	1.05	1.15	1.03	1.08	1.08	0.92	0.99	1.14	0.90	1.04
Dirkwin	SW	0.95	0.93	0.98	0.99	0.98	0.79	0.61	0.93	0.73	0.88
Juan	Triticale	1.11	1.07	0.90	0.83	0.97	0.77	1.25	1.04	0.85	0.98
Klasic	HW	0.89	0.94	1.08	1.21	0.84	1.19	0.83	0.86	0.81	0.96
Owens	SW	1.05	1.08	1.01	0.98	0.94	0.81	0.81	1.05	0.92	0.96
Penawawa	SW	0.93	1.03	0.98	1.08	0.96	0.78	0.76	1.05	0.83	0.93
Treasure	SW	1.15	1.16	1.00	0.99	1.05	1.03	1.00	1.01	1.04	1.05
Trical Victoria	Triticale	1.10	1.04	0.91	0.93	1.14	1.17	1.59	1.16	1.20	1.14
Westbred 926R	HR	0.98	0.89	1.00	0.95	0.99	1.27	0.97	0.87	1.18	1.01
PLSD (5%)											0.12
PLSD (10%)											0.10
1993-95 average yield (bu/a)		50	78	53	76	45	33	33	115	49	59
Spring barleys											
Baronesse	2RF	1.23	1.05	1.06	0.97	1.09	1.17	--	1.03	--	1.09
Colter	6RF	0.98	1.02	0.98	1.03	1.01	0.92	--	1.07	--	1.00
Crest	2RM	1.00	0.93	1.06	0.93	0.97	0.98	--	0.96	--	0.98
Maranna	6RF	0.94	1.13	0.92	1.10	1.04	0.88	--	1.02	--	1.00
Russell	6RM	0.90	0.94	1.02	0.90	0.93	0.88	--	0.85	--	0.92
Steptoe	6RF	1.09	0.98	0.93	1.07	1.08	1.24	--	1.07	--	1.06
PLSD (5%)											0.08
PLSD (10%)											0.07
1993-95 average yield (lb/a)		3774	5267	4415	5206	3535	2865	--	6916	--	3997

Table 13.—1994-95 spring grain yields expressed as a percent of trial average yield across Oregon locations.

Variety/line		Corvallis	Klamath	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	Average
Spring wheats and triticales				1994-95 average yield expressed as a percent of trial average								
Alpowa	SW	1.12	1.05	1.17	1.08	1.07	1.03	1.10	1.06	1.06	1.14	1.09
Calorwa	Club	1.05	0.91	1.10	0.91	1.09	1.09	1.00	0.96	0.91	0.99	1.00
Centennial	SW	1.11	1.11	1.01	1.07	1.17	1.09	0.93	1.18	1.10	0.94	1.07
Dirkwin	SW	1.04	0.97	1.00	0.98	0.93	0.96	0.64	0.71	0.90	0.68	0.88
ID 377S	HW	1.15	1.12	1.05	1.09	1.13	1.06	1.41	0.80	1.00	1.12	1.09
Juan	Triticale	0.98	1.07	0.78	0.90	0.96	0.86	0.67	0.97	1.02	0.77	0.90
Klasic	HW	0.88	0.92	1.04	1.14	1.04	1.00	1.32	0.87	1.02	0.88	1.01
Owens	SW	1.06	1.04	1.01	0.96	1.03	1.01	0.67	0.92	1.02	0.86	0.96
Penawawa	SW	1.02	1.09	0.98	1.02	1.00	0.99	0.66	0.89	1.13	0.90	0.97
Treasure	SW	1.20	1.19	1.02	1.02	1.11	1.04	0.98	1.05	1.01	1.05	1.07
Trical Victoria	Triticale	1.07	1.03	0.86	1.03	0.96	1.02	1.16	1.28	1.05	1.13	1.06
Wakanz	SW	1.21	0.89	0.98	0.93	1.00	1.05	0.97	0.73	0.96	1.27	1.00
Wawawai	SW	1.03	0.95	0.96	1.01	0.92	1.08	0.81	0.46	0.49	1.34	0.91
Westbred 926R	HR	0.91	0.94	1.10	0.87	0.89	1.05	1.34	0.74	1.08	1.34	1.03
Yecora Rojo	HR	0.85	0.86	1.13	1.04	0.86	1.12	1.40	0.91	0.88	0.95	1.00
PLSD (5%)												0.12
PLSD (10%)												0.10
CV												20
1994-95 average yield (bu/a)		54	82	48	81	90	45	25	33	115	49	62
Spring barleys												
Baronesse	2RF	1.24	1.02	1.08	0.95	1.17	1.10	1.26	--	1.00	1.12	1.11
Colter	6RF	1.03	0.99	1.00	1.02	0.91	1.05	0.86	--	1.09	1.08	1.00
Crest	2RM	0.97	1.01	1.08	0.99	0.94	0.98	1.03	--	0.90	0.99	0.99
Maranna	6RF	0.96	1.16	0.88	1.06	1.14	1.03	0.79	--	1.04	0.94	1.00
Russell	6RM	0.90	0.97	0.98	0.89	1.06	0.93	0.88	--	0.93	0.87	0.93
Steptoe	6RF	1.15	0.90	0.90	1.11	0.87	1.09	1.27	--	1.05	1.06	1.05
PLSD (5%)												0.09
PLSD (10%)												0.08
1994-95 average (lb/a)		3434	5646	3715	4684	4392	3250	2365	--	7057	4700	4360

Table 14.—1995 state-wide variety testing program spring grain test weights across ten sites in Oregon.

Variety/ line	Market class	Corvallis	Klamath	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	10-site average
Spring wheats and triticales						Test weight (lb/bu)						
Alpowa	SW	62.3	62.8	59.0	61.5	62.4	62.5	60.0	63.5	64.1	63.1	62.1
Anza	HR									63.3		
Calorwa	Club	60.5	59.6	60.1	56.4	61.8	60.8	59.0	63.0	61.4	62.3	60.5
Centennial	SW	60.6	61.9	57.6	58.0	62.9	62.3	59.7	62.8	64.0	62.3	61.2
Dirkwin	SW	58.1	58.5	54.8	56.4	59.4	58.4	57.5	61.5	58.6	57.8	58.1
Fieldwin	SW					61.2						
ID377S	HW	63.3	62.0	58.8	58.4	61.9	63.0	60.4	63.9	64.1	63.1	61.9
ID448	SW	58.5	61.6	54.8	57.5	60.1	62.3	58.1	62.4	60.9	60.9	59.7
ID471	SW	58.9	62.3	58.1	59.7	62.5	62.2	58.6	62.8	63.8	62.3	61.1
Juan	Triticale	53.3	53.4	43.1	53.0	54.3	52.0	43.4	47.9	54.7	51.7	50.7
Klasic	HW	64.1	62.0	61.9	59.6	62.5	62.3	58.3	62.4	63.6	62.4	61.9
Owens	SW	60.9	61.8	57.5	58.3	61.5	60.9	53.4	62.3	63.2	61.1	60.1
Penawawa	SW	61.3	61.7	58.1	59.7	61.4	61.4	57.4	62.9	63.2	61.9	60.9
Treasure	SW	61.0	61.8	57.2	59.8	61.7	62.0	54.9	63.1	62.2	61.2	60.5
Trical 2700	Triticale										53.7	
Trical Victoria	Triticale	55.0	52.4	48.4	52.4	53.9	55.1	47.5	53.1	52.9	53.6	52.4
Westbred Vanna	SW		58.8		58.8							
Westbred 881	Durum			56.5				59.6			59.9	
Westbred 906R	HR			0.0	58.8							
Westbred 926R	HR	63.0	61.2	60.0	59.0	61.9	62.8	60.9	63.8	64.1	61.3	61.8
Westbred 936R	HR		58.9		58.8					64.3		
Wakanz	SW	58.7	61.5	57.7	60.4	57.7	61.8	57.6	61.4		61.8	
Wawawai	SW	62.5	62.1	60.6	58.9	61.4	62.8	60.1	63.8	64.4	62.4	61.9
Yecora Rojo	HR	64.4	61.8	61.0	60.3	61.7	62.9	61.1	64.2	63.5	63.1	62.4
Yolo	HR									63.6		
Trial average		60.4	60.4	57.0	58.3	60.6	61.0	57.2	61.6	62.1	60.4	59.8
PLSD (5%)		1.6	1.0	3.0	2.2	0.8	1.3	3.9	1.1	1.0	1.1	--
PLSD (10%)		1.4	0.9	2.5	1.8	0.7	1.1	3.2	0.9	0.9	0.9	--
CV		2	1	3	2	1	1	4	1	1	1	--
Spring barleys						Test Weight (lb/bu)						
78Ab10274	2RF/M	51.8	54.9	52.0	52.8	52.9	54.7	53.4	50.9	54.1	55.3	53.3
82Ab23222 (Payette)	6RF	47.7	51.0	52.0	48.7	55.0	52.7	48.2	53.3	53.4	53.5	51.5
BSR 41	2RF/M	53.3	52.9				53.8	52.5		52.9	54.3	
BSR 45	2RF/M	52.1					53.8	52.3		53.9	55.4	
Baronesse	2RF	53.6	54.0	52.8	51.0	53.5	54.3	52.7	51.7	55.0	55.1	53.4
Colter	6RF	50.8	51.0	49.3	47.9	52.8	51.5	44.7	51.5	52.3	53.7	50.5
Columbia	6RF		46.8	48.3	46.8					51.2		
Crest	2RM	53.2	54.4	51.6	51.3	52.7	54.5	52.9	52.1	51.5	55.3	53.0
Crystal	2RM	51.8				54.2				54.3		
Gus	6RF		48.9									
Gustoe	6RF		49.6			52.7						
Harrington	2RM									54.1		
Maranna	6RF	46.8	51.2	50.6	49.7	54.2	51.6	47.9	50.4	52.2	53.3	50.8
Russell	6RM	51.3	51.8	51.8	49.8	53.6	53.6	51.6	52.3	55.5	53.8	52.5
Stander	6RM		51.9									
Steptoe	6RF	48.6	51.1	49.3	47.8	51.2	50.3	44.6	49.1	52.0	52.9	49.7
WA 11045-87	6R awnless	54.2										
WPB-BZ489-74	6R hulless	62.8	60.6	59.1	54.5	60.8	61.1	56.9	61.8	63.4	61.9	60.3
WPB-Sissy	6RF		52.9		49.9					54.2		
Trial average		52.2	52.3	51.7	50.0	53.7	53.8	50.7	52.6	53.9	54.9	52.8
PLSD (5%)		0.9	1.3	3.5	2.4	2.3	0.8	4.2	2.5	0.9	0.6	--
PLSD (10%)		0.8	1.1	2.9	2.0	1.9	0.7	3.4	2.0	0.8	0.5	--
CV		1	1	4	3	3	1	5	3	1	1	--

Table 15.—1995 state-wide variety testing program spring grain proteins across ten sites in Oregon.

Variety/ line	Market class	Corvallis	Klamath	LaGrande	Madras	Medford	Moro	Morrow	North Valley	Ontario	Pendleton	10-site average
Spring wheats and triticales						Protein percent (12% moisture basis)						
Alpowa	SW	6.8	11.3	14.0	11.3	11.5	10.9	10.2	9.4	10.5	11.3	10.7
Anza	HR									10.5		
Calorwa	Club	7.5	12.5	13.5	12.7	11.4	11.7	9.9	11.4	10.0	11.9	11.2
Centennial	SW	6.8	11.9	13.0	12.3	11.4	10.6	10.0	9.6	10.2	11.9	10.8
Dirkwin	SW	8.0	11.3	12.8	12.1	12.0	11.2	10.3	10.5	10.2	12.0	11.0
Fieldwin	SW	0.0				12.4						
ID377S	HW	7.9	12.6	13.3	13.4		12.0	10.4	10.9	11.3	13.2	10.5
ID448	SW	7.9	10.6	13.7	12.4	12.7	10.5	10.0	9.6	9.5	11.1	10.8
ID471	SW	7.0	11.4	12.1	11.9	11.1	10.7	10.0	9.3	9.9	11.5	10.5
Juan	Triticale	8.5	10.5	11.6	11.5	10.9	11.4	12.0	10.3	10.4	12.0	10.9
Klasic	HW	7.9	13.8	13.9	13.4	12.4	13.0	12.4	11.5	12.6	14.5	12.5
Owens	SW	7.1	11.5	13.4	12.5	11.6	11.2	13.6	9.8	10.5	11.6	11.3
Penawawa	SW	7.0	11.8	12.8	12.2	11.7	10.7	11.4	9.4	10.8	11.9	11.0
Treasure	SW	7.0	11.1	12.2	11.5	11.5	10.9	14.8	9.9	9.8	11.4	11.0
Trical 2700	Triticale										11.1	
Trical Victoria	Triticale	8.2	10.9	13.3	12.1	11.1	11.5	11.8	10.5	10.3	11.6	11.1
Westbred Vanna	SW		11.6		12.4					10.1	0.0	
Westbred 881	Durum			14.2				12.9			14.6	
Westbred 906R	HR				13.5							
Westbred 926R	HR	8.6	13.7	14.4	13.9	12.9	13.3	11.3	11.3	13.4	14.2	12.7
Westbred 936R	HR		14.2		14.1					12.4		
Wakanz	SW	8.4	11.3	12.9	11.9	12.2	11.4	11.5	10.5		12.0	
Wawawai	SW	7.8	12.0	11.8	12.5	11.8	11.3	10.9	10.2	10.0	12.2	11.0
Yecora Rojo	HR	8.5	13.9	14.5	13.3	13.1	12.4	10.8	11.5	13.3	14.5	12.6
Yolo	HR									10.3		
Trial average		7.8	12.1	13.2	12.5	11.3	11.5	11.4	10.4	10.8	12.4	11.2
PLSD (5%)		0.6	0.6	1.5	1.0	0.6	1.0	2.5	0.7	0.6	0.5	--
PLSD (10%)		0.5	0.4	3.6	0.8	0.5	0.8	2.0	0.6	0.5	0.4	--
CV		4	1	7	5	3	5	13	4	4	2	--
Spring barleys						Protein percent (12% moisture basis)						
78Ab10274	2RF/M	8.2	10.0	12.7	12.7	11.6	11.8	9.1	8.3	11.1	11.2	10.7
82Ab23222 (Payette)	6RF	8.9	10.5	12.6	12.8	11.1	11.1	11.1	9.8	11.4	11.4	11.1
BSR 41	2RF/M	8.3	10.7				10.4	8.6		11.6	11.6	
BSR 45	2RF/M	9.0					12.0	12.2		12.1	12.0	
Baronesse	2RF	7.6	10.7	12.5	13.0	11.2	11.0	9.1	8.3	11.3	11.3	10.6
Colter	6RF	8.0	10.4	11.6	11.5	9.7	9.7	9.9	8.3	9.8	9.4	9.8
Columbia	6RF		10.4	12.6	12.8					11.2		
Crest	2RM	8.0	11.4	13.3	13.0	11.9	11.6	8.8	8.6	10.9	11.5	10.9
Crystal	2RM	7.9				11.6				11.4		
Gus	6RF		11.0									
Gustoe	6RF		10.1			10.2						
Harrington	2RM									11.1		
Maranna	6RF	8.3	10.2	12.9	12.9	10.8	11.5	9.2	9.8	11.6	12.0	10.9
Russell	6RM	8.6	10.1	11.3	11.7	10.3	10.8	8.1	8.7	11.0	10.3	10.1
Stander	6RM		11.0									
Steptoe	6RF	8.4	9.8	12.3	11.9	10.4	10.3	9.5	9.3	10.3	9.8	10.2
WA 11045-87	6R awnless	9.1										
WPB-BZ489-74	6R hulless	8.4	13.7	15.1	15.5	12.8	13.4	12.6	9.2	13.4	14.6	12.9
WPB-Sissy	6RF		10.2		14.0					11.8		
Trial average		8.4	10.7	12.7	12.8	11.0	11.2	9.8	8.9	11.4	11.4	10.8
PLSD (5%)		0.3	0.9	1.2	1.0	0.6	0.8	2.6	0.7	0.6	0.5	--
PLSD (10%)		0.3	0.8	1.0	0.8	0.5	0.6	2.1	0.6	0.5	0.5	--
CV		2	1	5	4	4	4	15	5	3	3	--

Table 16.—1995 grower drill strip winter wheat variety tests across Oregon and southeast Washington.

Variety	Johns Athena	Barnes Salem	Rudden-klau Amity	Klages Joseph	Hales Midway	Glasers Tangent	Miller Dufur	Newtson Pendl	Nichols* Dayton,W	Macnab Moro	Rietmann Ione	Weimer Clem	Ericksen Condon	Brown Wasco	Reser Condon	Peck Heppner	Average over 11 sites
									Yield - bu/a								
Celia			92														
Gene		109	114	92	96	82	73	64	54	58	36	54	40	34	33	31	77
MacVicar	123	119	119	99	91	91	66	65	66	58	61	49	42	41	36	25	92
Macl	109				89			71									
Madsen		113	111	118	90	95	84	72	62	49	64	48	41	52		29	84
Rod	136	124	115	88	101	92	92	74	92	56	52	52	46	55	31	55	102
Rohde	119	116	113	95	98	84	80	73	74		38	55	46	48	38	30	93
Stephens	133	113	121	94	95	82	65	68	65	52	65	49	45		57	47	95
W301				108	100			71			46	52		26		32	
Yamhill						98											
Mixture		108					96			59					36		
Average	124	115	112	99	95	89	80	70	69	56	52	51	43	43	38	35	90
* Hail storm shattered grain. Estimated loss of 4-7 bushels for all varieties but MacVicar which was reduced in yield by @ 30 bu/a																	
Mixtures: Barnes = all six other varieties; Miller = Crew/Hyak; Macnab = Gene/MacVicar; Reser = Hyak/Rohde;																	
									Test weight (lb/bu)								
Celia			57.0														
Gene			56.8	55.4	57.4	57.5	57.4	55.8	57		58.0			60.5	54.3	57.0	
MacVicar			59.0	55.0	60.9	60.1	58.2	58.4	60.5		60.2			60.5	58.5	58.1	
Macl					61.6			59.1									
Madsen			60.6	57.8	60.4	58.2	60.4	59.4	59		59.7			61.5		59.2	
Rod		62.8	57.1	55.3	58.0	58.5		57.4	59		57.0			59.1	56.1	57.6	
Rohde		59.9	60.9	58.4	60.6	58.1	60.5	59.9	63		59.7			62.2	58.5	60.6	
Stephens			59.6	57.3	60.4	60.3	58.3	57.6	60					60.7	56.4	58.9	
W301				57.9	60.7			58.5			60.0			61.7		59.9	
Yamhill						59.1											
Mixture							58.0								55.5		
Average		61.4	58.7	56.7	60.0	58.8	58.8	58.3	59.8		50.7			60.9	56.6	58.8	
									Protein percent								
Celia			9.4														
Gene			9.6	11.6	10.6	10.0	9.41	9.9						11.68	9.3	8.1	
MacVicar			9.5	11.0	10.2	8.3	9.00	9.2						11.84	8.5	8.3	
Macl					11.1			9.7									
Madsen			9.6	11.4	11.3	8.8	9.16	9.6						12.38		8.7	
Rod		9.8	9.2	12.6	9.3	8.5		8.5						11.39	8.3	9.1	
Rohde		9.9	9.8	12.4	10.0	10.1	7.75	8.8						11.36	7.2	8.8	
Stephens			8.8	11.3	10.5	8.5	9.07	9.5						11.78	9.4	9.2	
W301				11.3	10.2			9.3						11.48		8.9	
Yamhill						10.7											
Mixture															8.5		
Average		9.9	9.4	11.6	10.4	9.3	8.9	9.3						11.7	8.5	8.7	

Due to field or harvest problems, some yield data were lost.

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THE PACIFIC NORTHWEST RAINFALL SIMULATOR: A RESEARCH TOOL FOR THE INTERIOR NORTHWEST

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INTRODUCTION

Rainfall simulation provides researchers a method to evaluate the hydrologic and erodibility properties of agronomic practices. It provides experimental control and repeatability. We can not depend on natural rainfall to occur when and where it is needed to experimentally evaluate soil hydrologic and erodibility properties. Simulated rainfall, however, controls storm location, storm intensity and duration, aids in timeliness of data collection, allows for all-season data collection, and increases the ease by which several treatments can be evaluated at one time. Our ability to simultaneously collect hydrologic and erodibility data from multiple treatments reduces variability caused by changing weather and soil conditions, and thus provides us with an even-handed evaluation.

New farm management techniques designed to contribute to soil and water conservation are generally evaluated for their effectiveness under extreme conditions, typically a 100-year storm, or as is the case in the Pacific Northwest (PNW), a 100-year rainstorm onto frozen soil. It is unlikely that a 100-year storm will occur when we need it for research. With rainfall simulation, we can simulate multiple 100-year storms and recreate storm attributes within a particular season so that climate, soil, and plant growth conditions are relatively constant. By conducting rainfall simulations when there is much potential for erosion and runoff, we evaluate management methods under the worst case scenario. We assume that the treatments will respond in the same relative fashion for less severe conditions.

The use and development of rainfall simulators began in the 1930's in the mid-western and south-central United States where erosive storms are typically convectional, monsoonal, or both. These simulators produce higher intensity rainstorms with larger raindrop sizes than storms in the PNW. Typically, storms in the PNW have intensities less than 1/3 inch per hour (in/hr) and have a median drop size approximately two-thirds the size of the high intensity simulators.

Erosion in the dryland farming area of the PNW occurs predominately during the winter months as a result of low intensity rainstorms, snow melt on frozen soil, or both (Zuzel et al., 1987). The highest intensity rainfall during 31 years of record in Pendleton was 0.52 in/hr in May 1949, outside of the frozen soil erosion season. In the months when soil freezing occurs, October through March, the highest intensity recorded was 0.43 in/hr. Ninety percent of the rain on the Columbia Plateau falls at an intensity less than 0.10 in/hr (Brown et al. 1983). Because the vast majority of rain storms occurring in the inland PNW are low intensity, the process of soil erosion is not driven to the same degree by impact energy as it would be if storms were of the convectional type. In the PNW, we are concerned with the erosion processes of saturation and movement at the soil surface over soil that remains frozen.

Bubenzer et al. (1985) designed a low intensity rainfall simulator (the Palouse Rainfall Simulator) to produce rainfall typical of rain storms occurring naturally in the PNW. Rainfall could be applied simultaneously to two 6 ft. x 6 ft. plots. Plots with longer lengths, more suitable for rill development research, were considered possible if multiple units were assembled, unfortunately the support platform made such a combination impractical. Our objective in designing the Pacific Northwest Rainfall Simulator (PNW Rainfall Simulator) was to enhance the Palouse simulator by maintaining the distribution and physical characteristics of the raindrops while increasing the size and number of plots that could be simultaneously evaluated, increasing control of the nozzle performance, and automating data collection.

SIMULATOR DEVELOPMENT

The central unit of the Palouse simulator is the rotating disk and nozzle assembly. We began with this foundation and made changes to everything except the nozzle. Bubenzer et al. (1985) chose a 1/4HH14WSQ Full Jet nozzle for its ability to produce a drop size distribution similar to naturally occurring rainstorms and uniform areal coverage at low flow volumes. We discussed these criteria with industry representatives, reexamined the specifications, and decided to continue using the same nozzle. The nozzle produces drops with a median diameter of 0.07 inches and a rainfall intensity of 1.4 in/hr when operated at 15 psi. The rotating disk has four equal size spoke/openings that decrease the intensity of the rainfall by one half to 0.70 in/hr. Further adjustment of the intensity is controlled by the number of openings that are not covered by slats during simulations

Bubenzer et al. (1985) had modified a design by Amerman et al. (1970) and Rawitz et al. (1972). We further modified the design with these changes:

1. Reducing the size and weight of the nozzle platform.
2. Developing a structure that both supported the nozzle platform and served as a wind guard frame;
3. Redesigning the nozzle platform to be easily suspended from the wind guard frame.
4. Redesigning the nozzle platform and rotor to reduce the creation of drip points and splash surfaces that create large drops continuously at single points over plots.
5. Developing a system of shutters to provide rainfall intensities of 0.70, 0.53, 0.35, and 0.18 in/hr.
6. Instrumenting nozzles for monitoring water pressure. Each nozzle was plumbed for independent pressure adjustment.
7. Providing temperature sensors to measure water temperature falling on the plot, runoff, and air temperature within the rainfall simulator.
8. Instrumenting collection tanks to provide a continuous record of runoff.
9. Spacing nozzles to produce even coverage across larger plots than the simulator has been used for in the past.

