ecial Report 1087
y 2008

Malheur Experiment Station Annual Report 2007

Oregon State UNIVERSITY | Agricultural Experiment Station

For additional copies of this publication

Clinton C. Shock, Superintendent
Malheur Experiment Station
595 Onion Avenue
Ontario, OR 97914

For additional information, please check our website

http://www.cropinfo.net/

Agricultural Experiment Station
Oregon State University

Special Report 1087
July 2008

Malheur Experiment Station Annual Report 2007

Common names and manufacturers of chemical products used in the trials reported here are contained in Appendices A and B. Common and scientific names of crops are listed in Appendix C. Common and scientific names of weeds are listed in Appendix D. Common and scientific names of diseases and insects are listed in Appendix E.

Contributors and Cooperators
Malheur Experiment Station Special Report
2007 Research

MALHEUR COUNTY OFFICE, OREGON STATE UNIVERSITY EXTENSION SERVICE

Jensen, Lynn	Professor
Norberg, Steve	Assistant Professor

MALHEUR EXPERIMENT STATION

Eldredge, Eric	Faculty Research Assistant
Feibert, Erik	Senior Faculty Research Assistant
Felix, Joel	Assistant Professor of Weed Science
Ishida, Joey	Bioscience Research Technician
Jones, Janet	Office Specialist
Saunders, Lamont	Bioscience Research Technician
Shock, Clinton	Professor, Superintendent

MALHEUR EXPERIMENT STATION, STUDENTS

Iida, Chelsey	Research Aide
Noble, Brian	Research Aide
Noble, Heather	Research Aide
Saunders, Ashley	Research Aide
Wells, Tabitha	Research Aide

OREGON STATE UNIVERSITY, CORVALLIS, AND OTHER STATIONS

Bassinette, John	Senior Faculty Research Assistant, Dept. of Crop and Soil Science
Charlton, Brian	Faculty Research Assistant, Klamath Falls
Hane, Dan	Potato Specialist, Hermiston
James, Steven	Senior Faculty Research Assistant, Madras
Karow, Russell	Professor, Dept. of Crop and Soil Science
Leroux, Laurie	Faculty Research Assistant, Hermiston
Simmons, Rhonda	Faculty Research Assistant, Madras
Vales, Isabel	Associate Professor, Dept. of Crop and Soil Science
Welch, Teresa	Manager Ag Publishing, Ext. and Exp. Station Communications
Yilma, Solomon	Senior Faculty Research Assistant, Dept. of Crop and Soil Science

OTHER UNIVERSITIES

Brown, Brad	Extension Specialist, University of Idaho, Parma, ID
Flock, Rebecca	Graduate Student, University of California, Davis, CA
Mohan, Krishna	Professor, University of Idaho, Parma, ID
Morishita, Don	Associate Professor, University of Idaho, Twin Falls, ID
Neufeld, Jerry	Associate Professor, University of Idaho, Caldwell, ID
Novy, Rich	Research Geneticist/Potato Breeder, USDA, Aberdeen, ID
O'Neill, Mick	Superintendent, New Mexico State University, Farmington, NM
Pappu, Hanu	Associate Professor, Washington State University, Pullman, WA
Ransom, Corey	Weed Scientist, Utah State University, Logan, UT
Reddy, Steven	Extension Educator, University of Idaho, Weiser, ID
Sampangi, Ram	Extension Support Scientist, University of Idaho, Parma, ID

OTHER PERSONNEL COOPERATING ON SPECIAL PROJECTS

Anderson, Brian	Clearwater Supply, Inc., Othello, WA
Camp, Stacey	Amalgamated Sugar Co., Paul, ID
Donar, Larry	Fresno Valves and Castings, Inc., Kennewick, WA
Eaton, Jake	Greenwood Resources, Inc., Boardman, OR
Erstrom, Jerry	Malheur Watershed Council, Ontario, OR
Foote, Paul	Amalgamated Sugar Co., Paul, ID
Futter, Herb	Malheur Owyhee Watershed Council, Ontario, OR
Hansen, Mike	M.K. Hansen Co., East Wenatchee, WA
Hawkins, Al	Irrometer Co., Inc., Riverside, CA
Hill, Carl	Owyhee Watershed Council, Ontario, OR
Jensen, Scott	USFS Shrub Science Lab, Provo, UT
Johnson, Doug	USDA-ARS Forage and Range Research Lab, Logan, UT
Kameshige, Brian	Cooperating Grower, Ontario, OR
Kameshige, Randy	Cooperating Grower, Ontario, OR
Klauzer, Jim	Clearwater Supply, Inc., Ontario, OR
Komoto, Bob	Ontario Produce, Ontario, OR
Leiendecker, Karen	Oregon Watershed Enhancement Board, La Grande, OR
Martin, Jennifer	Coordinator, Owyhee Watershed Council, Ontario, OR
Meyer, Therese	Utah Division of Wildlife Resources, Ephraim, UT
Mittlestadt, Bob	Clearwater Supply, Inc., Othello, WA
Nakada, Vernon	Cooperating Grower, Ontario, OR
Nakano, Jim	Malheur Watershed Council, Ontario, OR
Page, Gary	Malheur County Weed Supervisor, Vale, OR
Penning, Tom	Irrometer Co., Inc., Riverside, CA
Petersen, Ed	Natural Resource Conservation Service, Ontario, OR
Pogue, Bill	Irrometer Co., Inc., Riverside, CA
Polhemus, Dave	Andrews Seed Co., Ontario, OR
Richardson, Phil	Oregon Dept. of Environmental Quality, Pendleton, OR
Shaw, Nancy	USDA Forest Service, Boise, ID
Shock, Cedric	Computer Programer, Springfield, OR
Stander, J.R.	Betaseed, Inc., Kimberly, ID
Taberna, John	Western Laboratories, Inc., Parma, ID
Weidemann, Kelly	Malheur Watershed Council, Ontario, OR

GROWERS ASSOCIATIONS SUPPORTING RESEARCH

Idaho-Eastern Oregon Onion Committee
Malheur County Potato Growers
Nyssa-Nampa Beet Growers Association
Oregon Potato Commission
Oregon Wheat Commission

PUBLIC AGENCIES SUPPORTING RESEARCH

Agricultural Research Foundation
Oregon Department of Agriculture
Oregon Watershed Enhancement Board
USDA Cooperative State Research, Education, and Extension Service
USDA Forest Service
Western Sustainable Agriculture Research and Extension

COMPANY CONTRIBUTORS

ACH Seeds
AMVAC
Amalgamated Sugar Co.
American Takii, Inc.
Andrews Seed, Inc.
BASF
Bayer CropScience
Bejo Seeds, Inc.
Betaseed, Inc.
Crookham Seed Co.
Dow AgroScience
D. Palmer Seeds
Global Genetics
Gowen Co.
HelmAgro
Hilleshog/Syngenta
Holly Hybrids
Irrometer Co., Inc.
Monsanto
Nunhems USA, Inc.