SIMULATOR TESTING

McCool et al. (1978) and the nozzle manufacturer tested the nozzle for droplet size and droplet size distribution. Our major objective with attempting to enhance the simulator was to manufacture a simulator that would produce an even areal distribution across larger plots than the Palouse Simulator.

Initial calibration consisted of creating depth/volume tables for the runoff collection tanks at two water temperatures, and preliminary tests of the areal distribution of rainfall. We tested distribution within the 5 ft x 30 ft area using 3.125 inch diameter cans, spaced 14 inches apart. In these tests, nozzles were operated for 30 minutes, the water in the cans measured, and the intensity in inches per hour calculated. The coefficient of application uniformity (Christiansen, 1942) was and will be used to evaluate nozzle performance and relative positioning within each module at the previously mentioned intensities. The coefficient of application uniformity is:

Cu = [1 - (Average deviation from mean\mean depth applied)]*100

RESULTS AND DISCUSSION

The construction of the PNW Rainfall Simulator required an intensive team effort that began in August. We began, examined, and abandoned several avenues of design that looked promising initially, but initial testing proved them to be unacceptable. For instance one of our goals was to keep the weight of the unit as low as possible to improve portability and storage, and reduce set-up time in the field. The nozzle platform, which includes the rotating disk assembly, is one of the bulkiest and heaviest components. An alternative intensity control to the rotating disk design is the sweep design used in the Lafayette and Purdue Rainfall Simulators (Meyer and McCune, 1958; Foster et al. 1979). The nozzle used in the sweep design produces a narrow-fan pattern, which cuts off quickly when swept over a rectangular opening. The 1/4HH14WSQ Full Jet nozzle used produces a wide-square pattern, which we were not able to adapt to the sweep design. We thought we might eliminate the weight and the space requirements of the disk assembly by using an electrical solenoid shutoff to control the intensity. Unfortunately, nozzle performance was unacceptable with this method because of pressure fluctuations at the nozzle. Lacking a viable alternative, we redesigned the rotating disk assembly. It is now smaller, constructed of aluminum, easily installed on the support frame, and has fewer drip points than the original rotating disk assembly.

A major problem faced with the development and use of any rainfall simulator is the wind. Wind commonly occurs with natural rainfall, but simulated rainfall falls outside of the plot if the slightest of breezes is present. This problem is especially troublesome to efforts to simulate the rainfall characterized by small drops common in the PNW during rapid warming events associated with high winds. One solution to this problem is to block the wind using a sheet of plastic supported by fence posts. This solution is often used for small plots (3 ft x 3 ft). On larger plots, the simulations are conducted during periods without wind, usually in the morning hours shortly after daybreak. These methods work well if the plot size is small and the equipment extremely portable, however, given the amount of time required to set up a simulator for large plots, the schedule can not be dependent upon the vagaries of the weather. An efficient wind guard would also support the nozzle platforms. A Quonset-style portable garage serves as both wind guard and support.

One test at two levels of rainfall intensity has been completed for one rainfall simulator module. The Christiansen coefficient values are 85 for 0.73 in/h and 80 at 0.33 in/h. These values compare well with values obtained by Bubenzer et al. (1985) for areal distribution of a single nozzle at various rates (Table 1).

SUMMARY

The PNW Rainfall Simulator is a modified design of the Palouse Simulator. The new rainfall simulator is portable, rug ged, produces four rainfall intensities, and is instrumented to monitor nozzle pressures for control of rainfall drop size and distribution characteristics. With a four-module set, we can simultaneously apply rainfall onto four 5 ft x 30 ft plots to study the influence of soil and crop residue management systems on rill formation and erosion under PNW rainfall conditions, and collect data on air, soil, and water temperature and runoff. Each module

Table 1. Uniformity of rainfall application results, January, 1996, Pendleton OR.

Intensity in/h	Uniformity of application (%) Size of Plot 6.5 ft x 6.5 ft	5 ft x 30 ft
0.24	80	-
0.35	-	80
0.47	90	-
0.70	-	85
0.91	90	-

consists of three nozzle platforms housed inside of a Quonset-style shelter, which proved easy to move and also protected rainfall distribution from wind. We successfully used the PNW Rainfall Simulator in February 1996 to evaluate soil erosion control of four tillage systems under soil thaw conditions critical to PNW erosion events.

The PNW Rainfall Simulator will be used in coming years, during all seasons, to evaluate soil and water conservation in crop residue management and tillage systems. In the future, it will be used to develop basic seasonal knowledge of soil hydrologic and erodibility properties, evaluate new tillage methods and residue management systems, and elucidate the role of hillslope processes for use in watershed models such as the Watershed Erosion Prediction Project (WEPP).

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NITROGEN IN SURFACE RUNOFF AND SEDIMENT

C.L. Douglas, Jr., K.A. King, and J.F. Zuzel

INTRODUCTION

Soil management practices can critically affect the amount of nutrients in sediment and surface runoff. Reducing the amount of erosion is considered crucial, and modern tillage systems are frequently aimed at this goal. Soil management practices that reduce the amount of soil erosion may not reduce water soluble nutrient concentrations, but can be effective in reducing total nutrient loss by controlling the amount of sediment-transported nutrients (Barisas et al., 1978).

In eastern Oregon and Washington, where greater than 60 percent of the annual precipitation occurs from November through April (Douglas et al., 1988), surface runoff and erosion events occur infrequently during a typical year. An event is usually the result of unique weather and soil conditions, and a few extreme events generate most of the surface runoff and eroded sediments (Zuzel et al., 1993). The purpose of this study was to evaluate the effects of a wheat-pea rotation on the amount of nitrogen in surface runoff and eroded sediments.

MATERIALS AND METHODS

Six plots were established on the Kirk farm in the fall of 1977 on a 16 percent north-facing slope in the foothills of the Blue Mountains of northeastern Oregon. However, data to evaluate N in runoff and sediments were collected only in crop years 1980 through 1984. The 0.03 acre (110 by 13 ft.) plots were on a Thatuna silt loam (fine-silty, mixed mesic Xeric Argialboll) soil, located approximately 10 miles east of the Columbia Plateau Conservation Research Center at an elevation of 2,400 ft. The plow layer had greater than 4 percent organic matter and there was a slowly permeable clay layer at a depth of 30 in. Four of the plots were in a wheat-pea rotation during the experimental period. These plots had fall-seeded winter wheat (WW) (*Triticum aestivium,* L.) one crop year followed by spring-seeded fresh peas (SP) (*Pisum sativum L.*) the next crop year. During any given crop year, two plots were seeded to wheat and two to peas. Two plots were maintained in continuous fallow (CF) throughout the study.

All plots were moldboard plowed cross slope, disked, and springtoothed and/or harrowed up-and-down slope in the fall. Up and down slope tillage is a very poor practice, however, these plots were initiated primarily to monitor erosion and evaluate the Universal Soil Loss Equation (USLE) factors. This type of tillage was done to give the practice factor of the USLE a value of one (Zuzel et al. 1993). All fertilizer was surface-applied by hand at recommended rates for each crop. Winter wheat plots were fertilized with 50 lb N/acre as either ammonium nitrate or ammonium sulfate, packed, and seeded with a double disk drill in an up-and-down slope direction in the fall. They were topdressed in the spring with 50 lb N/ac. Pea plots were tilled in the fall, kept weed free with herbicides over winter, fertilized at seeding with 16, 20, and 11 lb N, P, and S/ac, respectively, and seeded up-and-down slope in the spring. Continuous fallow plots received a simulated seeding (no seed) with the same double disk drill in the fall and were never fertilized throughout the study.

After planting, plot borders were installed in October and removed in May, to contain surface runoff within plots and keep outside contamination to a minimum. Plot border installation and runoff and sediment collection are explained by Zuzel et al. (1993). Sediment concentration was calculated using the difference between the wet and oven dry weights and the liquid volume. Samples were analyzed for total N (TN) and soluble nitrate and ammonium N (SOL-N).

Sediment N (SED-N) in lb/ac was determined by subtracting SOL-N from TN. Flow weighted SED values (lb/ton) were calculated by dividing SED-N by the amount of transported sediment (ton/ac) (Laflen et al., 1984). Flow weighted SOL-N values (lb/ac-in) were determined by dividing SOL-N by inches of surface runoff. (Alberts et al., 1978).

RESULTS AND DISCUSSION

Average annual precipitation during the five year study was 25 in., which is slightly above average (23 in.), and ranged from 21 in 1980 to 28 in 1983. Approximately 80 percent fell during October to May when plot borders were in place (Fig. 1). There were a total of 258 measurable events during the study period, 112, 35, and 111 from the WW, SP, and CF plots, respectively (Fig. 2). These numbers differ from values in Zuzel et al. (1993) as they evaluated 12 years of data and only reported on erosion events greater than 225 lb/ac. Precipitation during September through December was 37 percent of the total for five years, and resulted in 12, 0, and 16 percent of the runoff events for WW, SP, and CF, respectively (Fig. 1 and 2). These low percentages are probably the result of time required to fill the soil profile with water (approximately 6 to 9 in.) to a depth of 48 to 60 in. after rains start in the fall.

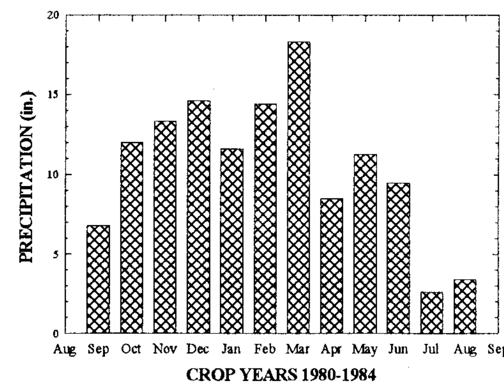

Figure 1. Average monthly precipitation at the Kirk farm for 1980-1984.

Events during February and March accounted for 53, 63, and 46 percent of the WW, SP, and CF events, respectively (Fig. 2). Thus, the largest number of events occurred after the soil profile was saturated during the winter.

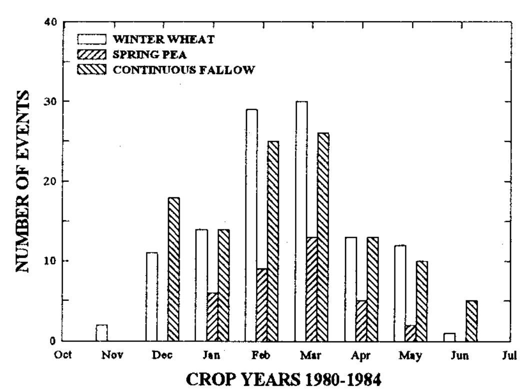

Figure 2. Number of measurable erosion events at the Kirk farm during 1980-1984.

Soluble N from each treatment varied widely from year to year (Fig. 3), however, highest values were during

January, February, and March. Soluble N concentrations were consistently highest for the WW treatment, which had mean weighted SOL-N concentrations of 0.1 lb N/ac-in of runoff for an individual event and a five-year total of 11.7 lb N/ac-in. Both spring peas and continuous fallow had mean concentrations of 0.07 lb N/ac-in., and five-year totals of 4.8 and 6.9 lb N/ac-in., respectively. Nitrogen mineral-ization from soil OM probably accounted for the SOL-N lost from the CF treatment as there was no fertilizer applied during the five years.

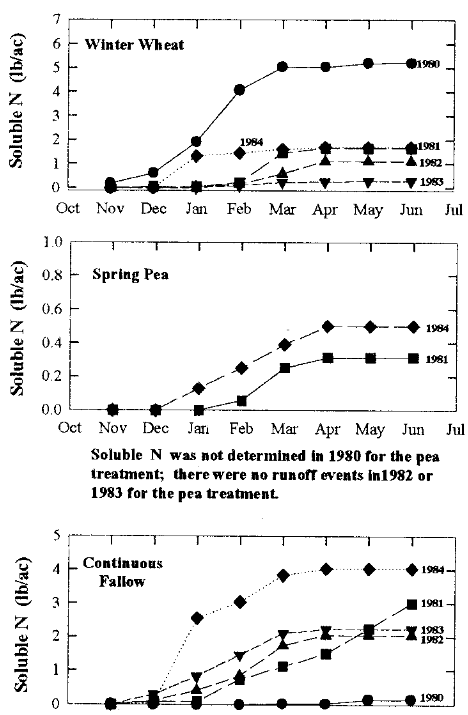

Figure 3. Cumulative soluble nitrogen for each treatment at the Kirk farm for years when there were measurable events.

Soluble N was a very small proportion of the N applied as fertilizer. Soluble N in surface runoff from the WW and SP treatments never exceeded 6 and 4 percent of the 100 and 16 lb N/ac/yr applied as fertilizer, respectively. This represented less than 2 percent of the total fertilizer N applied over the five-year period for both treatments.

Most of the N lost was associated with sediment loss (Fig. 4). The WW, SP, and CF plots had total sediment losses over the five- year period of 61, 10, and 260 tons/ac, respectively. Mean lbs of SED-N lost per ton of sediment lost, was 3.0, 4.4, and 2.0 for WW, SP, and CF, respectively. The high value for SP was a result of fertilizing and seeding in the spring when the soil was saturated with water. Thus, any precipitation that fell on the essentially bare soil surface resulted in loss of soil and nutrients. Winter wheat was also fertilized in spring, however, wheat plants had grown

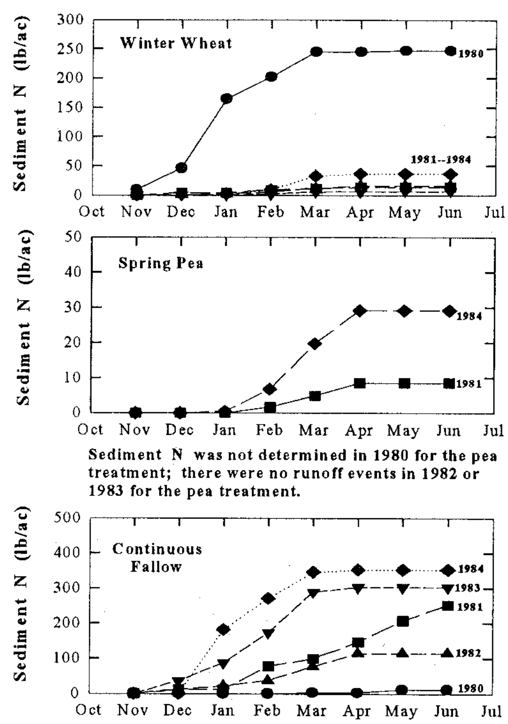

Figure 4. Cumulative sediment nitrogen for each treatment at the Kirk farm for years when there were measurable events.

over winter, removing soil moisture and creating ground cover to help control runoff and erosion.

CONCLUSIONS

Soluble N averaged less than 2 percent of the total N applied as fertilizer over the five year period for both the WW and SP treatments. Thus, fertilizer applied at recommended rates to this steeply sloping land was not an important source of N in surface runoff. Sediment N was the most significant source of N in surface runoff events. It is imperative that sediment loss be minimized to reduce the amount of N contaminating surface waters. Management systems that keep residues on the soil surface and even slightly reduce tillage will greatly decrease the amount of sediment loss and thus N loss.

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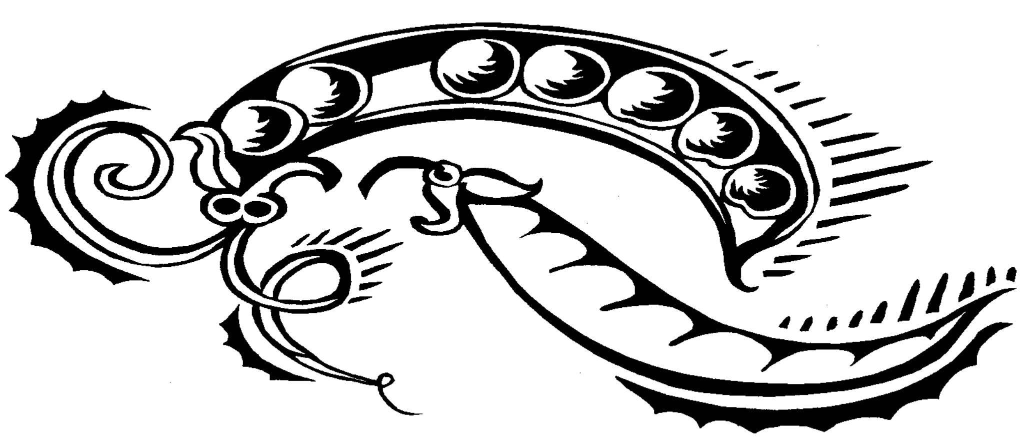

IMPACT OF NITROGEN FERTILIZATION AND STUBBLE BURNING ON THE DOWNY BROME SEEDBANK IN A WHEAT-FALLOW ROTATION.

Daniel A. Ball, D. L. Walenta, and
P. E. Rasmussen

INTRODUCTION

Downy brome (*Bromus tectorum* L.) is one of the major weed problems facing dryland winter wheat growers in the Pacific Northwest. Many of the practices used for the production of dryland winter wheat have an impact on downy brome, either directly or indirectly. For example, it has been shown that application of nitrogen fertilizer, if improperly timed, can increase downy brome growth (Anderson, Ball et al.). Burning of wheat crop residue after harvest has commonly been used as a method of controlling downy brome (Rasmussen). The objective of field burning is to destroy downy brome seed produced in the previous wheat crop. The effectiveness of stubble burning in reducing downy brome seed has not been well documented, although its use for this purpose is common. Knowing the relative contribution of nitrogen fertilization and stubble burning to the overall downy brome problem could help our understanding of why downy brome is such a problem for growers of winter wheat. Practices that affect the distribution, viability, and number of seeds in the seedbank have a definite impact on weed populations (Ball). The "seedbank" is defined as the reserve of seeds in the soil that give rise to weed infestations.

Experimental plots initiated in 1931 at the Pendleton Experiment Station have been used to study the long-term the effects of crop residue management practices such as nitrogen fertilization and stubble burning on soil properties and crop production in a dryland winter wheat crop rotation. Our objective was to utilize this long-term study to examine the effects of nitrogen fertilization and stubble burning on the quantity of downy brome in the seedbank.

METHODS AND MATERIALS

The study site is located at the Columbia Basin Agricultural Research Center near Pendleton, OR. The crop rotation is dryland winter wheat-fallow with conventional moldboard plow tillage. Experimental treat-ments employed on the site in each crop cycle since 1931 include nitrogen fertilization rates, organic amendment application, and stubble burning. This site is one of the oldest replicated research experiments in the western United States with a documented history of crop variety, tillage, date of seeding, and grain yield (Rasmussen and Parton). Treatments are imposed on plots each crop year in the wheat-fallow rotation, and a corresponding set of plots are treated in alternate years so that both fallow and cropped plots are available for observation in any given year. Soil samples were taken in both post-harvest stubble and pre-plant winter wheat in November 1994 to evaluate differences in downy brome seed populations due to various long-term treatments.

The experimental design is an ordered block consisting of nine treatments and two replications. Plot size is 38 by 132 ft. Treatments included: no burning + 80 lb/A N, no burning + 40 lb/A N, no burning + 0 lb/A N, no burning + pea vine addition (equivalent to 30 lb/A N), no burning +

manure addition (equivalent to 100 lb/A N), spring burning of wheat stubble + 80 lb/A N, spring burning of wheat stubble + 40 lb/A N, spring burning of wheat stubble + 0 lb/A N, and fall burning + 0 lb/A N. These treatments have been applied in each crop year since initiation of the study in 1931. Treatments that received N (32-0-0 shanked 6 inches deep with 10 inch spacing) were fertilized in October prior to seeding. Pea vines, or manure were broadcast in April prior to plowing down wheat stubble.

Multiple soil cores to a depth of 2 inches were taken in November of 1994 in post-harvest winter wheat stubble and to a depth of
6 inches in the pre-plant winter wheat plots. Downy brome seed was separated from the soil mineral fraction by flotation in a magnesium sulfate solution and sieving to extract seed. Downy brome seed were counted and expressed as number of apparently viable seed per m^2. Seeds that were physically damaged or decayed were also counted and recorded as dead seed per m^2.

RESULTS AND DISCUSSION

A general comparison between live and dead downy brome seed for samples taken in November pre-plant to wheat, and for samples taken in post-harvest wheat stubble illustrates that considerable downy brome seed mortality occurs during the time between the post-harvest period and when wheat is again seeded after a year of fallow (Table 1).

Long-term application of 40 or 80 lb/A of N to winter wheat without stubble burning resulted in higher post-harvest levels of live downy brome seed in the soil than in the control (0 lb/A) (Table 1). The higher level of seed from 40 compared to 80 lb/A N pre-plant and post-harvest may have been a function of increased wheat competitiveness with downy brome at the

Table 1. Downy brome seedbank estimates from soil samples taken in November 1994 from pre-plant winter wheat (6 inch depth) and post-harvest wheat stubble (2 inch depth) - Pendleton.

		Pre-plant (1995 crop)			Post-harvest (1994 crop)		
Burn	Nitrogen	Live	Dead	Total	Live	Dead	Total
	lb/A	seed/m^2					
NB	80	26	1395	1421	947	39	986
NB	40	197	1842	2039	1500	26	1526
NB	0	13	237	250	237	53	290
NB	M(100)	132	1000	1032	592	0	592
NB	P(30)	26	513	539	224	13	237
SB	80	53	671	961	329	0	329
SB	40	66	171	237	105	0	105
SB	0	39	368	407	118	0	118
FB	0	26	53	49	118	0	118
LSD	(0.10)	89	535	576	359	NS	392

NB = No residue burning, SB = spring burn, FB = fall burn, M(100) = manure supplied approximately 100 lb N/A, P(30) = pea vines supplied approximately 30 lb N/A.

higher N application rate. This suggests that optimum N fertilization of winter wheat, although necessary for maximal wheat yields, can also be a long-term factor contributing to the overall downy brome problem by increasing the size of the downy brome seedbank. Mineral N fertilizer, as applied in this study, increased the downy brome seedbank.

Organic amendments of pea vines or manure did not significantly increase ($p > 0.10$) post-harvest downy brome seedbank levels to the extent of mineral N application, even though the rates of N applied were comparable to, but in a different form than the mineral N treatments. This indicates that the form of applied N and the time that N is available to the wheat crop and downy brome plant can control the size of the downy brome seedbank.

Spring burning of wheat stubble reduced the post-harvest downy brome seedbank in the 40 and 80 lb/A N fertilization treatments. Spring burning reduced the pre-plant levels of live downy brome seed only at the 40 lb/A N fertilization rate. From these results, it can be concluded that long-term burning of wheat stubble can be used to reduce downy brome seedbank levels.

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EFFECT OF RESIDUE MANAGEMENT ON PREDICTED SOIL LOSS

Dale Wilkins, Hebing Liu and John Williams

INTRODUCTION

The Food Security Act of the 1985 and 1990 Farm Bills required conservation plans for highly erodible land (HEL) if farmers wanted to participate in farm programs. Conservation farming plans were developed based on predicted average annual soil loss. These soil loss predictions were made using the USLE (Universal Soil Loss Equation) erosion model described by Wischmeier and Smith (1965 and 1978). An updated version of USLE called RUSLE (Revised Universal Soil Loss Equation) is now available on diskettes for PC's (Personal Computers) from the Soil and Water Conservation Society, Ankeny, Iowa. NRCS (Natural Resources Conservation Service) uses RUSLE to help guide farmers in developing conservation management systems.

RUSLE is the third version of USLE. It is an empirical equation derived from theory of erosion processes and a vast amount of data from natural runoff and rainfall simulator plots (Renard et al. 1996). The RUSLE equation is as follows:

$$A = RK(LS)CP$$

A is average annual soil loss from sheet and rill erosion in tons per acre per year. R is a rainfall-runoff erosivity factor that is composed of a rainfall erosion index plus a factor for runoff associated with snowmelt. R is expressed in units of hundreds of foot ton inches per acre hour year. K is soil erodibility; a factor that accounts for the influence of soil properties on erosion and is determined from data collected on plots managed under a standard set of conditions. K has units of ton acre hour per hundred acre foot ton inch. LS is a combined effect for slope length and slope steepness and is dimensionless. C is a factor for crop residue and cover management and is dimensionless. P is a dimensionless factor for support practices such as contour and stripfarming.

The objectives of this research were to use RUSLE to compare predicted soil loss from four tillage and residue management systems and to provide an opportunity for exchange of soil erosion technology with Mr. H. Liu, a visiting scientist from China.

MATERIALS AND METHODS

Data from a winter wheat/summer fallow crop residue management experiment located adjacent to Wildhorse Creek near the Columbia Plateau Conservation Research Center was used to demonstrate the use of RUSLE. This experiment had four treatments providing different primary tillage and amounts of crop residue on the soil surface after seeding winter wheat. Treatment 1 used chisel plowing as the primary tillage. Moldboard plowing was the primary tillage for treatments 2, 3 and 4. Residue was removed before plowing in treatments 3 and 4 and returned to the soil surface after plowing. Treatments 3 and 4 had 1,800 and 5,500 lb per acre of residue placed on the soil surface after moldboard plowing, respectively. Secondary tillage during the fallow summer was the same for all plots. After seeding, residue cover was measured by the line transect method and found to be 39, 9, 21 and 38 percent for treatments 1, 2, 3 and 4, respectively.

A combination of the RUSLE Field Office Technical Guide (USDA, 1995) and the computer version of RUSLE (Soil and Water Cons. Soc., Ankeny, Iowa) was used to determine RUSLE factors R, K, LS, C and P. The procedure was as follows:

1. Erosivity Factor R:

When RUSLE is used to estimate sheet and rill erosion in the dryland crop areas of the Pacific Northwest the effect of melting snow, rain on snow, and/or rain on thawing soil poses unique problems. Soil losses in this region are much greater than the values that might be expected from conventional R values. Therefore, an R equivalent (R_{eq}) is used instead of the conventional R. R_{eq} was selected by locating the site on the county R_{eq} map and selecting R_{eq} from the closest isoerodent (R_{eq}) line (USDA, 1995). The R_{eq} value was found to be 60.

2. Soil Erodibility Factor K:

In Oregon, Kf values are used for the K factor in RUSLE. Kf represents soil erodibility of fine soil (<0.08 inches). From the Soil Survey Map of Umatilla County Area, the soil at this site is Walla Walla Silt Loam and the Kf value is 0.43 (USDA, 1988).

3. Slope Length and Steepness Factor LS:

The slope length/slope steepness factor (LS) includes the combined effect of slope length and steepness on erosion. LS represents how erodible the particular slope length and steepness is relative to the 72.6 ft. long, 9 percent steep, standard USLE plot. Slope length and steepness at this site were measured and found to be 250 feet and 23 percent, respectively. LS values were calculated with the computer version of RUSLE and found to be 3.21.

4. Support Practices Factor P:

The effects of supporting practices like contouring, stripcropping, and terraces are described by the P factor in RUSLE. Support practices are often used in combination. In this case, contouring and cover-management were used. Cover management conditions were classified as condition 5, "Light cover and/or moderate roughness (Table 1, "Cover Management Conditions", USDA, 1995). The site was seeded on contour with a double disc drill. Factor P was determined by identifying the site characteristics hydrologic soil group, slope gradient and length, grade along furrows, and 10-year storm erosivity (10-yr EI). Using this information, P was determined from the appropriate table (USDA, 1995). The site characteristics used to determine critical slope length were as follows:

a) Hydrologic soils group C (moderately high runoff potential).
b) Landscape profile slope was 23 percent, and the horizontal slope length was 250 feet. Furrow grade was 0.0 percent.
c) For a dryland farm site near Pendleton, the 10-yr EI = 10 (USDA, 1995).
d) Small grain with cover-management condition 5 .
e) A ridge height of 1.5 inches is classed as a very low ridge.
f) Seeded on contour.

P subfactor value was determined to be 0.59 (Table 3 section II , USDA, 1995). Because the furrow grade was 0.0 percent, there was no need to adjust P.

The critical slope lengths was 680 ft for hydrologic soil group C, 23 percent slope, 10-yr EI = 10, and cover and management condition 5 (Figure 31, USDA, 1995). The critical slope length exceeded the 250 feet slope length and therefore the P subfactor value was applied without adjustment.

5. Cover-Management Factor C:

The treatments at the Wildhorse Creek Site represent four cover-management systems. The treatments were as follows. Treatment 1 = chisel plowing. Treatment 2 = moldboard plowing (traditional tillage). Treatment 3 = mow-plow ; 1,800 pounds of residue per acre. Treatment 4 = mow-plow ; 5,500 pounds of residue per acre. Crop residue cover measurements from the field site on October 5 and 6, 1995 after seeding these plots were 39 , 9 , 21, and 38 percent for treatments 1, 2, 3, and 4, respectively. The RUSLE C values for winter wheat/fallow crop rotation, producing 60 bushels of grain per acre, seeded early and having residue covers of 39, 9, 21 and 38 percent, were determined by the computer program and found to be 0.038, 0.13, 0.087, and 0.04 for treatments 1, 2, 3, and 4, respectively.

RESULTS AND DISCUSSION

Average annual soil loss caused by rainfall as predicted by RUSLE for these tillage and site conditions varied from 1.9 to 6.4 tons per acre per year (Table 1).

C was the only RUSLE factor that was different for the four treatments. The variation in predicted soil loss was due to the amount of surface residue cover. There is no differentiation made for the variation in the nature of the surface residue or the influence of maintaining the crop residue near the soil surface. Chisel plowing incorporates residue in the top 4 inches (Wilkins and Kraft, 1988) and this includes wheat plant crowns. The moldboard plow buries wheat crowns more than 4 inches deep. If these treatments were practiced continuously, it is possible that the infiltration characteristics of the surface soil would be different between soil that was chisel plowed and moldboard plowed.

RUSLE is an erosion model designed to predict the longtime average annual soil loss by runoff from specific field

Table 1. Average annual soil loss at Wildhorse Creek site located near Pendleton, Oregon..

Treatment	Residue Cover	R_{eq} †	RUSLE factors Kf‡	LS	C	P	Soil Loss A§
	%						
Chisel plow	39	60	0.43	3.21	0.038	0.59	1.9
Moldboard plow	9	60	0.43	3.21	0.130	0.59	6.4
Mow-plow - 1,800 lb/ac of residue	21	60	0.43	3.21	0.087	0.59	4.3
Mow-plow - 5,500 lb/ac of residue	38	60	0.43	3.21	0.040	0.59	2.0

† R_{eq} has units of hundreds of foot ton inches per acre per hour per year.
‡ K has units of ton acre hour per hundreds of acre per foot per ton per inch.
§ A is shown in tons per acre per year.

slopes in specified cropping and management systems. RULSE is not designed to predict soil loss from individual events.

Field measurements of runoff and soil loss associated with natural runoff events and simulated rainfall are being collected at this site. It will be interesting to see if predicted soil loss and measured loss agree.

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FUNGICIDE SEED TREATMENTS INFLUENCE EMERGENCE OF WINTER WHEAT IN COLD SOIL

Richard W. Smiley, Lisa-Marie Patterson and Chad W. Shelton

INTRODUCTION

Drought during 1994 delayed winter wheat planting. Most growers "dusted" the seed shallowly into dry soil before the first significant rain occurred in late October. Once started, rain was nearly continuous through December. Wheat planted into cold, wet soil during November required as many as seven weeks to emerge.

Stands were generally worse in plantings made after the rains began than where seed was dusted into dry soil, even when the same drill and drill adjustments were used on both planting dates. This timing effect on stand establishment appeared to be associated with soil compaction by drills equipped with press wheels operated on wet soil. In certain instances emergence appeared better from seed treated with RTU Vitavax Thiram than Dividend. This was surprising because Dividend generally improves seedling emergence, grain yield, and net economic return on investment, compared to RTU Vitavax Thiram (Smiley and Patterson, 1995; Smiley et al., 1996).

Pythium and *Rhizoctonia* species cause seed rot, pre-emergence damping-off, and post-emergence root rot and stunting in cold soil (Cook and Haglund, 1991; Hering et al., 1987; Mazzola et al., 1996). *Pythium* damage is recognized mostly in higher rainfall (>16 inches) regions where wheat is planted into cold soil that is cropped annually, such as in the winter wheat-green pea rotation. During February 1995, *Pythium* species were isolated from every rotted seed and dying seedling collected from fields with poor wheat stands. This occurred in areas of very low and high mean annual precipitation. This suggested that *Pythium* was involved in the emergence problem during 1994. Dividend is inhibitory to a broad group of pathogenic fungi but is not toxic to *Pythium*. Thiram is moderately toxic and Apron is highly toxic to *Pythium*.

Objectives of this study were to improve seed treatment recommendations for winter wheat planted into cold soils in the wheat-fallow region of the Pacific Northwest. Experiments examined the influence of Dividend, Apron, and RTU Vitavax Thiram on seedling emergence in the field during late autumn 1994 and under comparable conditions in the greenhouse.

METHODS

Weather and soil environment data were collected for 12 reporting sites in winter wheat-summer fallow rotation areas in the Pacific Northwest. Data were collected from two sites operated by Oregon State University and 10 sites affiliated with the Public Agricultural Weather System operated by Washington State University. This information was used to establish experimental variables for experiments in the greenhouse.

Cold, dry soil in the greenhouse:
Emergence was evaluated in the greenhouse by incubating seed in cold, dry soil before adding water. Stephens wheat was treated with RTU Vitavax Thiram (5 fl oz/cwt), Dividend (0.5 fl oz/cwt), Dividend + Apron (0.5+0.09 fl oz/cwt), Dividend + Thiram (0.5+1.4 fl oz/cwt), or no fungicide. Walla Walla silt loam was air dried and passed through a sieve with 0.1-in. openings.

Soil was placed into 3-in. diameter x 6-in. high plastic cylinders with solid bottoms. This dry soil weighed 1.5 lb/cylinder. Four wheat seeds were placed at planting depths of 0.75- or 1.5-in., with four replicate pots for each of the five fungicide treatments. Four additional treatments included RTU Vitavax Thiram and Dividend treatments placed into soil sterilized by autoclaving. All pots of dry soil with wheat seed were incubated at a continuous 38 °F for one week and then wetted with chilled (38 °F) water to 25 percent (by weight) soil water content. Field capacity for this soil is 28 percent. The experiment was terminated when no further emergence was evident 49 days after planting. The experiment was repeated.

Cold, wet soil in the greenhouse:

Undisturbed soil columns (3-in. diameter x 6-in. high) were collected from a Ritzville very fine sandy loam in a field with poor winter wheat emergence. Variables included two soil moisture contents (18.5 and 25 percent, by weight), and five fungicide treatments (described above). Four seeds per column were planted at 1.5-inch depth by drilling tiny channels laterally into the undisturbed soil columns. Seed was inserted without disrupting the soil surface. Selected fungicide treatments were also evaluated at a planting depth of 0.75 inch. Soil columns were adjusted to appropriate water contents and temperature (38 °F) before planting. The experiment was terminated when no further emergence was evident (40 to 49 days).

The experiment was repeated in a revised form because emergence was very poor in compact soil collected from the field. The surface inch of soil was loosened by thorough mixing. Other parameters were the same as in the first experiment.

Cold, dry soil in the field:

Winter wheat was "dusted" into cold, dry soil near Milton-Freewater, Waitsburg, and Pomeroy. Two seed treatments were compared with no seed treatment at Milton-Freewater and Waitsburg, where winter wheat followed green peas in a two-year rotation. The Milton-Freewater and Waitsburg sites were characterized, respectively, by Athena and Palouse silt loams, 18 and 22 inches annual precipitation, and 90 and 100 lb N/acre applied as a surface broadcast. Seedbeds were prepared by moldboard plow (8-inch depth), disk and harrow near Milton-Freewater, and by disk (3-inch depth) and harrow near Waitsburg. Harmony Extra, Buctril, and Lexone (0.4+12+2 fl oz/acre) were applied before planting near Milton-Freewater and no herbicides were applied near Waitsburg. Plots were planted with a Hege plot drill equipped with hoe openers, 12-inch row spacing, and press wheels. Stephens wheat was placed 1-1.5 inches deep and at 18 seed/sq ft into dry soil on 9-10 Oct 1994. Soil temperature at planting depth was 55-60 °F. Seed was treated with Dividend + Maxim (1+0.16 fl oz/cwt), RTU Vitavax Thiram + FloPro IMZ (5+0.5 fl oz/cwt), or no fungicide. Each plot was 10 x 24 ft and replicated six times in a randomized complete block design. Seedling emergence was quantified on 7 Nov 1994 and 9 Feb 1995. Plots were harvested during August and grain yield and test weight were calculated.

Three seed treatments were compared with no seed treatment near Pomeroy WA. Winter wheat followed summer fallow in a two-year rotation. The soil is an Athena silt loam in a region with 18 inches annual precipitation. Fertilizer (70 lb N + 10 lb S/acre) was applied and the seedbed prepared. Plots were planted with a Hege plot drill equipped with double-disk openers, 8-inch row spacing, and press wheels. Madsen wheat seed was placed 2-3 inch deep and at 100 lb/acre into dry soil (65

°F) on 18 Oct 1994. Seed was treated with Dividend (0.5 or 1 fl oz/cwt), RTU Vitavax Thiram (5 fl oz/cwt), or no fungicide. Plots were 5 x 75 ft and replicated three times in a randomized complete block design. Seedling emergence was quantified on 2 Mar 1995. Plots were harvested during August and grain yield and test weight were calculated.

Cold, wet soil in the field:

Five seed treatments were compared at a second location near Pomeroy. Winter wheat followed summer fallow in a two-year rotation. The soil is an Onyx silt loam in a region with 14 inches annual precipitation. Fertilizer (60 lb N + 8 lb S/acre) was applied and the seedbed prepared. Plots were planted with a Hege plot drill equipped with double-disk openers, 8-inch row spacing, and press wheels. Stephens wheat seed was placed 1-1.5 inches deep and at 100 lb/acre into cold (45 °F), wet soil on 3 Nov 1994. Seed was treated with Dividend (0.5 or 1 fl oz/cwt), Dividend + Maxim (0.5 fl oz+0.09 oz/cwt), Dividend + Maxim + Apron (0.5 fl oz+0.09 oz+0.07 oz/cwt), or RTU Vitavax Thiram (5 fl oz/cwt). Plots were 5 x 75 ft and replicated three times in a randomized complete block design. Seedling emergence was quantified on 2 Mar 1995. Plots were harvested during August and grain yield and test weight were calculated.

All data were evaluated by analysis of variance using the CoStat Statistical Analysis program. Least significant differences are reported for data significant at 95 percent or higher confidence intervals.

RESULTS

Soil temperature and rainfall near Pendleton, OR (Fig. 1) during autumn and winter 1994 are presented to depict climatic conditions represented by this research. Soil in most areas was too dry for seed germination until the last week of October and was consistently wet from late-October through December. Soil temperature at 1-inch depth near Pendleton declined from 65 °F to 39 °F during October, to 33 °F during early November, and 25 °F during early December. The range of growing degree days accumulated at 12 weather stations in the inland PNW ranged from 150 to 330 during November 1994.

Cold, dry soil in the greenhouse:

Data for 0.75- and 1.5-inch planting depths were combined because they were statistically equivalent. Emergence of Dividend-treated seed was lower than for seed treated with RTU Vitavax Thiram (Table 1). Emergence of seed treated with mixtures of Dividend + Apron or Dividend + Thiram was excellent and equivalent to treatment with RTU Vitavax Thiram. Rate of emergence was more rapid for Dividend + Apron than other treatments. Percentages of seedlings with Pythium root rot damage were greater in Dividend- than RTU Vitavax Thiram-treated seeds. There was no damage from Pythium root rot on seedlings produced from seed treated with both Dividend and Apron.

When soil was autoclaved to remove pathogens, emergence was not improved in the RTU Vitavax Thiram treatment (97 percent emergence) and was improved in the Dividend treatment (62 percent in natural soil and 94 percent in sterilized soil).

Cold, wet soil in the greenhouse:

Emergence was very poor and was not affected by water content or fungicides in undisturbed, compact soil columns (Table 2). Emergence improved when the soil surface was loosened. Emergence of seed through compact soil was improved when treated with RTU Vitavax Thiram and planted at 0.75-

Figure 1. Maximum and minimum soil temperature (4-inch depth until 1 Nov. and then 1-inch depth) and rainfall during the 1994 winter wheat planting and seedling establishment period near Pendleton OR.

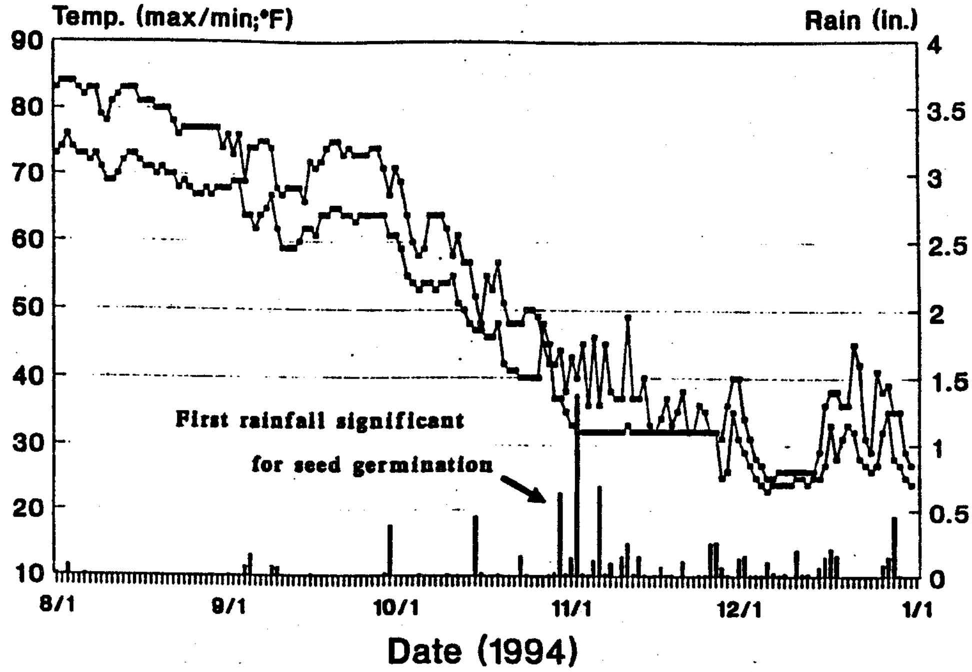

Table 1. Influence of fungicide seed treatments on emergence and Pythium root rot of Stephens wheat planted into cold (38 °F), dry soil that was wetted to 25 percent soil moisture one week after planting into greenhouse pots; data were collected as soon as emergence was complete at 49 days after planting.

Seed treatment and rate (fl oz/cwt)	Emergence (percent)	Pythium root rot (percent plants)
Untreated	68	35
RTU Vitavax Thiram (5)	95	4
Dividend (0.5)	50	53
Dividend + Apron(0.5+0.09)	98	0
Dividend + Thiram(0.5+1.4)	90	7
lsd (0.05)	16	13

Table 2. Influence of fungicide seed treatments on emergence (percent) of Stephens wheat planted 1.5-inch into cold (38 °F), wet soil collected as intact columns from the field and incubated in the greenhouse.

Seed treatment and rate (fl oz/cwt)	Firm surface†	Loose surface‡
Untreated	3	60
RTU Vitavax Thiram (5)	16	73
Dividend (0.5)	3	63
Dividend + Apron (0.5+0.09)	3	85
Dividend + Thiram (0.5+1.4)	10	55
lsd (0.05)	ns	ns

†Soil surface was unaltered from "field" status.

‡ Soil surface was loosened by mixing.

Table 3. Influence of fungicide seed treatments on emergence and yield of winter wheat planted into dry or wet cold soils infested with species of *Pythium*; results of two field experiments near Pomeroy, WA during 1994-1995.

Seed treatment† and rate (fl oz/cwt)	Seedlings/ ft of row		Grain yield (bu/ac)	
	Dry	Wet	Dry	Wet
Untreated	5.9	-	61	-
RTU Vit. Thir. (5)	6.1	5.0	62	64
Div. (0.5)	7.3	3.1	67	54
Div. (1.0)	7.2	3.3	63	53
Div.+Max. (0.5+0.09)	-	4.0	-	53
Div.+Max. +Apr. (0.5 +0.09+0.07)	-	10.9	-	74
lsd (0.05)	ns	1.9	3	2

† Treatments include RTU Vitavax Thiram, Dividend, Maxim, and Apron.

compared to 1.5-inch depth (88 and 25 percent emergence, respectively). Emergence of Dividend-treated seed was poor at both planting depths in compacted soil; 19 and 6 percent for seed at 0.75- and 1.5-inch depth, respectively. *Pythium* species were isolated from all seeds that failed to germinate.

Cold, dry soil in the field:
Seedling emergence was evaluated at plots near Milton-Freewater and Waitsburg two weeks after rains began in late October. Soils were saturated and near freezing at that time. Coleoptiles were about 0.5-inch long and uniform in all treatments at both locations. Seedling growth was also uniform among treatments on 9 Feb 1995. Grain yields did not differ among treatments (135-137 bu/acre) near Milton-Freewater and were lower for treated (107-108 bu/acre) than untreated (112 bu/acre; lsd = 3) seed near Waitsburg. Grain test weights did not differ among treatments at either location.

On 2 Mar 1995 near Pomeroy there were no differences in seedling stand among seed treatments (Table 3). Grain yield from seed placed into dry soil was higher in the Dividend (0.5 fl oz rate) than in other treatments. Test weights were 59-61 bu/acre.

Cold, wet soil in the field:
On 2 Mar 1995 near Pomeroy there were fewer plants in the Dividend treatments than for RTU Vitavax Thiram (Table 3). Applying Maxim with Dividend did not improve stand density. When Apron was applied with Dividend + Maxim the stand density was twice as high as in the RTU Vitavax Thiram treatment. Grain yields were also highest for the treatment containing Apron. Test weights were 59-61 bu/acre.

DISCUSSION

Dividend is a triazole fungicide developed to control smut diseases. In the greenhouse, seed treated with Dividend emerged more poorly from cold soil than seed treated with RTU Vitavax Thiram. When Dividend was supplemented with either Thiram or Apron the emergence was comparable to RTU Vitavax Thiram. Results were similar for seed planted into cold, wet soil in the field. These findings support the hypothesis that *Pythium* seed rot and pre- and post-emergence damping off were the primary cause of poor stand establishment for Dividend-treated seed in some fields during the autumn of 1994.

It also appears that *Pythium* can affect emergence of unprotected seed under at least some circumstances when seed is dusted into the surface of cold, dry soil before rainfall begins. Dividend-treated seed planted under cold, dry conditions was associated with reduced emergence in the greenhouse but not the field. Experiments in the greenhouse therefore demonstrated a potential for *Pythium* damage that was not realized under the field conditions evaluated during 1994.

Experiments with intact columns of soil also illustrated that surface compaction can easily prevent establishment of acceptable winter wheat stands. Packer wheels on double-disk and hoe-type drills, and split- or solid-packers on deep-furrow drills, are usually essential for proper stand establishment in soils with a dry surface, but are often detrimental in silt loams that are moist or wet when planted. Poor emergence during 1994 was frequently associated with the use of packer wheels on drills operated on wet soil.

Diseases caused by *Pythium* are widespread (Cook et al., 1987) and include seed rot, seedling damping-off, and browning root rot. *Pythium* is most important in regions where annual precipitation exceeds 16 inches (Cook et al., 1990; Cook and Haglund, 1991). Pythium root rot is particularly severe in fields with minimum or no tillage, especially when cropped annually and seeded late. Under those conditions *Pythium* is frequently isolated from embryos of germinating seeds and from juvenile root tissues. Apron fungicide is available for suppressing the seed rot and damping-off stages, but is less effective against root rot of older seedlings (Cook and Zhang, 1985). Seed of poor quality is more prone to damage than high-quality wheat seed (Hering et al., 1987).

Hering et al. (1987) showed that *Pythium* species can invade unprotected wheat seed within 24 hours. The optimum rate for germination of wheat occurs above 54 to 68 °F. Germination and emergence are very slow in soil colder than 45 °F. Spring wheat usually requires 42 days to emerge from soil at 42 °F. Winter wheat requires approximately 80 growing degree days (GDD) for germination and 50 additional GDD for each inch of planting depth. Calculated times for emergence from soil at 38 °F, as in our greenhouse experiments, are 18 and 26 days for planting depths of 0.75 and 1.5 inch, respectively (105 and 155 GDD). Wheat planted in the PNW during November 1994 required 130 to 180 GDD for emergence. Temperature records at 12 PNW locations indicated an accumulation of 150 to 330 GDD during November 1994. Thirty or more days were required for emergence in most situations where stand failures were reported. Seed planted without a protectant active against *Pythium* was at a definite disadvantage under those circumstances.

Our results clearly illustrated that *Pythium* is potentially important even in very dry regions. Routine use of Thiram as a co-fungicide with Vitavax appears to have reduced the potential for emergence problems associated with late plantings in past years. The experience with late plantings into wet soil during 1994 defined the need for a *Pythium*-controlling fungicide on wheat seed planted after about October 15 in all regions of the Pacific Northwest.

SUMMARY

Emergence of winter wheat from cold (38 °F) soil was more complete when seed was treated with mixtures of Dividend+Apron, Dividend+Thiram, or RTU Vitavax Thiram than with Dividend alone or untreated. Differences in emergence were caused by Pythium root rot. Treatments including Thiram, Apron or other fungicides toxic to *Pythium* species are recommended for winter wheat seed planted after about October 15.

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TOWARD A WINTER MALTING BARLEY

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INTRODUCTION

This is our seventh season of a concerted effort to develop a winter six-row malting barley. I doubt there is anything in the field today the U.S. malting and brewing industry would clamor for tomorrow. However, if we imagine a winter malting barley as a puzzle composed of interlocking genetic pieces, then I am optimistic that some pieces of the puzzle are present in our breeding program.

In envisioning a winter malting barley, we need to consider what makes a winter barley, what makes a malting barley, and what makes for profitable barley production. The first two issues we can begin to address through genetic analysis and breeding.

We have addressed winter malting barley variety development in several ways. First, we produce all our breeding lines through the doubled haploid (DH) technique. This shortens the breeding cycle and ensures that materials are homozygous. Secondly, we have been active in barley genome mapping. The idea is to locate, on maps of the seven chromosomes of barley, genes that are of economic importance. Examples of such genes are those that distinguish winter from spring varieties, that determine resistance to diseases, and that contribute to malting quality. Very often, these genes are rather elusive and we have to describe them in statistical terms - as Quantitative Trait Loci (QTL) - rather than as specific DNA sequences. In any event, if you know where the genes are, you can more effectively move them around in a conventional crossing program. To date, our DH breeding and QTL detection efforts have proceeded in an essentially parallel fashion. We are now in a position to begin integrating the two efforts.

Winter habit is determined by a number of quantitatively inherited traits, including growth habit, vernalization response, photoperiod reaction, and cold tolerance. We have used marker-based strategies to identify QTL associated with these traits in the DH progeny of a winter x spring cross (Hayes et al., 1993a; Pan et al., 1994). In the lines we have studied, the genes determining winter growth habit and those determining malting quality are not located in close proximity. Thus, there appears to be no genetic barrier to combining quality and winter growth habit.

No winter malting varieties are currently in commercial production in North America. In Europe, considerable progress has been made in winter malting barley improvement, although winter types in general have not achieved the level of quality found in spring genotypes (Schildbach, 1987) (Table 1). Malting quality specifications vary between Europe and North America, reflecting different brewing practices, and these differences are principally related to desired levels of grain protein and enzyme activities.

Malting quality is determined by a number of component traits. Foremost among these are grain protein and extract percentages, the ratio of soluble to total protein, diastatic power, α-amylase, the difference in extract percentage between finely and coarsely ground malt, and the wort ß-glucan content. A comprehensive review of the biochemical basis of malting quality in the context of barley improvement is presented by Burger

Table 1. Performance of European winter malting barley varieties in EBC trials compared to a representative average of spring varieties. (Source: Schildbach, R. Malting barley worldwide. 1994. Brauwelt 4:292-308).

	Plaisant	Clarine	Petula	Fighter	Sprite	Astrid	Angora	Spring Ave. 13 var.
Origin/no. of rows	F/6	F/2	F/2	GB/2	GB/2	D/2	D/2	-./2
Yield, t/ha	6.4	6.3	6.1	6.2	6.1	6.1	6.4	5.4
Plump fraction, %	77	83	94	87	85	92	91	75
Protein,%	10.2	10.7	11.2	10.9	10.9	11.7	11.1	10.5
Extract	80.1	80.2	80.4	80.5	80.4	80.4	81.2	81.4

and LaBerge (1985). Briefly, malting is a carefully controlled germination processes in which complex proteolytic pathways are manipulated to develop an ideal substrate for subsequent fermentation. Kernel carbohydrates are hydrolyzed by α- and ß-amylases, and the selection criteria of a-amylase and diastatic power are thus measures of individual (α) and combined (α plus ß) enzymatic activities. Proteinase activity is expressed as the ratio of soluble to total protein (S/T). Malt extract percentage is a measure of the percentage of the malt rendered soluble. The fine-coarse difference and the wort ß-glucan percentage are additional measures of the completeness of the malting process (modification). Experimental evidence indicates that the components of malting quality are quantitatively inherited (Peterson and Foster, 1973). QTL for a number of malting quality characters have been reported in spring and winter germplasm (Hayes et al., 1993b; Hayes et al., 1996).

In addition to winter growth habit and malting quality, a winter barley adapted to the Pacific Northwest (PNW) needs additional attributes. It needs to equal or exceed feed barley yields and it should be resistant to barley stripe rust. Yield is the ultimate character, and can be addressed through QTL mapping procedures, although the applicability of the information may vary from cross to cross (Hayes et al., 1996). Likewise, the genetic determinants of stripe rust resistance can be located through QTL mapping procedures (Chen et al., 1994).

RESULTS AND DISCUSSION

As stated earlier, our QTL mapping efforts and our DH breeding have proceeded essentially in parallel. Our DH breeding has generated high yielding, stripe rust resistant genotypes with significantly better malt extract than the feed barley checks (Tables 2 and 3). These selections do not meet domestic quality specifications in terms of enzyme activity and viscosity. Our QTL mapping efforts have revealed the locations of malting quality genes, but often these genes are located in breeding populations that are not likely to produce variety candidates. Thus, we know that DH breeding works, but we have hit a barrier in terms of enzyme activity. We also know QTL mapping works, but much of the information is often not immediately useful. The logical step is to integrate QTL mapping with our breeding effort. Thus, we can begin putting together the puzzle pieces of the winter malting barley variety. Kold, Strider, and other advanced lines in our DH breeding nurseries are important contributors; they have good malt extracts, good yield performance, and stripe rust resistance.

Table 2. Agronomic summary of OSU winter barley selections Strider, ORW7, ORW8, ORW9 compared with check varieties; averaged over Pendleton, Pullman, Aberdeen for the years 1992-1995. Values in ( ) are # of station years.

Line	Heading date	Height	Lodging	Test weight	6/64 Plump*	Thin	Yield
	Julian	in	%	lbs/bu	%	%	lbs/A
Scio	149 (4)	36 (7)	7 (7)	49 (7)	83 (4)	3 (4)	7008 (9)
Hundred	151 (5)	35 (8)	7 (7)	48 (8)	80 (4)	4 (4)	6866 (10)
Gwen	147 (5)	38 (8)	12 (8)	49 (8)	77 (4)	4 (4)	6805 (8)
Plaisant	140 (5)	38 (8)	4 (8)	52 (8)	88 (4)	2 (4)	6220 (10)
Eight-twelve	146 (4)	34 (7)	19 (7)	49 (7)	78 (4)	4 (4)	6457 (9)
Kold	147 (5)	38 (8)	9 (8)	51 (8)	75 (4)	5 (4)	7468 (8)
Strider	145 (3)	38 (7)	9 (7)	51 (7)	89 (4)	2 (4)	7660 (9)
ORW-7	150 (3)	38 (7)	4 (7)	55 (8)	95 (4)	1 (4)	6921 (9)
ORW-8	139 (3)	39 (7)	5 (7)	55 (7)	94 (4)	1 (4)	6016 (9)
ORW-9	143 (3)	42 (7)	2 (7)	53 (7)	90 (4)	3 (4)	5714 (9)

* A 6-row malting barley should have 85% or higher plump kernels when passed over a 6/64'' sieve.

Table 3. Quality Profiles for Strider , and ORW-7, 8, and 9 with Scio and Plaisant Data from Pendleton, Pullman, Aberdeen and Corvallis locations 1991 - 1994. Lower case numbers represent number of tests.

Variety or Selection	Plump 6/64	Grain Protein	S/T*	Malt Extract	F-C	DP	α-amylase
	%	%	%	%	%	(Deg)	(20 deg)
Scio	76.2	10.1	41.4	75.6	4.1	76.2	33.9
	5	7	7	7	5	7	7
Plaisant	86.4	10.0	38.6	79.1	2.8	90.9	37.0
	12	14	14	14	11	14	14
Strider	85.1	9.6	39.8	78.9	2.1	63.8	37.7
	12	13	15	15	10	15	15
ORW-7	91.9	9.7	38.7	79.0	2.9	89.4	29.3
	12	13	14	14	9	14	14
ORW-8	90.7	10.2	40.6	79.0	2.0	92.1	41.6
	12	13	14	14	9	14	14
ORW-9	89.7	10.6	40.7	79.5	2.4	107.1	35.8
	12	13	14	14	9	14	14

* For malt analysis, samples of barley grain are malted in a small-scale pilot malting unit. A number of chemical analyses are conducted on the products of this malt. While the specific target quality profile will vary depending on the type of barley (6-row or 2-row) and the intended use (domestic vs. export/microbrewery) the following definitions and ranges of trait expression are adequate generalizations. The total grain protein should be less than 13.5%. S/T is a measure of the soluble to total protein ratio and should be around 40%. Malt extract should be greater than 78%. F-C is the difference in extract between fine and coarse-ground malt and should be around 2%. DP is diastatic power, which is a measure of total enzymatic activity. Domestic brewers would like to see this value greater than 130, but microbrewers and the export market want it less than 100. α-amylase values should be greater than 40% for all markets. In general, there is a negative correlation between grain protein and malt extract and a positive relationship between grain protein and enzymatic activity. Thus, malt quality is a balance of extract, total protein, and activity of certain enzymes.

Table 4. Malting quality data for winter barley varieties and selections grown six years in irrigated winter barley trials at Aberdeen, Idaho, 1988-89 to 1993-94.

Entry	Plump	Malt extract	F-C	Grain protein	S/T	DP	Alpha amylase
	(%)	(%)	(%)	(%)	(%)	(Deg)	(20 deg Units)
88Ab536+	89	77.5	2.2	13.7	37.8	152	39.5
Wintermalt	79	74.5	4.1	13.4	31.9	114	30.0

Table 5. Summary of agronomic data for 88Ab536 and selected winter barley varieties grown under irrigation at Aberdeen, Idaho, 1989-90, 1991-92 and 1992-93.

Entry	Yield	Test weight	Height	Heading Date	Lodging
	(bu/A)	(lbs/bu)	(in)	(Julian)	%
No. Years	3	3	3	3	2
88Ab536	154.7	51.8	35	141	5
Eight-Twelve	200.0	51.8	32	146	4
Schuyler	183.5	50.9	34	152	10
Scio	195.8	50.9	31	148	4

The other contributor is 88Ab536-B. This genotype, developed by Dr. Darrell Wesenberg (USDA-ARS, Aberdeen, Idaho) has the best malting quality profile ever seen in a U. S. winter 6-row barley (Table 4). However, it pays a significant yield penalty in comparison to feed barleys (Table 5). Although it is cold tolerant, its growth habit is com-

What we propose to do in the coming years is focus on putting these puzzle pieces together. DH production plays a central role, as we will make large DH populations for crosses of OSU lines with 88Ab536-B. Phenotyping plays an important role. Our strategy will be to check actual performance, whenever possible. For example, we can determine photoperiod response (heading date) in field or greenhouse plantings at Corvallis. Winter survival can be determined in controlled freeze tests in cooperation with Hungarian colleagues who are expert in such things, and stripe rust reaction can be determined in cooperation

pletely inappropriate for regions with fluctuating winter temperatures. It will try to flower at the first warm spell. can begin putting together the puzzle pieces of the winter malting barley variety. Kold, Strider, and other advanced lines in our DH breeding nurseries are important contributors; they have good malt extracts, good yield performance, and stripe rust resistance.

with PNW pathologists and in our cooperative program with ICARDA/CIMMYT. At the same time, molecular markers can be used to identify those lines that have the maximum overall genome composition, and maximum genome composition in target areas, tracing to 88Ab536-B. The lines coming out of these selection programs can be rapidly advanced to multiple location testing in Oregon, Idaho, and Washington for yield and quality confirmation. At any point, retroactive mapping can be used to locate determinants of key traits, to determine if negative genetic associations are limiting selection response, or to ensure that specific loci are pyramided into single genotypes.

Is the investment in winter malting barley worth it? Intuitively, it seems that winter barley has a place in certain regions of the PNW and that a malt premium would make production even more attractive. However, economic constraints need to be identified and rigorously defined. Our strategy is to develop lines that equal or exceed current feed types in yield, test weight, and kernel sizing and that have superior quality. While our efforts may be modest compared to those in Europe that have produced the quality profiles shown in Table 1, our program has contributed to generating basic knowledge regarding gene location and expression and should provide varieties adapted to the Pacific Northwest.

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SOUND PATTERNS REVEAL SOIL ROUGHNESS AND POROSITY

Ron W. Rickman

INTRODUCTION

Sound reflections show promise as a measuring tool for some physical properties of the soil surface (Sabatier et al. 1990). Soil surfaces in field conditions always contain pores and include roughness of some form. Large pores tend to slow water erosion by allowing water to infiltrate. Small pores slow the infiltration of water. Rough surfaces contain catchment volumes for local ponding of water. Smooth surfaces provide little resistance to flow of water and do little to slow erosion by either wind or water. Changes in roughness, for example a loss from slaking or an increase from a tillage operation, will influence the susceptibility of a soil to erosion by wind or water. Currently we have neither a rapid technique for monitoring the effect of alternative management practices on soil surface roughness and porosity, nor a way to determine the stability of that surface. The development of a tool that can rapidly detect pores in the soil surface and provide a measure of surface roughness will allow more rapid evaluation of alternative practices for erosion control than is now possible.

Sound reflection from any surface is dependent upon the size of pores in that surface and upon its texture or roughness (Zwikker and Kosten, 1949). Theoretical computations are available that allow the estimation of porosity and roughness of a surface based on the pattern of reflection of sound from that surface (Sabatier et al. 1993, Attenborough, 1995). The objective of this paper is to report the comparison of predicted and actual reflected sound patterns over flat and roughened soil surfaces with known porosity and roughness. Agreement of observations with predicted patterns will lead to procedures for extracting porosity and roughness values from observed sound patterns above the surfaces in production fields.

METHODS

Sound patterns between a heavy duty acoustical speaker and a pair of conventional dynamic microphones were recorded above a fine and a coarse textured sand (fig. 1) with a variety of roughened surfaces (Sabatier et al. 1993). Particle size distribution of the sands is shown in fig. 2. Both sands were level to the top of 18-inch deep 8

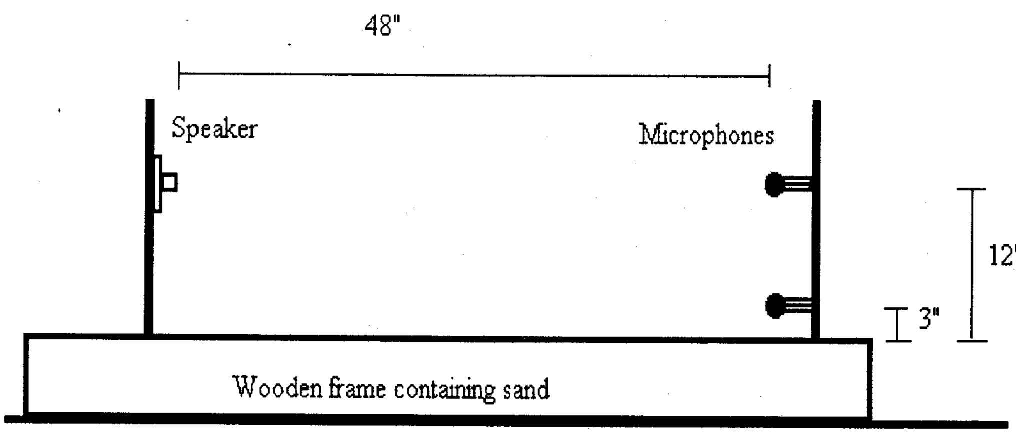

Figure 1. Speaker-microphone arrangement for sound pattern measurement at Pendleton, OR in 1995.

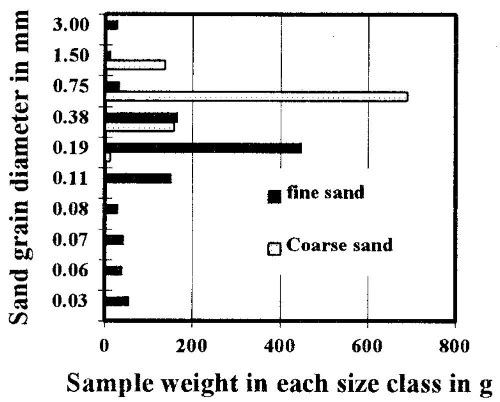

Figure 2. Particle size distribution of coarse and fine sand used for sound pattern measurements in Pendleton OR in 1995.

ft. x 8 ft. wooden frames. The frames were located in a cultivated field on the Columbia Plateau Research Center grounds at least 300 ft. from the nearest structure.

Three surface conditions were created and observed for the fine sand, and two surface conditions for the coarse sand. A flat surface and a surface with furrows at 3 inches center-to-center spacing were observed on both sands. On the fine sand the small 3-inch furrows were triangular, 3 inches across at the top with a depth of 1.0 inch from the bottom of the furrow to the top of the ridge. In the coarse sand the ridge depth was ½ inch and the shape of the ridge tops was rounded and semicircular. Large furrows at 6-inch spacing were observed on the fine sand. The large furrows were triangular, 4 inches across at the top, 2 inches deep, and were separated by 2 inches of flat sand.

During measurements both the speaker and microphone stands were located within the respective frames that held the sand (fig. 1). All furrows were perpendicular to the line from the speaker to the microphones, filled the 4 ft. space between them, and extended at least 2 ft. on either side of the center line connecting the speaker and microphones. Reflective objects were removed from the surrounding area. Instruments and operator were located 15 ft. or more behind the speaker during any measurement. The speaker-to-upper-microphone distance was 4 ft. with the center of the speaker and upper microphone 12 inches above the level surface. The lower microphone was 3 inches from the flat surface, directly below the upper microphone (Fig. 1). All distance measurements were accurate to ±½ inch.

A 20-inch diameter Peavey speaker broadcast sound between 200 and 2,000 Hz. The Prologue model 10L-LC dynamic microphones were not matched so each measurement was taken twice with the microphones interchanged and the signals were averaged to obtain the sound pattern. Data were collected at 16,000 Hz on a high speed dual channel data acquisition board in a portable microcomputer and the sound pattern computed as described by Sabatier et al. (1993). Roughness effects on the pattern were computed according to relationships provided by Attenborough (1995). Computed sound patterns were fitted to those observed by using measured porosity, roughness element size, and source-receiver distances with estimated values for flow resistivity and tortuosity that provided the best fit for each surface condition.

DISCUSSION

Values for the parameters needed for the sound pattern computations are shown in Table 1. Porosity was computed from observed bulk density. Tortuosity and flow resistivity were selected to fit the observed sound patterns. Roughness elements and source-receiver dimensions were measured. Figure 3B and 3C show the fitting of the

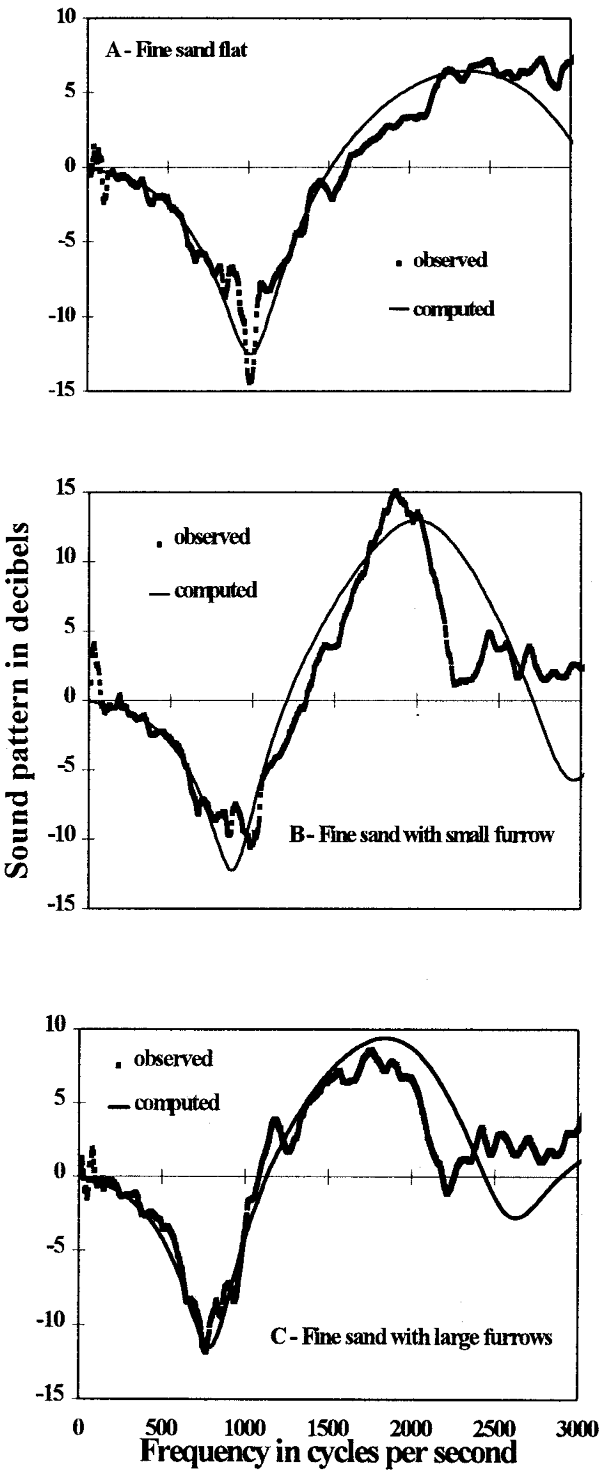

Figure 3. Sound patterns over a fine sand as measured in Pendleton OR in 1995.

observed and computed sound patterns above the roughened surfaces of the fine

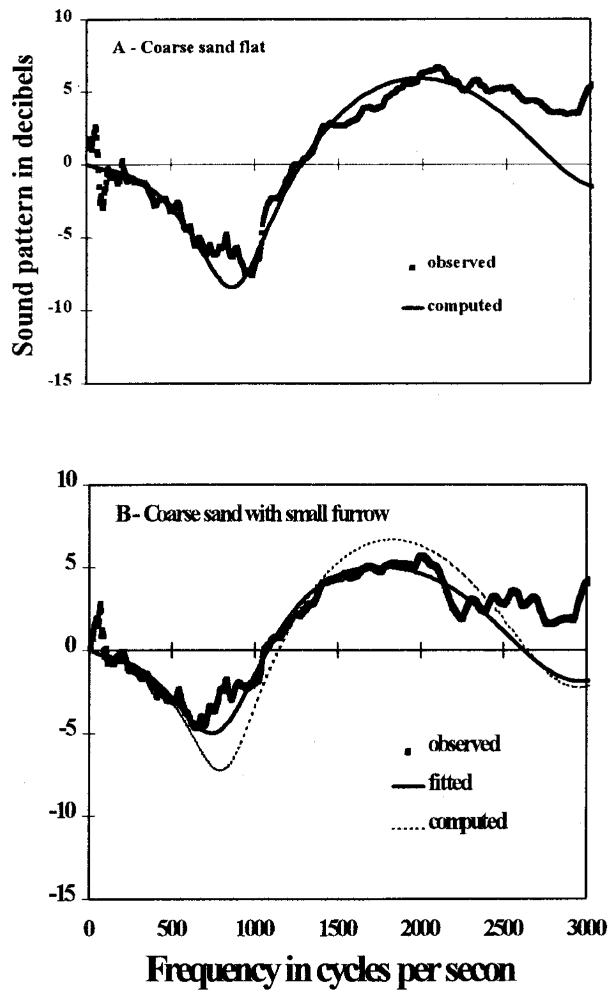

Figure 4. Sound patterns over a coarse sand as measured in Pendleton OR in 1995.

sand using the furrow depths and spacings as observed with the same flow resistivity, porosity, and tortuosity values as for the flat surface in fig. 3A. Agreement between predicted and observed curves was quite good within the range of frequencies observed.

The sound patterns for the coarse sand with flat and furrowed surfaces are shown in figure 4. For the flat surface, agreement between predicted and observed patterns is excellent. To fit the sound pattern above the finely furrowed surface of the coarse sand, the flow resistivity had to

Table 1. Parameter values for matching computed sound patterns with those observed in Pendleton, OR in 1995.

Sand	Surface	Source, Receiver distance inches	Upper mic. and speaker elevation inches	Lower mic. elevation inches	Porosity	Tortuosity	Flow Resistivity mks units	Roughness Element inches		
								height	length	repeat distance
fine	flat	48	12	3	0.43	3	500000	0		
fine	small furrows	48	12	3	0.43	3	500000	1	3	3
fine	large furrows	48	12	3	0.43	3	500000	2	5.5	5.5
coarse	flat	48	12	3	0.39	1.5	140000	0		
coarse	small furrows	48	12	3	0.39	1.5	80000	0.5	3	3

be reduced by almost a factor of 2 (Table 1). The dotted line in fig. 4B is the computed sound pattern with the same flow resistivity as the flat sand. The implication of the reduced flow resistivity is that the "tilling" of the sand surface to create the furrows made the surface more permeable to air than when it was packed flat.

CONCLUSION

Computed and observed sound patterns above both smooth and furrowed surfaces matched for a fine textured sand when actual furrow shapes and sizes are incorporated in the computations. Above a coarse textured sand, sound patterns matched for the furrowed surface only if the value for flow resistivity was reduced below that found for a smooth surface. Since as many as six parameter values enter the sound pattern computations, to determine a unique set of parameter values it may be necessary to observe sound patterns at six or more different speaker-microphone arrangements above each new surface. While such a requirement will increase the time for completing a measurement, the total time required is still only a few minutes. The dimensions of the measuring system must be precisely determined for each field observation. Speaker to microphone distances must be accurate to within 1/16 of an inch. Soil surface to microphone heights must be accurate to better than ¼ inch. A portable frame that will hold the speaker-microphone system rigidly in place relative to one another and to the soil surface is being designed for use in continuing field trials during the summer of 1996.

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FORMATION OF WEAKLY CEMENTED SILICEOUS PANS INDUCED BY LONG-TERM AGRICULTURAL MANAGEMENT

John Baham and Said Al-Ismaily

INTRODUCTION

Soil pans commonly appear on the agricultural landscape of the Colombia Plateau. These features form largely as the result of tire and machine traffic. However, the weathering, migration, and re-precipitation of water soluble silica, (Si_w) may enhance the strength of these pans through cementation of the soil particles. The source of the water soluble Si is most likely a recent (geologically speaking) dusting of volcanic ash. The weathering of Si-rich minerals can be significantly influenced by agricultural practices (e.g. addition of N fertilizers) that acidify the soil. We feel that the potential for the chemical cementation of these pans is largely influenced by agricultural management practices.

This preliminary report includes discussion of 1) the potential and magnitude of Si weathering by agricultural practices, 2) the sources and amounts of readily soluble Si that form the cementing agents, 3) a number of biogeochemical acidification processes involving N cycling, and 4) plant removal. The major goal of this work is focused on the understanding of the formation of these cemented pans, with the implied goal that this understanding will provide us with the knowledge necessary for their management.

MATERIALS AND METHODS

Soil cores were collected from long-term residue management plots during the spring fallow and after harvest (August) in 1995. These plots have been managed under a continuous wheat-fallow system for over 50 years. Four treatment plots were sampled: 1) 80 lbs. N(nitrogen)/acre, 2) 40 lbs. N/acre, 3) manure/straw additions (equivalent to a rate of 80 lbs. N/acre), and 4) a control plot to which no N is added. Field penetrometer readings were measured in each plot in the spring of 1995.

The soil cores were sectioned at 1 inch intervals to 20 inches, and at 4 inch intervals thereafter. Bulk density and water content values were measured in the laboratory. Soil pH_w (pH in H_2O, 1:2) values were measured with a combination glass electrode and a pH meter. Total acidity was determined by the $BaCl_2$- Triethanolamine method. Water soluble silica, Si_w (mg Si/ kg soil) is defined as the amount of Si dissolved in water (5 g of soil in 20 mL of deionized water for 2 hours). This produces a labile pool of Si. Amorphous Si is measured as the amount of Si soluble in 0.5 *M* NaOH at 85 ^{o}C, for ten minutes. Si was determined colorimetrically.

RESULTS AND DISCUSSION

Soil penetrometer (Fig. 1) and bulk density values taken during the spring from the fallow segment of the management cycle are consistent with the formation of a compacted traffic pan. The maximal expression of the pan occurs at approximately 10-12 inches soil depth (Allmaras et al., 1982). There appeared to be no relation between the treatments and soil strength values taken in the spring when the soil was still moist. Values measured for the soil strength in the fall, after the soil dried, are nearly double those of the spring (Douglas et al., 1983). It appears the strength of the pans is expressed most markedly in the fall when the soil is dry. This observation is consistent with the presence of a cementing agent such as Si.

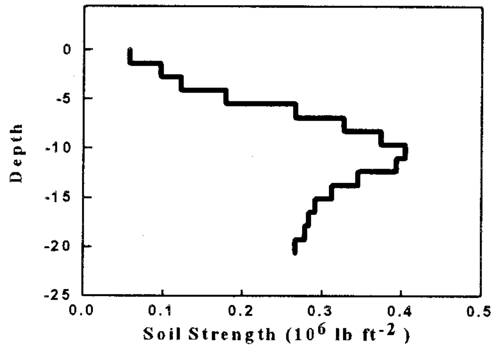

Figure 1. Average soil penetrometer values obtained from the long-term residue management plots, Pendleton OR, spring, 1995.

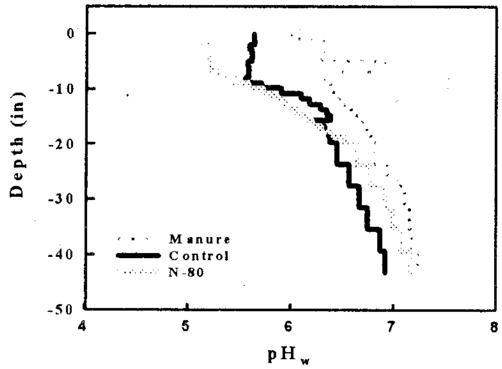

Figure 2. Soil pH_w values for the manure/straw, N-80, and the control treatments in the long-term residue management plots, Pendleton OR, spring 1995.

The weathering and release of Si is driven by the production of soil acidity. The two main sources of acidity in the dryland wheat agricultural ecosystem are the removal of basic cations in harvest and the nitrification and leaching of excess nitrogen as nitrate. Soil pH_w values (Fig. 2) clearly show that soils that have been fertilized with 80 lbs/acre of reduced N and have yields of wheat on the order of 80 bushels per acre are experiencing acidification of the surface horizons. The manure plot is more basic than the control plot. This is a result of the "liming" effect of return of basic elements to the soil.

Perhaps more informative are the data for total acidity stored in the soils (Fig. 3). The difference in acidity, produced over 60 years, between the control plot (no N) and the treatment receiving 80 lbs N/acre on an annual basis is equivalent to the amount of acid needed to neutralize approximately 250-350 lbs of pure limestone per acre on an annual basis. This amount of acid is more than sufficient to mobilize Si in the soil profile.

Two major pools of silica comprize the majority of the Si in these soils, water soluble Si (Si_W), and amorphous Si. The extraction procedure used to obtain the amorphous Si values is very aggressive and would be expected to dissolve all Si present in the forms of biogenic opal and volcanic glass. Opal and volcanic glass represent the pool of readily weathereable Si. Since the pool of amorphous Si is several hundred times larger than the water soluble pool (Si_w), the profile distribution of amorphous Si is nearly the same for all of the management conditions. The amorphous Si distribution can be represented as the average value for all of the treatment plots (Fig. 4). Since the total pool of amorphous Si is rather large when compared to the annual amount that might be expected to be released by weathering, one

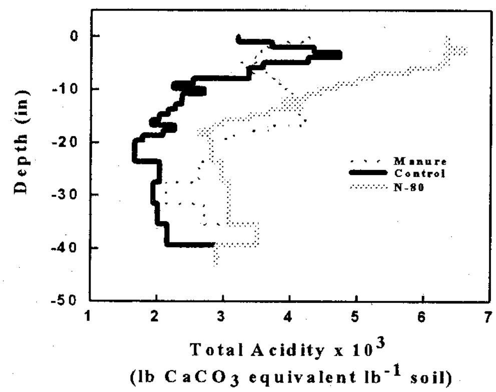

Figure 3. Total acidity for the manure/straw, N-80, and the control treatments in the long-term residue management plots, Pendleton OR, spring 1995.

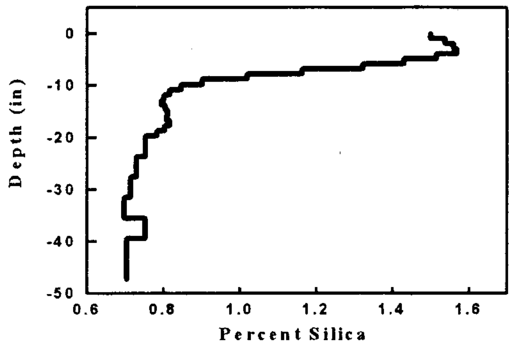

Figure 4. Average concentration of amorphous Si in the four treatment plots, Pendleton OR, 1995.

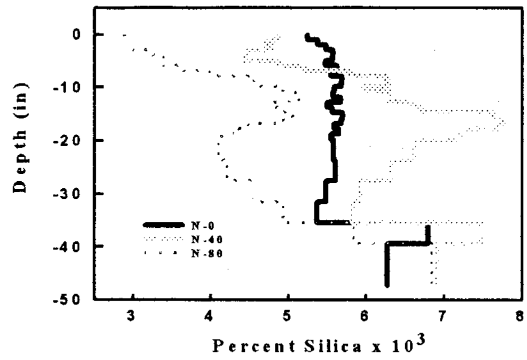

Figure 5. Concentrations of water soluble Si in the soil profile for the control (N-0), N-40, and N-80 management treatments Pendleton OR, 1995.

does not expect to see a difference in treatments reflected over 50 years. Most of the amorphous Si occurs in the surface of the soil profile. This is likely the result of the deposition of volcanic glass or the biological cycling of Si to the surface of the soil via plant uptake, or some combination of both processes. We expect to learn more about the distribution of amorphous Si by direct examination of the soil in thin section and scanning electron microscopy.

The water soluble pool of Si is thought to be responsible for the cementation of the soil particles in the layer just below the plow pan (Douglas et al., 1983; Brown and Mahler, 1988). Both of the plots that have received N have obvious "spikes" in their Si_w distributions in the soil layer, which correspond to the lower portion of the plow pan. Values for the concentration of Si_w on a solution basis are very high. This suggests that the source of Si_w is likely due to the weathering of amorphous volcanic glass or biogenic opal Si. The concentration of Si_w is lower in the surface horizons for both nitrogen treatments, suggesting the source of Si_w has been depleted by acid induced weathering. In the case of the higher nitrogen fertilization rate, the Si_w concentration is less than the control to a depth of 1 meter (39 in.). This suggests that weathering has exhausted the sources of Si_w while the total amorphous Si pool remains relatively unchanged (Fig. 5).

CONCLUSIONS

The weathering of soil minerals and release of water soluble Si is accelerated by the production of agricultural acidity. The greatest concentrations of water soluble Si appear to occur at the boundary between the plow zone and the undisturbed soil. This may be the result of the migration of Si to this layer with water when it moves upward as moisture is lost from the soil. The degree to which Si fills the soil pores in this region will be explored in the next phase of our research. We plan to examine soil fabric by thin section and scanning electron microscopy.

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EARLY EFFECTS OF CROP ROTATION ON DOWNY BROME IN DRYLAND WINTER WHEAT

Daniel A. Ball and Darrin L. Walenta

INTRODUCTION

It is well known that changing a crop rotation sequence can be used as a means to manage particular weed problems in dryland winter wheat (Blackshaw, Lyon and Baltensperger). Advocating a crop rotation sequence different from those typically employed by commercial operators creates difficulties. Production practices are poorly defined, commodity programs restrict adoption, and most importantly, short-term profitability might be less than from more commonly practiced crop rotations, particularly if equipment purchases are necessary. Weed problems such as downy brome (*Bromus tectorum* L.) and jointed goatgrass (*Aegilops cylindrica*) in dryland winter wheat-fallow crop rotations cannot be controlled consistently by methods other than crop rotations that exclude winter wheat for more than two years. Because winter wheat/conservation tillage systems are especially susceptible to downy brome infestations, a study was initiated to investigate the agronomic and economic feasibility of utilizing crop rotation sequences other than winter wheat-fallow in conjunction with conservation practices to manage downy brome under climatic and edaphic conditions that exist in substantial areas of the dryland wheat production areas of northeastern Oregon.

METHODS AND MATERIALS

Large, replicated plots were established in spring 1993 on a commercial field near Pilot Rock, Oregon (Gilliland Site) to compare the effectiveness of several dryland wheat crop rotations for downy brome control, soil and water conservation, and economic viability. A second site with the same crop rotation treatments was established in spring 1994 (Shaw Site). A standard wheat-fallow cropping system was compared to cropping systems designed to optimize downy brome management and maintain compliance regulations. The experiment will conclude when all plots are planted to winter wheat (6 years each location). Cropping systems strategies include:

1) Winter wheat-fallow system utilizing conservation tillage without chemical fallow.

2) Winter wheat-fallow system utilizing conservation tillage with chemical fallow.

3) Winter wheat-barley-fallow rotation utilizing conservation tillage without chemical fallow.

4) Winter wheat-barley-fallow rotation utilizing conservation tillage with chemical fallow.

5) Winter or spring wheat-fallow-canola rotation utilizing conservation tillage.

6) Winter wheat-fallow system utilizing moldboard plowing (conventional practice).

7) Continuous, no-till spring wheat (Shaw site only).

Individual plots are approximately 0.5 acres in size with four replications and managed by growers and research station staff using field scale equipment. Conservation tillage treatments (1 through 5) employ chisel plowing as the primary tillage and are compared to the conventional, commercial practice of moldboard plow primary tillage (treatment 6). The chemical fallow treatments (2 and 4) consist of a currently registered herbicide treatment (Roundup, Landmaster, or

Sure-Fire) applied after grain harvest in the fall, and if necessary, again in the spring before a summer fallow period. Conventional fallow treatments (treatments 1 and 3) utilize sweep or disc tillage in the fall, and if necessary, a non-residual herbicide treatment (Roundup) in the spring.

The second site established in spring 1994 (Shaw Site) consists of the same crop rotation treatments as in the first site plus a continuous, no-till spring hard, red wheat rotation. Evaluations were made of total weed populations with emphasis on downy brome at both sites in January 1995 and again in late April. Surface residue cover measurements were made using a line transect method in December 1995. Crop yields at both sites were estimated by harvesting the entire plot area with commercial equipment and weighing .

RESULTS AND DISCUSSION

At the Shaw site, January weed counts (Table 1a) showed that downy brome and volunteer wheat were most prevalent in the wheat-barley three year rotation utilizing sweep tillage on stubble in the fall (treatment 3) and in the no-till (treatment 7) due to no herbicide application the previous fall. Downy brome and volunteer cereals were not evident at the April weed count (Table 1b) for treatments 3 and 7 where grass weeds were controlled by spring-applied Roundup. Also at the April weed count, the three year rotation utilizing chemical fallow (treatment 4) had greater levels of broadleaf and grass weeds than the three year rotation utilizing fall tillage (treatment 3) due to depletion of residual chemical control (Command + Atrazine) applied to treatment 4 the previous fall. At this site, fall tillage and spring-applied Roundup controlled downy brome and volunteer cereals in post-harvest stubble more effectively than did a single residual herbicide on stubble in the fall.

Downy brome populations were not different between plow (treatment 6) and chisel (treatments 1 and 2), but were greater compared to the other crop rotations since they were in winter wheat production at the

Table 1a. Influence of cropping system on weed populations, January 27, 1995 - Shaw Site.

Tmt. No.	Treatment*	Downy Brome	Vol. Cereal	Russian Thistle	Kochia	Prickly Lettuce	Other Weeds
		----	----	plants/ m^2	----	----	----
	Chisel						
1	W-F Conv Fallow	7	0	0	0	0	0
2	W-F Chem Fallow	4	0	0	0	0	0
3	F-W-B Conv Fallow	10	27	0	0	0	0
4	F-W-B Chem Fallow	1	1	0	0	0	0
5	C-W-F Conv Fallow	3	0	0	0	0	0
7	SW No-Till	19	36	0	0	0	0
	Plow						
6	W-F Conv Fallow	3	0	0	0	0	0
	(LSD 0.05)	8	9	NS	NS	NS	NS

* The first crop indicated on the treatment list was present at the time of weed counts.
F = fallow, W = winter wheat, SW = spring wheat, C = canola, B = barley.

Table 1b. Influence of cropping system on weed populations, April 25, 1995 - Shaw Site.

Tmt. No.	Treatment*	Downy Brome	Vol. Cereal	Russian Thistle	Kochia	Prickly Lettuce	Other Weeds
		----------	----------	plants/ m^2	----------	----------	----------
	Chisel						
1	W-F Conv Fallow	37	0	0	0	1	0
2	W-F Chem Fallow	42	0	1	0	1	0
3	F-W-B Conv Fallow	0	1	0	0	2	0
4	F-W-B Chem Fallow	19	37	13	10	47	0
5	C-W-F Conv Fallow	--	--	--	--	--	--
7	SW No-Till	0	0	17	9	4	3
	Plow						
6	W-F Conv Fallow	30	0	2	0	1	1
	(LSD 0.05)	16	6	8	4	10	2

* The first crop indicated on the treatment list was present at the time of weed counts.
W = winter wheat, SW = spring wheat, F = fallow, B = barley, C = Canola.

time of weed counts (Table 1b). No downy brome was present in spring seeded wheat at the time of April weed counts (treatment 7).

The crop rotations in 1995 were in a different phase at the Gilliland and Shaw sites. At both the January (Tables 1c), and April (Table 1d) weed sampling dates the three year wheat-barley rotation utilizing sweep tillage for fall weed management in stubble (treatment 3) resulted in less downy brome in the subsequent wheat crop than did the three year wheat-barley rotation utilizing chemical weed management on stubble in the fall (treatment 4). Downy brome levels in January were extremely high in winter wheat following a fall seed canola crop (treatment 5, Table 1c), which necessitated removal of the winter wheat crop and reseeding with spring wheat in February. This heavy downy brome infestation after fall canola production constitutes a major constraint to re-cropping winter wheat after a fall seeded canola crop. Moldboard plowed wheat-fallow plots (treatment 6) had more downy brome than did chiseled wheat-fallow plots (treatments 1 and 2) because moldboard plowing had not been completed and chiseling had been performed at the time of April weed counts (Table 1d). Changes in downy brome, and other weed problems, will be further elucidated from evaluations made in coming years.

Surface residue cover has been adequate to meet conservation compliance regulations on all conservation tillage treatments. Surface residue counts reflected the crop rotation phase present when the residue measurements were taken. Percent residue cover in newly seeded winter wheat was higher in wheat-fallow rotations utilizing chisel compared to moldboard plowing. Fall seeded canola provided high amounts of green cover going into winter (Table 2).

Wheat yields in 1995 from the chisel based wheat-fallow rotation at the Shaw site were slightly lower than the conventional crop rotation practice. These crop yields reflect the lower yields that can occur when changing tillage regimes (Tables 3a). Fall canola yields were also disappointingly low at the Shaw site in 1995. Wheat yields at the Gilliland site in 1995 were typical for that site (Table 3b).

Table 1c. Influence of cropping system on weed populations, January 27, 1995 - Gilliland Site.

Tmt. No.	Treatment*	Downy Brome	Vol. Cereal	Russian Thistle	Kochia	Other Weeds
		------------------- plants/ m^2 -------------------				
	Chisel					
1	F-W Conv Fallow	28	52	0	0	0
2	F-W Chem Fallow	16	7	0	0	0
3	W-F-B Conv Fallow	31	0	0	0	0
4	W-F-B Chem Fallow	76	0	0	0	0
5	SW-F-C Conv Fallow**	135	0	0	0	0
	Plow					
6	F-W Conv Fallow	3	16	0	0	0
	(LSD 0.05)	48	15	ns	ns	ns

* The first crop indicated on the treatment list was present at the time of weed counts.
** Counts made prior to planting spring wheat.
F = fallow, W = winter wheat, SW = spring wheat, C = canola, B = barley.

Table 1d. Influence of cropping system on weed populations, April 27, 1995 - Gilliland Site.

Tmt. No.	Treatment*	Downy Brome	Vol. Cereal	Russian Thistle	Kochia	Other Weeds
		------------------- plants/ m^2 -------------------				
	Chisel					
1	F-W Conv Fallow	0	0	4	0	0
2	F-W Chem Fallow	1	0	20	0	0
3	W-F-B Conv Fallow	65	0	1	0	0
4	W-F-B Chem Fallow	137	0	2	0	0
5	SW-F-C Conv Fallow	0	0	44	1	99
	Plow					
6	F-W Conv Fallow	90	285	47	0	32
	(LSD 0.05)	31	30	20	ns	14

* The first crop indicated on the treatment list was present at the time of weed counts.
F = fallow, W = winter wheat, SW = spring wheat, C = canola, B = barley.

New production practices, fertilizer needs, tillage requirements, and pest management operations were required to establish and maintain these crop rotations, which emphasizes the need for more agronomic information before successful development of alternative crop rotation systems can occur. Specifically needed are acceptable protocols for fertilization, and tillage methods, and methods to establish winter wheat following canola, canola following winter wheat, or recropping of spring barley following winter wheat. Recommendations for these alternative cropping practices will be partly developed from this study.

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Table 2. Influence of cropping system on ground cover, Gilliland and Shaw Sites.

Treatment*	Gilliland Site, Dec. 1, 1993 Residue	Green Cover	Clods >2"	Shaw Site, Dec 1, 1994 Residue	Green Cover	Clods >2"
	% cover					
Chisel						
W-F Conv Fallow	5	21	1	19	27	2
W-F Chem Fallow	9	16	1	20	29	0
F-W-B Conv Fallow	75	0	3	18	0	7
F-W-B Chem Fallow	89	0	0	30	0	0
C-W-F Conv Fallow	1	89	0	4	82	0
No-Till						
SW-SW	--	--	--	31	0	1
Plow						
W-F Conv Fallow	1	5	10	8	33	1

* The first crop indicated on the treatment list was present at the time of weed counts. W = winter wheat, SW = spring wheat, F = fallow, B = barley, C = Canola.

Table 3a. Crop yield summaries from Shaw site for 1995.

Treatment	Description	Yield	Notes
1	Winter Wheat (chiseled)- Conventional Fallow (swept stubble)	'Madsen' 77.7 bu/A	Seeded 9/19/94, Hoe-drill
2	Winter Wheat (chiseled)- Chemical Fallow (standing stubble)	'Madsen' 78.5 bu/A	Seeded 9/19/94, Hoe-drill
5	Fall Canola-W Wheat-Conventional Fallow (swept stubble)	'Arabella' 1380 lb/A	Seeded 8/29/94, JD HZ drill, 8 #/A
6	Winter Wheat (plowed)- Conventional Fallow	'Madsen' 90.0 bu/A	Seeded 9/19/94, Hoe-drill
7	Continuous Spring Wheat (no-till)	'936R' HRS 46.4 bu/A	Seeded 3/7/95, Great Plains drill

Table 3b. Crop yield summaries from Gilliland site for 1995.

Treatment	Description	Yield	Notes
3	Winter Wheat (chiseled)- Spring Barley- Conventional Fallow (swept stubble)	'Stephens' 57 bu/A	Seeded 10/13/94, Double Disk, 82#/A
4	Winter Wheat (chiseled)- Spring Barley- Chemical Fallow (standing stubble)	'Stephens' 60 bu/A	Seeded 10/13/94, Double Disk, 82#/A
5 *	Spring Wheat (chiseled)- Conventional Fallow-Fall Canola	'Wakanz' 40 bu/A	Seeded 3/6/95, Double Disk, 80#/A

* This treatment was originally seeded with 'Stephens' winter wheat in canola stubble on 10/28/94, but was tilled out with disking due to heavy downy brome, and reseeded with 'Wakanz' spring wheat on 2/21/95.

CLUB WHEAT BREEDING PROGRAM PROGRESS REPORT

Warren Kronstad, Mike Moore, Karen Morrow, Vicky Correa

The goal of the club wheat breeding program is to produce club wheat varieties that have the agronomic performance to make them profitable for growers of the PNW and the quality performance to satisfy market demands. Agronomic characteristics such as yield, disease resistance, emergence, growth habit, and straw strength can make a new variety profitable when present at acceptable levels in a cultivar. Quality characteristics include protein, test weight, flour yield, cookie diameter, and sponge cake volume. These agronomic and quality characteristics must all be present at acceptable levels for an experimental line to be considered for release as a variety.

Two candidates for release, 92CL0049 and 92CL0054, have received preliminary approval from the OSU pre-release committee. They are currently being tested in the Western Regional White Winter Wheat Nursery at locations throughout the PNW to assess agronomic and quality characteristics. Table 1 shows 1995 yield data from three locations, but three years of data from this nursery are necessary before a variety can be considered for release through the Tri-State Wheat Agreement. Purification efforts are ongoing to provide a pure seed source in the event that a release decision is made. The goal is to release a club wheat variety that yields competitively with varieties of soft white winter wheat with disease resistance that will eliminate the need for fungicide applications. This combination will make it possible for growers to take advantage of premiums without suffering a

Table 1. Western Regional White Winter Wheat Nursery Data

1995 - Pendleton

Line/Variety	Yield	Rank In Nursery	Test Weight
	bu/acre		lbs/bu
Stephens	102.5	34	61.5
Tres	86.0	44	61.7
92CL0049	92.0	42	57.9
92CL0054	90.3	43	59.5
90CLO138	111.3	16	54.9
Hiller	119.9	3	58.1
Nursery Ave.	103.3		60.6

1995 - Moro

Line/Variety	Yield	Rank In Nursery	Stand [1]
	bu/acre		%
Stephens	58.9	11	70
Tres	59.0	10	60
92CL0049	57.4	15	70
92CL0054	59.4	8	70
90CLO138	47.1	49	40
Hiller	56.7	16	30
Nursery Ave.	55.5	-	55

1995 - Corvallis

Line Or Variety	Yield	Rank In Nursery	Plant Height	Lodging [2]
	bu/ac		cm	%
Stephens	85.1	21	42	0
Tres	32.1	46	41	99
92CL0049	105.0	·1	42	0
92CL0054	65.3	34	41	99
90CLO138	18.6	50	43	99
Hiller	51.6	39	40	70
Nursery Ave.	74.8	-	-	37

1. Stand percent based on percentage of full stand.
2. Lodging percent based on portion of plot that lodged.

yield loss or spending more on pesticides. Quality data for the two potential releases and quality checks are shown in Table 2. The check varieties are considered by the milling and baking industry to be standards by which to measure new varieties, and performance inferior to that of the checks is not acceptable. Given the nature of the wheat markets today, a cultivar must at least equal the checks in all areas and exceed them in some, or it should not be released.

As a part of the statewide wheat breeding program, the club wheat program is benefiting from the combined efforts the two staffs. With both programs under the direction of one person, there have been efficiencies of location, allowing the club program personnel to assist with notetaking, planting, harvesting, and plot maintenance with shared labor and equipment at sites in eastern Oregon. The common wheat program quality lab has tested early generation club wheat lines, allowing the elimination of those that do not meet the most basic quality standards of protein and hardness. The F1 generation is sent to Corvallis, where selected crosses in a greenhouse crossing program improve the chances of obtaining target characteristics.

The club wheat program has gained another environment to test its material, as the two programs now share the Barnet-Rugg site five miles east of the Columbia Basin Agricultural Research Center (CBARC). This location typically receives more rainfall than the CBARC, and has pre-seeding irrigation capabilities, providing the opportunity for improved plant development, even in dry years. The site should allow selections to be made based on yield potential and plant development under improved stand establishment and higher rainfall conditions. The CBARC and the Sherman County Experiment Station will remain the primary locations for testing efforts, as those two locations typify the environmental conditions of the majority of the wheat production acreage in Oregon and Washington.

The club wheat program seeded 6.6 acres of early generation headrows, yield trials, and disease screening nurseries at the Columbia Basin Agricultural Research Center, 1.7 acres of yield trials at the Sherman County Experiment Station, and 4.9 acres of early generation headrows and yield trials at the Barnett-Rugg site between September 7, 1995 and October 27, 1995. The early generation headrow nurseries previously seeded at the Sherman County Experiment Station have been discontinued. Growing conditions there often limit growth and mask characteristics that are essential to selecting productive club wheat lines when selection is based solely on plant morphology.

Russian wheat aphid (RWA) seedling screening tests continue at the CBARC. Vicky Correa manages populations of pure Russian wheat aphids and tests material for resistance to aphid feeding damage using a seedling test. Materials are scored using a 1 (resistant) to 3 (susceptible) scoring system. A "1" is characterized by seedlings with flat leaves and little or no chlorosis. A seedling with flat leaves containing small chlorotic areas covering 5 to 10 percent of the leaf is a "2." A "3" indicates a plant with rolled leaves and greater than 80 percent chlorosis and necrosis. A total of 14 common wheat lines were tested for RWA resistance. Two lines scored 1, two lines scored 2, and the remainder scored 3. One hundred and sixty three club elite and advanced lines were tested, with six lines scored 2 and the remainder scored 3. Of the six, two remain in the program for further testing as potential new varieties, while the others will be used as crossing material. A majority of the germplasm with RWA resistance that is available for crossing is hard red, and the plant types do not have the height and straw strength characteristics conducive to performance in the PNW. It is encouraging to find adapted lines with tolerance to aphid infestation.

The club wheat program continues to cooperate in the Statewide Cereal Testing Program by planting, taking notes, and harvesting five locations in cooperation with farm operators and Experiment Station personnel. This relationship directly benefits the club wheat program by increasing the interaction with producers and other people in the industry through field tours. These interactions allow the program to stay abreast of the immediate concerns of area producers and provides guidance for future efforts.

The 1995 crop year was an excellent year for grain production, as spring rains pushed yields in trials as high as 141 bushels per acre for a club line in a non-replicated trial, and Rohde as high as 124 bushels per acre in a replicated trial. A common line in the Western Regional White Winter Wheat Trial was best in the nursery at 131 bushels per acre. The year was also characterized by significant infestations of cheatgrass at all locations. Erosion at the Sherman Experiment Station damaged and mixed plots to the extent that data accuracy from that location was questionable. Early generation headrows seeded the first week of November 1994, at the CBARC emerged poorly and were so heavily infested with cheatgrass that selections were often based on the fact that plants existed rather than plant morphology.

Trials were seeded into excellent moisture conditions in fall 1995, and stands are good to excellent at all locations. Early generation headrows and yield trials were

seeded closer to the normal time frame for each location than in the 1994-1995 season, which should give the lines an opportunity to make the best use of what nature provides over the next few months. Thanks to the continued support of the wheat growers of Oregon through the Wheat Commission, this program continues to strive to produce club wheat varieties that are profitable for producers and desirable to the milling and baking industry.

Table 2. Club Wheat Quality Data

Line Or Variety	Test Weight [1]		Flour Yield [2]		Whole Grain Protein [3]		Cookie Diameter [4]		Cake Volume [5]	
	-----lbs/bu-----		-----%-----		-----% -----		-----cm-----		-----cc-----	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Pendleton										
92CL0049	57.4	58.5	74.5	72.2	6.1	9.4	9.21	8.44	1420	1350
Paha [6]	59.7	58.5	74.1	72.8	6.2	8.5	9.25	8.89	1385	1365
92CL0138	54.9	57.1	74.4	72.2	6.8	9.3	9.09	8.70	1410	1385
Moro										
92CL0049	58.7	56.4	75.3	73.2	6.2	8.1	9.26	8.60	1370	-
Paha	60.1	58.3	72.4	73.1	6.4	8.0	9.44	8.74	1405	-
92CL0138	58.7	54.6	74.7	73.3	7.6	8.1	9.18	8.82	1390	-

Line Or Variety	Test Weight		Flour Yield		Whole Grain Protein		Cookie Diameter		Cake Volume	
	----lbs/bu----		-----%-----		-----%-----		-----cm-----		-----cc-----	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Pendleton										
92CL0054	60.0	61.9	72.4	75.1	7.2	8.4	9.21	8.85	-	1270
Paha	60.1	60.4	71.6	74.1	7.3	8.1	9.36	8.93	-	1365
Tres	60.6	-	68.6	-	7.4	-	9.21	-	-	-
92CL0099	59.9	60.9	72.5	75.2	6.8	8.6	9.49	8.99		1365
Moro										
92CL0054	60.5	58.6	70.7	74.1	7.1	6.9	9.06	8.86	1330	-
Paha	61.1	58.7	70.2	73.8	7.4	7.3	9.71	9.04	1325	-
Tres	62.0	-	71.5	-	7.6	-	9.24	-	1255	-
92CL0099	61.5	57.5	72.3	72.7	7.2	7.2	9.40	9.27	1290	-

1. Test weight should be 58 pounds per bushel or higher.
2. The higher the flour yield the better. Based on percent of flour returned from the amount of wheat milled.
3. The whole grain protein target range is from 6.5 to 8.5.
4. The larger the cookie diameter, the better (units are in centimeters - 1 inch = 2.54 centimeters).
5. The larger the cake volume the better (units are in cubic centimeters).
6. Paha is the quality standard for club wheats, and new varieties must meet or beat its performance.

COMPARISON OF HARVEST TECHNIQUES ON GRAIN YIELD OF WINTER CANOLA

Don Wysocki, Sandra Ott, Dale Wilkins and Clyde Douglas

INTRODUCTION

Two methods of harvesting Canola are available to producers, direct combining or swathing followed by combining. Direct combining is less costly than swathing, but is more risky because of potential shatter loss during the dry down period. Swathing increases harvest costs, but reduces the risk of shatter loss and makes harvest more timely. Current recommendations are to direct combine when seed is at 9 percent or less water content or to swathe when the bottom one third of pods have brown seed. Comparisons of direct combining and swathing are needed to develop regional recommendations for harvesting.

METHODS

Arabella winter Canola (*Brassica napus*) was sown in a randomized complete block experiment with four replications on 27 September 1994. Treatments are described in Table 1. Plots (8 X 40 ft) were sown at a seeding rate of 7 lb/acre using a John Deere HZ drill with 14-inch row spacing. Soil type was a Walla Walla silt loam, 0-2 percent slope. Nitrogen fertilizer was applied as anhydrous ammonia in June 1994 at 70 lb N/acre, and as dry ammonium nitrate as topdress on 28 February 1995 at 30 lb N/acre.

Spodnam was applied June 26 at 1 pint/acre in 50 gallons of water. Agitation was applied to appropriate treatments prior to combining by passing a horizontal, hand-held, 1-inch diameter wooden rod through the crop canopy. Swathing was done with a Swift Current swather with a 5-foot header. A Hege 140 combine at nominal settings of 900 RPM cylinder and fan speed, and 3/16-inch concave clearance was used for harvest.

Seed loss was measured by placing two 4 X 45-inch sheet metal trays with 1-inch high sides in each plot during combining. Trays were inserted in the interior of plots by sliding them between the rows. Reported seed loss was computed by extrapolating weight of seed collected per unit of tray area to a rectangular area of 2.5 X 40 feet. This is the area the combine separator covers as it travels through the plot.

Table 1. Harvest techniques used on winter Canola, Pendleton Oregon, 1995.

	Date	
Treatment	Swath	Combine
Swath first brown seed	30 June	11 July
Swath 1/3 brown seed	10 July	19 July
Swath 2/3 brown seed	13 July	19 July
Direct Harvest No Spodnam Not Agitated		17 July
Direct Harvest No Spodnam Agitated		19 July
Direct Harvest Spodnam Not agitated		17 July
Direct Harvest Spodnam Agitated		19 July

RESULTS AND DISCUSSION

Yields and seed losses were variable and inconsistent among the treatments (Table 2). Care must be used when interpreting these data. The only clear result is that swathing at first brown seed consistently yielded less than other treatments. Harvest at this crop stage generally yielded about 20 percent less than the other treatments. The obvious conclusion is that this stage is too early to swathe. Apparently, seed is not sufficiently mature to ripen without further plant metabolism. Swathing too early limits seed maturity and reduces yield.

Table 2. Yield and seed loss from various harvest treatments of Arabella winter Canola at Pendleton, Oregon, 1995.

Treatment	Yield lb/acre	Seed Loss lb/acre
Swath first brown seed	1082	155
Swath 1/3 brown seed	1559	205
Swath 2/3 brown seed	1521	154
Direct Harvest No Spodnam Not Agitated	1402	168
Direct Harvest, No Spodnam Agitated	1632	94
Direct Harvest Spodnam, Not Agitated	1293	170
Direct Harvest Spodnam Agitated	1526	133
LSD (p = 0.05)	372	NS

Yields in other treatments were statistically equal. This means that we were not able to distinguish differences in yield from swathing versus direct combining, application of Spodnam versus no application, or canopy agitation versus no agitation. We speculate that the lack of difference between swathing and direct harvest is the result of plot size and timing of harvest. Because our experimental plots are comparatively small in relation to grower's fields, we were able to have timely harvest for all treatments. If harvest is always timely, it is reasonable to expect little difference in yield between swathing and direct harvest. Also note that there was no difference in time of harvest between swathing and direct cutting (Table 1). This would not likely be the case in commercial fields.

We feel the lack of differences in yield with or without Spodnam, or with or without agitation resulted from random yield variation across the plots and the lack of our ability to correctly measure seed loss and shatter. Because of the methods used to collect lost seed, we think most loss resulted from combining and not pod shatter. Plots that received no Spodnam and those that were agitated may be losing more seed than other treatments, but seed losses from the combine may be overwhelming these differences.

We plan to repeat this experiment to get additional data on harvest treatments. The method used to measure seed loss will be changed to more clearly separate loss due to shatter and combining. At this time, we recommend swathing no earlier that one third brown seed. We also see no advantage to swathing versus direct cutting, if both are done on a timely basis. However, swathing may improve harvest timeliness in commercial fields because it can be done more quickly and evens crop maturity. From our data, we are unable to comment on the usefulness of Spodnam.

EFFECT OF ANNUAL BURN-NOTILL WHEAT ON SOIL ORGANIC MATTER CONTENT AND BULK DENSITY

Paul E. Rasmussen and Stephan L. Albrecht

INTRODUCTION

Nothing in recent years is quite so controversial as stubble burning. Burning has the capability to increase crop yield under some cropping conditions, but if repeated consistently, has the potential to lower soil quality. Changes in soil quality take place very slowly, and it might be many years before they are detectable (Biederbeck et at., 1980). Stubble burning to facilitate no-till cropping may enhance yield in the short-term, but prove detrimental to soil organic matter (SOM) quality in the long-term.

Reports continue to appear stating that stubble burning is "maintaining or increasing soil organic matter (SOM) after 2 or 3 years in no-till systems." There are some biological considerations that suggest that burning is not likely to increase SOM in our area. Burning volatilizes from 50 to 70 percent of the crop residue into carbon dioxide where it is lost to the atmosphere. Long-term experiments indicate there is a direct relationship between the amount of crop residue incorporated into soil and change in SOM content (Rasmussen and Dick, 1995), so any reduction in residue should reduce SOM. Therefore, it is contrary to expectations that burning of crop residue will increase in SOM.

We are continuing to investigate the less-visually-evident effects of stubble burning to determine what changes really occur over time. Does burning affect SOM within 5 years? What fraction of the residue is burned? What is the quality of the material left on the soil surface after burning? Residue burning leaves behind black charred residues that are considered resistant to decomposition by soil microorganisms (Shindo, 1991). We report here on the influence of a 5-year burn/no-till study on SOM (soil C) content and bulk density in the top foot of soil.

MATERIALS AND METHODS

This study was located on the Columbia Plateau Conservation Research Center 8 miles NE of Pendleton. A crop rotation of winter wheat/spring wheat was grown from 1984 through 1988. All wheat was grown no-till (a one-pass seeding/fertilizing operation was the only tillage event), with herbicides used to control weeds. The experimental design was a randomized factorial with four replications. Treatments included four N rates (0. 50, 100, and 150 lbs N/acre) and two residue treatments (stubble burned, stubble flailed). Soil was a Walla Walla silt loam 55-inches deep. The site was nearly level (slope <1 percent). 'Stephens' winter wheat was grown in 1984, 1986, and 1988. Dirkwin spring wheat was grown in 1985, and WB906R hard red spring wheat in 1987. The site was fallowed in 1989, and Stephens winter wheat was grown no-till in 1990 without any treatments imposed.

Soil samples for C content and bulk density were collected in April 1991 from the 0-4, 4-8, and 8-12 inch soil depths of each treatment. Sampling intensity consisted of 6 cores/plot composited. Soil C was determined by dry combustion using a LECO CHN600 analyzer. Soil C was multiplied by 1.72 to obtain an estimate of organic matter. Soil bulk density was determined by extraction of cores with a bulk density sampler followed by drying and weighing. Bulk density is reported in pounds per cubic foot of soil.

RESULTS AND DISCUSSION

Five years of stubble burning had no effect on SOM content (Table 1). This result supports the prevailing opinion that many years are required for burning effects on SOM to be measurable (Biederbeck et al., 1980). Increasing N application did increase SOM slightly in the top 4 inches of soil, with no changes occurring at deeper depths. Nitrogen increased straw production, which increased the amount of crop residue returned to the soil, and accounts for the N effect on SOM. The effect of N was similar to results found in western Canada wheat regions (Campbell et al., 1989).

Neither stubble burning nor N fertilization had an effect on soil bulk density (Table 2). Surface soil (0-8 inches) after 7 years of no-till (1984-1991) had a bulk density only slightly higher than in nearby conventionally-tilled soil (79 vs. 77 pounds per cubic foot). Differences are considered inconsequential in terms of soil quality.

But even if burning has not reduced the quantity of SOM, has it changed soil quality? We are continuing to investigate that question. Initial laboratory incubation tests (Albrecht et al., 1995) confirm the supposition of Shindo (1990) that charred residues are only very slowly decomposed by microorganisms. Because we found no change in SOM content, it is likely that a substantial amount of crop residue remains in the soil as inert charred material and less residue is cycled through microorganisms into biologically-derived SOM. We are concerned about this trend. It seems inevitable that sustained stubble burning will eventually reduce soil quality, which might decrease water infiltration and increase the erodibility of soil. But we are not sure. There is data in the literature suggesting that some of the C components in charred residue might be chemically incorporated into SOM (Shindo, 1991; Haumaier and Zech, 1995). Thus, a chemical transformation might substitute for a biological one, and if true, it might help to retain a more porous structure in soil and

Table 1. Effect of nitrogen fertilization and stubble burning in no-till wheat from 1984 through 1988 on soil organic matter content in 1991. Pendleton, OR

Nitrogen Rate (lb/ac/yr)	Soil Depth (inches) and Burn Condition: 0 - 4, Burn	0 - 4, No Burn	4 - 8, Burn	4 - 8, No Burn	8 - 12, Burn	8 - 12, No Burn
	Soil Organic Matter (%)					
0	2.30	2.40	2.13	2.08	1.64	1.67
50	2.37	2.25	2.08	2.05	1.66	1.74
100	2.48	2.36	2.14	2.08	1.73	1.66
150	2.43	2.47	2.09	2.10	1.69	1.68
Average	2.40	2.37	2.11	2.08	1.68	1.69
Comparison	Statistical Significance[1]					
N Rate	**[2]		NS[3]		NS	
Burning	NS		NS		NS	
NxB Interaction	NS		NS		NS	
CV (%)[4]	3.9		2.4		6.0	

[1] Statistical significance determined by multiple least-squares analysis (Steel and Torrie, 1980)
[2] ** = Differences significant at a probability of 0.05.
[3] NS = Differences are not significant.
[4] CV (%) = Coefficient of variation; values less than 7 percent indicate good precision in sampling and measureent.

Table 2. Effect of nitrogen fertilization and stubble burning in no-till wheat from 1984 through 1988 on soil bulk density in 1991. Pendleton, OR.

Nitrogen Rate (lb/ac/yr)	Soil Depth (inches) and Burn Condition					
	0 - 4		4 - 8		8 - 12	
	Burn	No Burn	Burn	No Burn	Burn	No Burn
	Soil Bulk Density (lbs/ft^3)					
0	77.8	75.4	81.8	82.7	80.8	79.6
50	77.7	78.7	83.2	82.8	80.0	80.8
100	74.7	78.1	80.6	81.9	80.0	79.3
150	76.7	76.9	82.0	82.7	81.8	80.4
Average	76.7	77.3	81.9	82.5	80.7	80.0
Comparison	Statistical Significance[1]					
N Rate	NS[2]		NS		NS	
Burning	NS		NS		NS	
NxB Interaction	NS		NS		NS	
CV (%)[3]	3.1		2.2		2.9	

[1] Statistical significance determined by multiple least-squares analysis (Steel and Torrie, 1980)
[2] NS = Differences are not significant.
[3] CV (%) = Coefficient of variation; values less than 7 percent indicate good precision in sampling and measurement.

mitigate some deleterious effects of burning. Fire might also reduce the population of microorganisms in the upper 2 inches of soil, thereby temporarily decreasing microbial activity and increasing the opportunity for soil crusting until populations return to normal. We must have the answers to these questions before we can lend even tacit approval to repeated stubble burning on steeply-sloping land. Investigations into soil quality are continuing.

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FUNGICIDE SEED TREATMENT EFFECTS ON EMERGENCE OF DEEPLY PLANTED WINTER WHEAT

Richard W. Smiley, Lisa-Marie Patterson, and Karl E.L. Rhinhart

INTRODUCTION

Winter wheat in low-rainfall regions of the Pacific Northwest (PNW) is generally planted into a stubble-mulch fallow consisting of moist soil below a deep mulch of dry soil plus crop residue. Moisture required for seedling emergence often occurs at depths greater than 4- to 6-in. below the surface. Deep-furrow drills move and pack dry soil above and to the side of the seed row so that coleoptiles emerge from effective seed depths of 2- to 5-in. Hazards associated with deep seed placement include seed rotting if seed-zone moisture is insufficient for germination and coleoptile growth, pre-emergence wind erosion that increases effective planting depth by filling drill rows, and rainfall that crusts the soil surface before seedling emergence. Lindstrom et al. (1976) concluded that germination is seldom a limiting factor in stubble-mulch fallow and that the rate of coleoptile elongation before emergence is the most important determinant of stand establishment. Factors that reduce the rate and magnitude of coleoptile elongation increase the risk for stand failure.

Most (95 percent) winter wheat seed planted in the PNW is treated with a fungicide to control smut diseases. Vitavax was the dominant treatment during the past 25 years. In some instances Vitavax delays germination and emergence (Gusta et al., 1994), although this effect is not known to be widespread. Thiram, FloPro IMZ, NuZone, and/or Apron are applied with Vitavax to broaden the spectrum of diseases controlled. FloPro IMZ and NuZone are systemically translocated fungicides (the active ingredient for both is imazalil) that can reduce emergence, stand establishment, and crown depth by reducing the length of wheat subcrown internodes (Chinn et al., 1980).

Baytan, Dividend, and Raxil are systemically translocated triazole fungicides that efficiently control smuts and several other diseases of cereals. Triazole fungicides affect many plant growth properties (Scheinpflug and Duben, 1988). Very low rates of seed treatment may stimulate shoot growth and increase tolerance to drought, heat, chilling, ozone, and sulfur dioxide (Fletcher and Nath, 1984; Gao et al., 1988). Higher application rates are phytotoxic. Potential growth regulatory effects for Baytan include delayed or reduced emergence, disturbed geotropism, and reductions in growth of coleoptiles, roots and shoots, and in tillering and freezing tolerance (Buchenauer and Rohner, 1981; Förster et al., 1980; Gusta et al., 1994; Montfort et al., 1996; Scheinpflug and Duben, 1988). Some of these effects have also been described for Raxil (Hack, 1994; Holderness, 1990; Kaspers et al., 1987).

In our experience (Smiley and Patterson, 1995) deeply planted winter wheat often appears to emerge more quickly when treated with Dividend than RTU Vitavax Thiram. Effects of seed treatments on winter wheat emergence have not been described for PNW stubble-mulch fallow systems. Objectives of this study were to determine effects of Dividend, FloPro IMZ, NuZone, and Raxil on seedling emergence relative to seed treated with RTU Vitavax Thiram, or untreated seed.

METHODS

Seed treatment fungicides were compared

in three greenhouse and seven field experiments from 1993 to 1995. Gaucho insecticide was included in field experiments during 1995. Winter wheat seed was planted into fields managed as winter wheat-summer fallow rotations; locations and conditions are listed in Table 1.

Emergence was evaluated in greenhouse experiments that simulated plantings at 5-in. depth into stubble-mulch fallow. The experimental design was a 3 x 4 factorial with six replicates; three levels of seed-zone moisture (7, 10, or 15 percent by weight) and four fungicide seed treatments (untreated, Dividend, RTU Vitavax Thiram, or NuZone). Batches of Walla Walla silt loam were wetted to specified water contents and placed into 3x6-in. plastic cylinders with solid bottoms. Dry soil weighed 1.5 lb/cylinder. Five seeds per cylinder were planted at 1-in. depth. A 4-in. layer of dry soil was placed into a second cylinder positioned and sealed above the cylinder containing wheat seed in moist soil. Soil columns were incubated in the greenhouse at 70-75 °F and emerged seedlings were counted daily. The study was performed three times and data were averaged before analysis.

Additional greenhouse experiments were performed to examine emergence of seed treated with Raxil Thiram. One study was performed as described above, by substituting Raxil Thiram for NuZone. Apron was applied as a co-fungicide with Dividend in accordance with requirements of revised commercial packaging of Dividend for the PNW. A repeated sequence included only two fungicide treatments (Raxil Thiram and Dividend + Apron), plus a planting depth variable (2 or 4 inches of dry soil overlying the moist soil), and a "surface crusting" variable (with or without crusting). Surface crusting was simulated by saturating the surface 0.75-in. of dry soil with water and promoting rapid drying by blowing air across the surface.

Field tests included up to five winter wheat varieties planted at the rate of 18 seeds/sq ft at 2- to 5-in. depth either with a Hege plot drill (5 rows at 12-in. spacing in 1993; 4 rows at 14-in. spacing in 1994) or a John Deere HZ drill (4 rows at 14-in. spacing in 1995). Planting depth was in accordance with commercial practices, 1 in. into moist soil below a dust mulch. Experiments were randomized complete block designs with five or six replications per treatment. Plots measured 5 x 20 ft in 1993 and 1994, and 5 x 40 ft in 1995.

Seedling emergence was monitored at 2- to 7-day intervals depending on the depth of planting and rate of seedling emergence. A qualitative emergence scale was used in view of the large number of plots, distance between plots, and frequency of observation. Ratings during 1993 and 1994 were as follows: 0 = <10 percent seedlings emerged, 1 = 10-50 percent, 2 = 50-85 percent, and 3 = >85 percent. Ratings during 1995 were as follows: 0 = no seedlings emerged, 1 = <15 percent seedlings emerged, 2 = 15-40 percent, 3 = 40-60 percent, 4 = 60-85 percent, and 5 = >85 percent. Stand counts in three 1-ft row sections of each replicate were made for selected treatments and experiments. If emergence did not differ among varieties, data for each fungicide treatment was summed across varieties before analysis of variance.

During 1995 an experiment evaluated emergence as affected by depth of planting at a single location. Summer rainfall was plentiful and the depth of dry soil mulch was only 1 in. Sweep rod-weeding was used to create dry mulches at two additional depths to establish planting depths of 1, 3, and 5 in.

Table 1. Characteristics of seven locations where seedling emergence was evaluated.

Location	Soil series and texture†	Annual precipitation (inch)	Planting date	Planting depth (inch)	Seed zone	
					Temperature (°F)	Moisture (percent wt/wt)
Arlington	Walla Walla	11	9 Sept 1993	4	74	7.7
Arlington	Walla Walla	11	25 Aug 1995	4.5	71	10.1
Benton City	Ritzville	11	10 Sept 1993	5	74	9.1
Benton City	Ritzville	11	2 Sept 1994	5	78	6.6
Echo	Adkins	10	28 Aug 1995	3.5	80	10.1
Helix	Walla Walla	15	13 Sept 1993	3.5	78	11.7
Ione	Ritzville	11	7 Sept 1994	4.5	78	4.9
Moro	Walla Walla	12	9 Sept 1993	2	75	10.1
Pendleton	Walla Walla	16	13 Sept 1993	3	75	17.0
Pendleton	Walla Walla	16	8 Sept 1995	1	77	15.9
Pendleton	Walla Walla	16	8 Sept 1995	3	73	14.9
Pendleton	Walla Walla	16	8 Sept 1995	5	71	12.6

† All soils were silt loams except for the Adkins fine sandy loam near Echo.

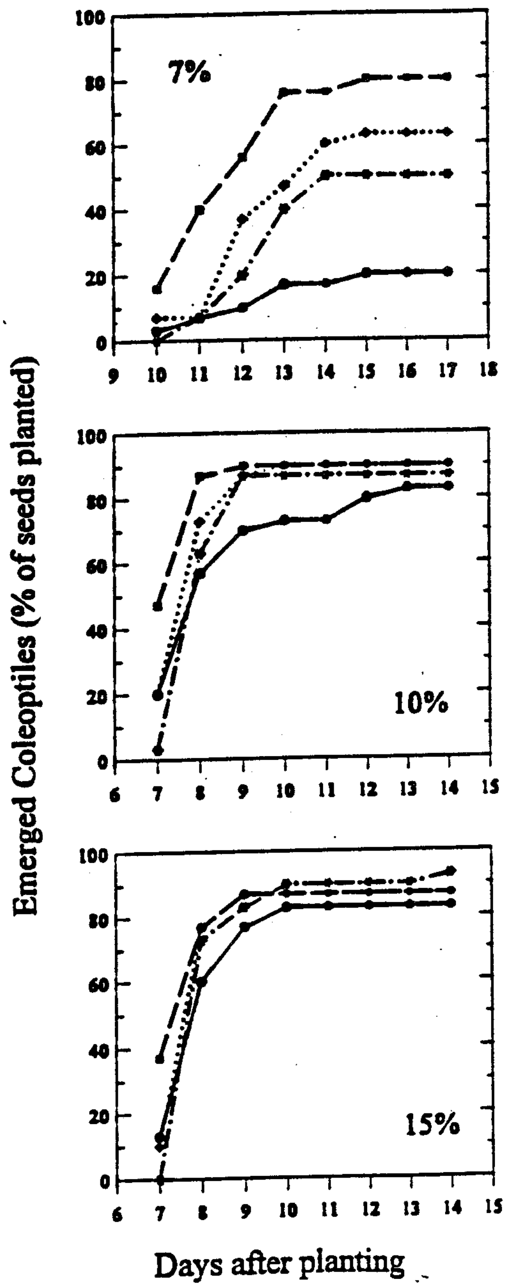
Wheat was planted as planned even though rain moistened the entire profile of each depth treatment before plots were planted. The experiment was a split-plot design; main plots were three planting depths replicated four times, and subplots were five seed treatments. Two 2-ft. intervals were randomly marked in each plot. Emerged seedlings were counted at 2-day intervals and data from the marked areas of each plot were summed before analysis.

RESULTS

Emergence through five inches of warm soil in the greenhouse was most successful when seed was treated with fungicides and seed-zone soil moisture contents were 10 percent or higher (Table 2). Main effects of soil moisture and fungicide were significant. Compared with untreated seed, Dividend and NuZone improved emergence at 7 percent moisture. Dividend and RTU Vitavax Thiram improved emergence at 15 percent moisture and also tended to do so at 10 percent.

Raxil Thiram was substituted for NuZone in a follow-up study. Seed treated with Dividend + Apron emerged from 5-in. depth one or two days more quickly than untreated seed or seed treated with RTU Vitavax Thiram or Raxil Thiram at each soil moisture (Fig. 1). This relationship was most apparent in the driest soil, where emergence was slower

Fig. 1. Emergence of Stephens wheat at daily intervals after planting at 5-inch depth (1-inch into moist soil covered by 4-inch dry soil) into warm (75 °F) silt loam at three moisture contents (7, 10 or 15 percent) in the greenhouse; ● = untreated, ■ = Dividend + Apron, ◆ = RTU Vitavax Thiram, and ★ = Raxil Thiram.



and less complete for all treatments. Emergence of seed treated with Dividend + Apron was significantly higher than for all other treatments up to 13 days after planting into soil at 7 percent water content. All fungicides provided superior emergence over untreated seed and this was significant at 7 percent soil moisture, 14 days after planting and later.

Soil moisture and fungicides did not affect percentages of seed that germinated (>97 percent in all treatments). At 7 percent water content, percentages of coleoptiles that did not emerge by 21 days after planting were higher for untreated seed (53 percent) than seed treated with Raxil Thiram (27 percent), RTU Vitavax Thiram (20 percent) or Dividend + Apron (17 percent).

Emergence through crusted soil was uniformly poor in the third greenhouse experiment. Final emergence was 0, 9, and 13 percent at seed-zone moisture contents of 7, 10 and 15 percent, and was unaffected by fungicides or planting depth. Emergence in uncrusted soil improved as soil moisture increased and planting depth decreased (Table 3). Emergence at 10 percent moisture was more complete with Dividend + Apron than Raxil Thiram 12 days after planting. Emergence 14 days after planting was significantly influenced by planting depth (78 vs 68 percent at 3- and 5-in.) and soil water content (46, 81 and 93 percent at 7, 10 and 15 percent water) but not fungicide (76 and 70 percent for Dividend + Apron and Raxil Thiram). Seed germination was 99 percent, but 23 percent of the coleoptiles did not emerge in the driest soil. Most emergence failures were due to inadequate plant turgor at 7 percent moisture, fan-folding of shoots at 10 percent, and damping-off by species of *Fusarium* and *Penicillium* at 15 percent.

Table 2. Emergence (percent) of Stephens wheat 14 days after planting at 5-inch depth into warm (75 °F), moist (7, 10 or 15 percent water content, by weight) soil in the greenhouse; simulating a stubble-mulch tillage planting.

Seed treatment and rate (fl oz/cwt)	Soil moisture (percent)			
	7	10	15	mean
Untreated	11	58	48	39
Dividend (0.5)	39	71	81	64
RTU Vitavax Thiram (5)	23	79	83	62
NuZone (0.75)	32	52	63	49
LSD (P=0.05)	20	ns	20	12

Table 3. Emergence (percent) of fungicide-treated Stephens winter wheat planted at 3- or 5-inch depth into soils of three moisture contents (7, 10 or 15 percent) in the greenhouse.

Days after planting	Seed treatment†	3-inch planting depth			5-inch planting depth		
		7%	10%	15%	7%	10%	15%
7	Dividend	0	60	90	0	0	0
	Raxil	0	3	80	0	0	0
9	Dividend	-	90	100	-	57	90
	Raxil	-	67	87	-	10	80
11	Dividend	40	97	100	17	67	90
	Raxil	23	90	87	7	57	87
13	Dividend	57	97	100	43	67	93
	Raxil	40	90	87	27	73	90
21	Dividend	63	93	100	50	67	90
	Raxil	53	90	90	53	77	87

† Seed treatments were Dividend + Apron at the rate of 0.5+0.09 fl oz/cwt, or Raxil Thiram at 3.5 fl oz/cwt. Data were not collected where designated by " - ".

Emergence of Dividend-treated winter wheat seed from shallow planting depths in the field was several days earlier than for RTU Vitavax Thiram-treated seed during 1993 (Table 4). Addition of NuZone to either Dividend or RTU Vitavax Thiram caused emergence to be slower than for either of the primary treatments. Soil moisture at planting depth was not restrictive to germination. These effects were noted as early as one week

Table 4. Emergence† of winter wheat seedlings from 3-3.5 inch planting depth near Helix and Pendleton during 1993.

	Days after planting at Helix‡		Days after planting at Pendleton§	
Treatment (fl oz/cwt)	10	16	8	14
Control	2.5	3.0	1.9	3.0
Dividend (0.5)	2.2	3.0	1.6	2.9
Dividend (1)	2.3	3.0	1.5	3.0
Dividend + Apron (0.5+1)	2.2	2.9	1.6	3.0
Dividend + NuZone (0.5+0.75)	1.3*	3.0	1.0*	2.7*
Dividend + NuZone (0.5+1.5)	1.0*	3.0	0.9*	2.6*
Dividend + NuZone + Apron (0.5+0.75+1)	1.2*	3.0	1.1*	2.9
RTU Vitavax Thiram (5)	1.5*	2.9	0.9*	2.7*
RTU + NuZone (5+0.75)	0.9*	2.8	0.6*	2.0*
RTU + NuZone (5+1.5)	0.5*	2.5*	0.5*	2.1*
RTU + NuZone + Apron (5+0.75+1)	0.9*	2.8	0.5*	2.4*
LSD (P=0.05)	0.4	0.2	0.4	0.2

† Emergence ratings; 0 = <10 percent of seedlings emerged, 1 = 10-50 percent, 2 = 50-85 percent, and 3 = >85 percent. Data within each column differ from untreated seed when marked by an asterisk (*). Stand counts for Stephens wheat 25 days after planting were 17-21 seedlings/ft. of row near Pendleton and 17-24 seedlings/ft. of row near Helix: representative stand counts near Helix were 24.2 for Dividend + NuZone (0.5+1.5), 20.0 for Dividend (1.0) and the untreated control, 17.8 for RTU Vitavax Thiram, and 17.0 for RTU Vitavax Thiram + NuZone (5+1.5).

‡ Combined data for three varieties (Madsen, Rohde, and Stephens) of soft-white winter wheat.

§ Combined data for two varieties (Madsen and Stephens) of soft-white winter wheat.

after planting and, with the exception of the combination of RTU Vitavax Thiram and NuZone, were mostly dissipated after the second week. Seed treated with Dividend alone or Dividend + Apron emerged as quickly as untreated seed. Final stand counts did not differ among fungicide treatments near Pendleton, and were higher for Dividend than RTU Vitavax Thiram and control treatments near Helix.

Table 5. Emergence† of winter wheat seedlings from 4-5 inch planting depths near Arlington and Prosser during 1993.

	Days after planting at Arlington‡		Days after planting at Benton City§		
Treatment (fl oz/cwt)	15	22	14	21	34
Control	2.4	2.9	1.5	2.1	2.0
Dividend (0.5)	2.8*	3.0	2.2*	2.6*	2.6*
Dividend (1)	2.5	2.8	2.2*	2.5	2.5*
Dividend + NuZone (0.5+0.75)	1.4*	2.6	1.4	1.8	2.1
Dividend + NuZone (0.5+1.5)	1.2*	2.3*	0.9*	1.3*	1.5*
RTU Vitavax Thiram (5)	1.3*	2.5	0.9*	1.5	1.7
RTU + NuZone (5+0.75)	1.2*	2.3*	1.0	1.6	1.8
RTU + NuZone (5+1.5)	0.9*	2.0*	0.4*	0.8*	1.3*
LSD (P=0.05)	0.4	0.4	0.5	0.5	0.4

† Emergence ratings; 0 = <10 percent of seedlings emerged, 1 = 10-50 percent, 2 = 50-85 percent, and 3 = >85 percent. Data within each column differ from untreated seed when marked by an asterisk (*). Stand counts for Weston wheat 34 days after planting near Benton City were 2-7 seedlings/ft. of row ($P<0.01$; LSD=1.1): representative stand counts were 7.0 for Dividend (1.0), 5.2 for Dividend + NuZone (0.5+1.5), 4.7 for the control, 4.3 for RTU Vitavax Thiram + NuZone (5+1.5), and 2.3 for RTU Vitavax Thiram (5).

‡ Combined data for two varieties; Rohde and Stephens.

§ Combined data for Rohde and Weston.

Dividend-treated seed also emerged more quickly and RTU Vitavax Thiram-treated seed more slowly than untreated seed planted deeply (4-5 in.) into soil with 8-9 percent seed-zone moisture (Table 5). Supplementation of the primary fungicide with NuZone tended to delay emergence. Stand density was higher for seed treated with Dividend than RTU Vitavax Thiram near Benton City and was not assessed near Arlington.

Emergence was evaluated near Benton City and Ione under critically low soil moisture during a drought in 1994. There was no significant rainfall at either site for eight weeks after planting. Most soft-white winter wheat cultivars emerged very slowly at Benton City (6.6 percent soil moisture at planting depth), and failed to emerge at Ione (4.9 percent moisture at planting depth). A hard-red winter wheat (cv. Weston) began to emerge two weeks after planting at both sites.

Compared to untreated seed, emergence of Weston was enhanced by both Dividend and RTU Vitavax Thiram (Table 6). NuZone reduced the initial rate of emergence when applied with Dividend at Benton City but not at Ione. FloPro IMZ did not influence the rate of emergence when applied with RTU Vitavax Thiram. One of 19 soft-white cultivars (cv. Rod) emerged as well as cv. Weston near Benton City. Emergence of Weston near Ione was extremely slow and seed rot caused stands to be unacceptably sparse. The trial was abandoned after emergence data was collected.

Seed treatment fungicides were examined near Arlington (10 percent soil moisture at 4.5-in. planting depth), Echo (10 percent moisture at 3.5-in. depth) and Pendleton (15 percent moisture at 3-in. depth) during 1995. Emergence did not differ significantly among fungicide treatments at any location although it tended to be slower for treatments containing Raxil Thiram (with or without Gaucho) than either Dividend or RTU Vitavax Thiram near Echo and Pendleton (data not presented). Final stand counts were 0-10 percent near Arlington, 30-43 percent near Echo, and 84-100 percent near Pendleton (data not presented). Rain (0.25 in.) followed by rapid drying seven days after planting caused surface crusting near Arlington. Reasons for poor emergence at Echo were not apparent.

The influence of planting depth on emergence of fungicide-treated seed was examined near Pendleton during 1995. The experiment was performed under conditions of plentiful soil moisture (13 percent to 16 percent at planting depth). Emergence was predictably delayed by increasing planting depth (Table 7). Dividend enhanced the rate of emergence for seed planted at 1.1-in. depth. When placed at 2.8- and 4.1-in. depth, Raxil Thiram-treated seed with or without Gaucho had slower emergence than other treatments. Raxil Thiram reduced the rate of emergence for more than three weeks compared to untreated seed placed at 4.1-in. depth.

DISCUSSION

Emergence of winter wheat in a stubble-mulch tillage system in the field and as a simulated system in the greenhouse was delayed and final stand density reduced by increasing planting depth, decreasing seed-zone moisture content, and surface crusting before emergence. Seed germination generally exceeded 95 percent at all except critically low soil water contents.

Seedling emergence in the field and greenhouse was often more rapid for seed treated with Dividend or Dividend + Apron compared to untreated seed or seed treated with RTU Vitavax Thiram, NuZone, or Raxil. Differences in emergence among treatments were as much as two days in the greenhouse and two weeks in the field. Improved emergence from Dividend treatment was observed at soil water contents ranging from sub-optimum to optimum for emergence. Dividend did not expedite emergence in several experiments, but in no instance did it delay emergence.

Final stand density differed among treatments in some of our field experiments. Dividend occasionally improved stand density and there was a potential for this fungicide to improve final stand density if surface crusting would have occurred between dates of emergence for treatments with the most rapid and slowest emergence. Rain two days after planting at Arlington during 1995, followed by rapid drying, caused crusting in all treatments before coleoptiles reached the surface. Dividend-treated seed did not emerge rapidly enough to prevent stand failure.

Table 6. Emergence† of Weston winter wheat seedlings from 4.5-5 inch planting depths near Benton City and Ione during 1994.

	Days after planting					
	Ione			Benton City		
Treatment (fl oz/cwt)	16	23	36	13	21	34
Control	0	0.4	0.7	0.8	1.8	2.8
Dividend (0.5)	0.2	1.0	1.4*	1.8*	2.2	2.8
Dividend (1)	0.8*	1.4	2.2*	1.6*	2.2	2.8
Dividend + NuZone (0.5+0.75)	0.2	1.0	1.4*	1.0	2.0	3.0
Dividend + Maxim (0.5+0.16)	0.8*	0.8	1.4*	1.6*	2.6*	2.8
RTU Vitavax Thiram (5)	0.8*	1.4	1.6*	1.6*	2.4	2.8
RTU + FloPro IMZ (5+0.5)	0.2	1.0	1.4*	1.2	1.6	2.2
LSD (P=0.05)	0.7	ns	0.7	0.6	0.7	ns

† Emergence ratings; 0 = <10 percent of seedlings emerged, 1 = 10-50 percent, 2 = 50-85 percent, and 3 = >85 percent. Data within each column differ from untreated seed when marked by an asterisk (*).

Table 7. Emergence† of Rod winter wheat seedlings from three planting depths (1.1, 2.8, and 4.1 inches) near Pendleton during 1995.

Treatment and rate (fl oz/cwt)	1.1-inch		2.8-inch		4.1 inch		
	7‡	13	7	13	7	13	24
Nontreated control	69	83	30	88	2	56	63
Dividend + Apron (1.0+0.09)	91*	100	21	86	0	50	58
RTU Vitavax Thiram (6.0)	65	90	19	83	0	48	56
Raxil Thiram (3.5)	59	86	8*	82	2	36	46*
Raxil Thiram + Gaucho (3.5+2.0)	70	95	6*	91	0	43	51
LSD (0.05)	21	ns	16	ns	ns	ns	12

†Percentage of emerged seedlings from 15 seed planted per foot of row. Data within each column differ from untreated seed when marked by an asterisk (*).
‡Days after planting.

However, differences in stand density would have been likely if a similar crusting event had occurred 14 days after planting at Arlington or Benton City during 1993, or 7 to 10 days after planting at Pendleton during 1995.

RTU Vitavax Thiram had a variable effect on seedling emergence. This fungicide improved emergence from extremely dry soil at two field sites during 1995, but more generally had either no effect compared to untreated seed, or caused delayed emergence and/or reduced final stand density compared to treatment with Dividend. Although inhibitory effects have been reported, the sparcity of reports on this topic, and our experience, suggests that Vitavax Thiram neither inhibits nor stimulates emergence in most instances.

NuZone and FloPro IMZ also had variable effects on seedling emergence and stand density. These imazalil fungicides had either no effect or inhibited emergence and stand establishment in the field. In contrast, NuZone stimulated emergence in very dry soil in the greenhouse. Reasons for the discrepancy between results with dry soil in the greenhouse and field remain unknown. Our results with imazalil fungicides in the field are comparable to inhibitory effects described by others.

Raxil Thiram was evaluated with or without Gaucho insecticide at four sites during 1995. Raxil Thiram-treated seed tended to emerge more slowly than other treatments, particularly when seed was planted more than 3-in. deep. This may not be a problem under commercial practice because the Raxil Thiram label states that this fungicide is not recommended for seed planted deeper than 1.5- to 2-in. In semiarid regions with stubble-mulch fallow Raxil Thiram is likely to be used mostly for shallow-planted cereals such as spring wheat or barley. Surface crusting is not common with spring plantings. Gaucho did not modify emergence characteristics compared to the fungicide alone.

Reasons for poor emergence near Echo during 1995 were not clear. Seed-zone moisture may have been depleted by mixing moist and dry soil during planting, although this was not known to have occurred at Echo or other sites. The seed-zone water content at planting (10.1 percent) was not low enough to impede germination of wheat. It is more likely that high temperature dormancy impeded seed germination. Seed-zone temperature near Echo was 80 °F at the time of planting. Seed dormancy is variable and typically occurs at temperatures above 68-77 °F (Austin and Jones, 1975). Elongation of coleoptiles and emergence are also impeded when seed is planted into hot soil (Allan et al., 1962).

Combined effects of temperature, moisture, and seed characteristics apparently contributed to poor emergence near Benton City during 1994. Emergence was poor for four soft-white winter wheat cultivars (cvs. Gene, Madsen, Rohde, and Stephens), and marginally acceptable for the only hard-red winter wheat (cv. Weston) in the fungicide seed treatment trial. In an adjacent disease screening nursery only one (cv. Rod) of 19 soft-white winter wheat cultivars emerged as well as two hard-red wheat cultivars (cvs. Hatton and Weston) in the nursery. Differences in emergence did not appear to be related to coleoptile length or protein content, both of which are related to seedling vigor and emergence (Austin and Jones, 1975; Torres and Paulsen, 1982). Rod was the only cultivar screened for seed size and only the plumpest kernels were delivered from a commercial seed dealer for this test. Seed of Rod was retained between A.S.T.M. screen mesh sizes 6 (0.131-in. openings) and 7 (0.110 in.), while seed of other cultivars was mesh 7 through 8 (0.0937 in.). Seed of Rod weighed 0.058g/kernel compared to about 0.038g/kernel for other cultivars. Large seed size has been associated with improved emergence and seedling vigor in some tests. While seed-zone moisture was definitely limiting at planting, it clearly did not prevent germination and emergence of hard-red cultivars and Rod soft-white wheat. We suspect that interactions among seed size and soil temperature and moisture resulted in outstanding emergence of Rod during periods of high moisture and temperature stress during 1994. This hypothesis is supported by the absence of differences in emergence of non-sized seedlots of Rod (mesh 7-8; 0.038g/kernel) and 18 other soft-white winter wheat cultivars at five locations during 1995.

Poor emergence near Ione during 1994 was dominated by effects of drought on seed germination. Seed-zone moisture was well below that required for optimal germination of wheat. Nevertheless, the ability of hard-red winter wheat to germinate and emerge under these conditions was measurably higher than for soft-white winter wheat cultivars.

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SUMMARY

Emergence of Dividend-treated seed over a range of soil moisture contents in the greenhouse was usually more rapid than for other fungicide treatments or untreated seed. Emergence in the field also tended to be superior for seed treated with Dividend in plantings made from 1- to 5-inches deep into soil with 5 to 17 percent seed-zone water content and 71 to 80 °F temperature. RTU Vitavax Thiram had variable effects on seedling emergence. NuZone and Raxil Thiram generally delayed emergence when treated seed was planted at depths more than 2 inch. This research demonstrated that emergence of winter wheat planted deeply into subble-mulch fallow is often improved when seed is treated with Dividend compared to RTU Vitavax Thiram.

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CARBON DIOXIDE RELEASE FROM THE SOIL DURING RESIDUE DECOMPOSITION

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INTRODUCTION

Soil bacteria and fungi drive most of the biogeochemical processes in agricultural soils (Paul and Voroney, 1980). Soil microorganisms impact agroecosystem productivity by regulating nutrient cycling and availability, determining soil carbon storage, and contributing to atmospheric carbon dioxide (CO_2). The soil near the surface is the most biologically active. Upper soil levels undergo greater diurnal and seasonal changes in temperature and moisture than the underlying soil, and are exposed to the largest fertilizer and residue inputs. These factors have a considerable influence on the populations and activities of soil microorganisms (Paul and Clark, 1989).

Most management practices, such as tillage or addition of crop residues, affect the activity of soil microorganisms. Residue decomposition in agroecosystems is an important process in the cycling of essential nutrients. Residue decomposition is a result of metabolic activity by soil organisms, with the accompanying production of CO_2. Biological decomposition is often characterized as a three phase process. In the relatively rapid initial phase, the readily utilizable compounds, such as sugars, amino acids, and organic acids, are oxidized. The decomposition process slows during the second phase as the more resistant materials, cellulose and hemicellulose, are attacked by the soil microorganisms. In the third, and slowest, phase the decomposition of the very resistant components, such as lignin, takes place (Tietema, 1993). Some residue or residue decomposition products might be lost by soil erosion or by water leaching through the soil profile (Joergensen and Meyer, 1990).

Carbon dioxide efflux measurements are regularly used in carbon cycling studies in terrestrial ecosystems. They provide data that are indices of rates of organic matter decomposition. The CO_2 efflux data are normally expressed per unit soil surface area or mass. In early laboratory studies Waksman and Starkey (1924) measured CO_2 evolution from soil samples to use as indices of soil fertility. Oxygen uptake by soil samples, determined by the Warburg manometric method, might also be used to estimate the decomposition process (Rovira, 1953). There has recently been an increased interest, aided by the development of various types of analytical equipment, in the use of CO_2 evolution measurements to assess soil microbial activity.

Factors such as residue additions, tillage, fertilization, and climate, have been intensively investigated to evaluate their effects on crop growth or productivity. However, surprisingly little work has been done to investigate their effect on the activity or population dynamics of soil microorganisms. In addition, there is increasing interest in the importance of agroecosystems in the global carbon balance, especially their role as either a source or sink for CO_2 under varying climatic conditions. This study was started to gain a better understanding of microbial activity, and CO_2 production, during residue decomposition in soils and climatic conditions of the inland Pacific Northwest.

MATERIALS AND METHODS

The study was conducted on a Walla Walla silt loam soil at the Columbia Plateau Conservation Research Center, located 9 miles northeast of Pendleton, OR. The center is about 1,500 feet above sea level and has annual precipitation of 12 to 16 inches. Soil samples were collected from the upper 3 inches in essentially level fields. Soils used to estimate basal soil respiration and substrate induced respiration were collected from a fallow field. Residue and plant roots were removed from these samples. Samples used to estimate residue amended respiration came from a field that had been harvested with a stripper-header and had 7,500 pounds of residue per acre (Wilkins, personal communication). Actively growing plant roots were also excluded from these samples. Soil moisture on all samples was determined gravimetrically.

Basal soil CO_2 respiration was estimated by placing approximately 10 g of nonamended soil in gas-tight 70 mL bottles. The sample bottles were buried in the soil, which allowed incubation at the prevailing soil temperature. Soil microbial biomass carbon was estimated by the substrate induced respiration method (Anderson and Domsch, 1978). Forty milligrams of glucose in aqueous solution was added to approximately 10 g of nonamended soil in 70 mL gas-tight bottles and the amended soil samples were incubated at soil temperature in the field. Estimation of the CO_2 respiration from residue amended soil was determined by adding approximately 130 g of residue containing soil to a gas-tight 1,000 mL bottle. The larger volume bottle allowed inclusion of the residue with a minimum disruption of the sample. Sample bottles were also placed in the soil for incubation.

Carbon dioxide production was determined with a Beckman infrared gas analyzer (Clegg et al, 1978). The CO_2 concentration was measured four times over a 90-minute period, and the rate of CO_2 production derived from linear regression analysis. Soil respiration rate per gram of soil (μg CO_2/g dry soil/hour) at each date was calculated as the mean of four measurements. Soil microbial biomass was computed from the substrate induced respiration rate as proposed by Kaiser et al. (1992). The distribution of sample means were calculated using standard statistical methods (Little and Hills, 1972).

RESULTS AND DISCUSSION

Soil temperatures at 1 inch were generally greater than at the 4 inch depth (Figure 1). Ambient air temperatures are also shown for reference. The largest temperature difference between depths occurred in June where the temperature at 1 inch was

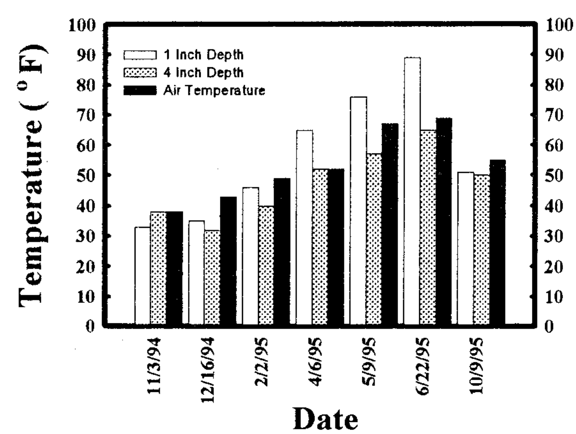

Figure 1. Soil Temperature. Bars are the hourly averages (11:00 AM to 1:00 PM) during the incubation time of the respiration measurements. Pendleton, OR.

1.36 times greater than the temperature at 4 inches, almost 90 °F and 65 °F, respectively. Soil temperatures remained above freezing on sampling dates and, thus, did not restrict the soil sampling procedures.

Overall soil moisture content was good; the soil was never extremely dry at any sampling date (Figure 2). Seasonal

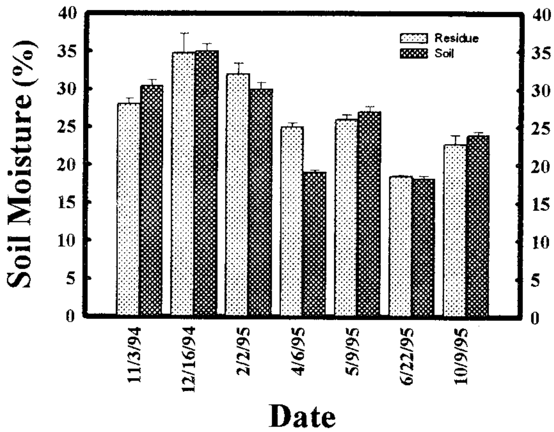

Figure 2. Soil Moisture Content. Bars are the means of gravimetric soil moisture measurements. Error bars are the standard error of the mean. Pendleton, OR.

variations in soil moisture content reflect the typical rainfall patterns in the inland Pacific Northwest, where cool wet winters and warm dry summers prevail. Precipitation in early May (1.56 inches from 5/1 to 5/9) and June (1.73 inches from 6/1 to 6/20) accounts for the relatively high levels of soil moisture found on the May and June sampling dates. Soil aeration is generally controlled by soil moisture; however, even at the greatest soil moisture content, it is unlikely that the top 4 inches of the soil was anaerobic.

Soil respiration was very low in the late fall and winter months, and increased in the spring, with peak activity in April and early May. Soil respiration declined in late June and October (Figure 3). Soil respiration remained detectable throughout

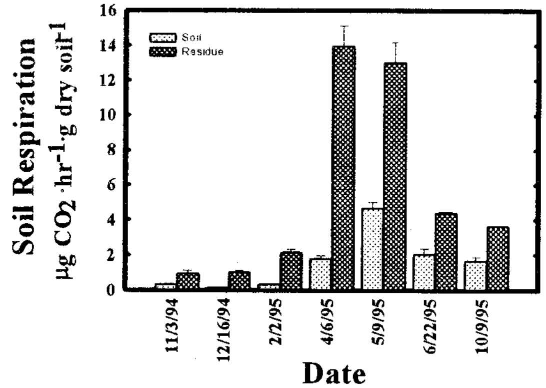

Figure 3. Soil Respiration. Bars are the means of CO_2 efflux from the soil. Error bars are the standard error of the mean. Soil bars are unamended soil, residue bars are soil amended with residue. Pendleton, OR.

the experiment, even when temperatures were almost at the freezing point in December and February. Overall, respiration was positively correlated with soil temperature, but showed little correlation to soil water content. These findings were similar to those of Alvarez and coworkers (1995). Koizumi and coworkers (1993) have suggested that temperature, not soil moisture, has the greatest effect on soil respiration in temperate climates and our findings support this hypothesis. The addition of residue greatly increased soil respiration, and the difference in amended and nonamended respiration was greatest during the winter. Residue amended soils had 10 and 18 percent greater respiration than the unamended soils in December and February respectively (Figure 3).

Comparisons between different techniques for measuring soil CO_2 efflux have shown that some bias is associated with all of them (De Jong et al, 1979). The amount of bias might reflect the amount of disturbance to the local environment caused by each method. The static type incubation technique used in this study might overestimate soil respiration. During the sampling procedure, sections of the soil are exposed to the air. In addition, cracks and fissures develop in the soil sample, which might increase the soil oxygen concentration and thus increase respiration. However, this method eliminates actively metabolizing root tissue that would contribute CO_2 and produce an over estimation of soil respiration. Allison and Killham (1988) have shown that the incorporation of plant residues produces a rapid proliferation of soil microorganisms. Initially, they are predominantly young cells, which give a higher CO_2 production per unit biomass (Anderson and Domsch, 1978), and might cause the overestimation of microbial carbon after recent addition of residue.

The carbon content in the soil microbial biomass (Figure 4), estimated by the substrate induced respiration method, is an indication of the population of metabolically active microorganisms in the soil at a given time. The seasonal variation in the microbial population, with low values in the winter, increasing through the spring then declining into summer and fall; was affected by soil temperature. The linkage of microbial biomass with temperature is consistent with the findings of others (Lynch and Panting, 1980; Ocio and Brookes, 1990). However, we observed a decline in microbial biomass in June when the soil temperature remains elevated. As the soil moisture was probably adequate for microbial activity, we propose that the reduction in biomass might be the result of the relatively high soil temperatures inhibiting microbial metabolisms, thus producing a decline in their populations.

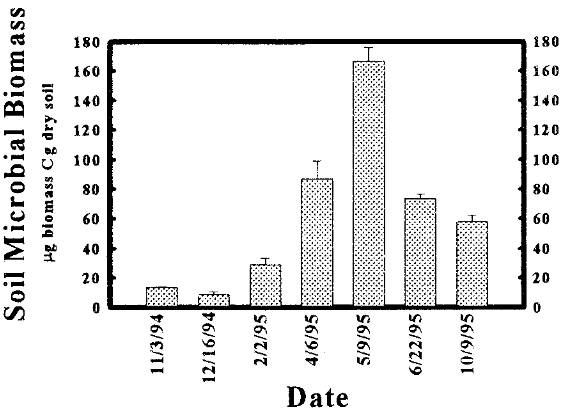

Figure 4. Soil Microbial Biomass. Bars are the means of four measurements. Error bars are the standard error of the mean. Pendleton, OR.

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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
66 Year Average	**.72**	**1.31**	**2.00**	**2.05**	**1.92**	**1.50**	**1.71**	**1.53**	**1.47**	**1.26**	**.36**	**.50**	**16.33**
1975-76	0	2.16	1.47	3.40	2.13	1.09	1.69	1.65	1.21	.58	.04	2.58	18.00
1976-77	.44	.53	.47	.59	.90	.57	1.72	.46	1.70	.31	.12	2.21	10.02
1977-78	1.54	.69	1.79	3.19	2.27	1.71	1.40	3.50	.81	1.27	.59	1.37	20.13
1978-79	1.61	0	1.68	2.28	1.31	1.54	1.74	1.82	1.15	.18	.12	2.08	15.51
1979-80	.17	2.56	2.31	1.05	2.85	1.55	2.12	1.20	2.45	1.42	.23	.18	18.09
1980-81	1.24	2.96	1.81	1.99	1.26	2.31	2.30	1.29	2.30	2.12	.40	.02	20.00
1981-82	1.51	1.62	2.41	3.27	2.61	1.86	1.99	1.54	.48	1.12	1.02	.50	19.93
1982-83	1.68	2.68	1.46	2.69	1.63	2.97	3.90	1.23	2.08	1.92	1.00	.68	23.92
1983-84	.82	.91	2.79	3.44	.99	2.56	3.23	2.37	2.11	2.05	.05	1.25	22.57
1984-85	.98	1.18	3.43	1.96	.69	1.49	1.33	.65	.89	1.42	.05	.98	15.05
1985-86	1.54	1.34	2.66	1.27	2.38	3.04	1.94	.83	1.79	.09	.61	.19	17.68
1986-87	1.87	.91	3.41	.95	2.08	1.31	1.85	.83	1.63	.62	.47	.06	15.99
1987-88	.04	0	1.44	1.61	2.60	.32	1.65	2.59	1.79	.94	0	0	12.98
1988-89	.40	.08	3.65	1.10	2.86	1.55	2.95	1.94	2.19	.33	.15	1.19	18.39
1989-90	.24	1.00	1.65	.49	1.43	.63	1.89	1.77	2.14	.70	.37	.76	13.07
1990-91	0	1.37	1.73	1.18	1.15	.86	1.71	1.01	4.73	2.22	.15	.24	16.35
1991-92	.03	.89	4.18	.97	.96	1.34	.85	1.29	.20	.90	1.74	.78	14.13
1992-93	.58	1.70	2.61	1.30	2.43	1.04	2.32	2.67	1.58	2.01	.47	2.60	21.31
1993-94	0	.30	.49	1.91	2.38	1.67	.52	1.18	2.88	.75	.33	.07	12.48
1994-95	.76	1.44	3.77	1.83	2.75	1.15	2.35	2.92	1.56	1.73	.22	.41	20.89
1995-96	.93	1.35	2.95	2.37	2.79	2.45	1.49						
20 Year Average	**.77**	**1.22**	**2.26**	**1.82**	**1.88**	**1.53**	**1.97**	**1.64**	**1.78**	**1.13**	**.41**	**.90**	**17.32**

PRECIPITATION SUMMARY - MORO

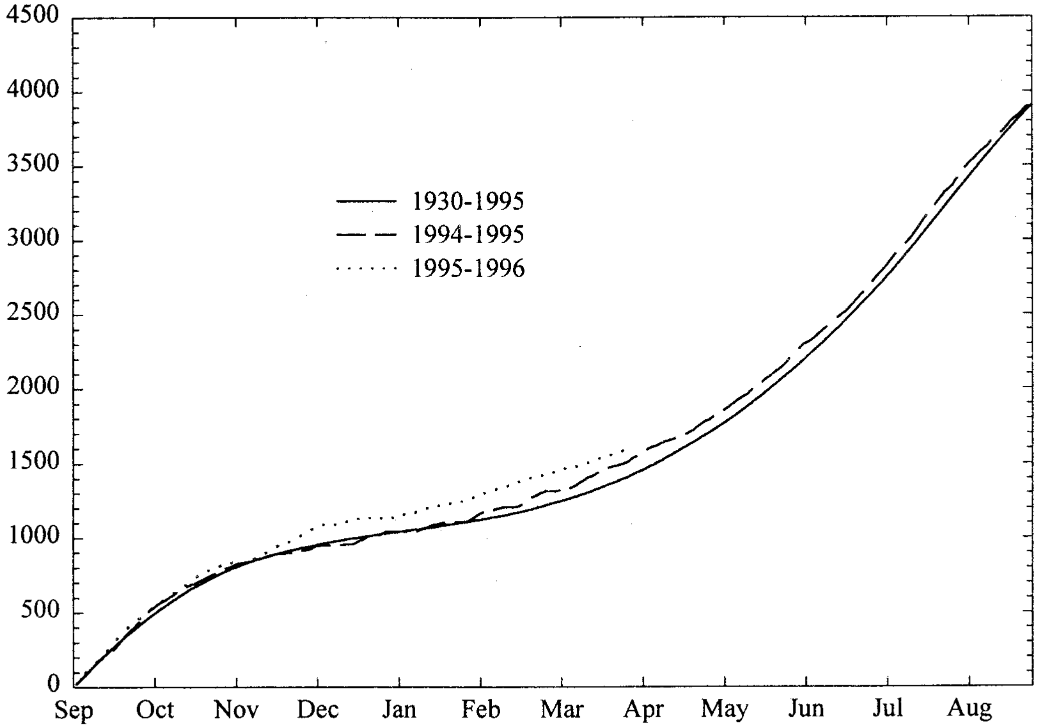
CBARC - Sherman Station - Moro, Oregon
(Crop year basis, ie; September 1 through August 31 of following year)

Crop Yr	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
86 Year Average	**.58**	**.92**	**1.69**	**1.63**	**1.63**	**1.15**	**.99**	**.79**	**.81**	**.70**	**.23**	**.29**	**11.42**
1975-76	0	1.17	1.34	1.26	1.25	.93	.95	1.06	.14	.06	.79	1.17	10.12
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	1.05	8.50
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	.97	1.09	.17	0	13.03
1984-85	.53	.86	3.18	.41	.27	.97	.44	.14	.63	.92	.05	.14	8.54
1985-86	1.11	1.09	1.19	1.12	1.84	2.39	.98	.34	.35	.06	.54	.07	11.08
1986-87	1.52	.45	1.53	.78	1.68	1.10	1.54	.28	.99	.29	.78	.11	11.05
1987-88	.07	.01	.66	3.23	1.60	.21	1.25	2.21	.55	1.02	.04	0	10.85
1988-89	.56	.02	2.51	.22	1.33	.77	1.91	.84	.91	.08	.11	.50	9.76
1989-90	.07	.59	.96	.48	1.91	.17	.76	.79	1.36	.39	.15	1.43	9.06
1990-91	.29	1.27	.61	.74	.87	.60	1.43	.40	.77	1.27	.33	.16	8.74
1991-92	0	1.40	2.57	1.02	.47	1.64	.64	2.38	.04	.28	.81	.02	11.27
1992-93	.68	.85	1.50	1.68	1.42	1.47	1.68	1.22	1.42	.87	.39	.30	13.48
1993-94	.02	.09	.41	.68	1.40	.90	.55	.40	.62	.61	.11	.07	5.86
1994-95	.19	2.27	1.79	.90	3.67	1.18	1.14	1.95	.97	1.45	1.10	.17	16.78
1995-96	1.02	.64	3.20	2.20	1.86	2.43	.65						
20 Year Average	**.51**	**.86**	**1.55**	**1.46**	**1.49**	**1.15**	**1.13**	**.96**	**.89**	**.66**	**.39**	**.43**	**11.48**

CUMULATIVE GROWING DEGREE DAYS

(BASE = 0^{0}C)

PENDLETON



MORO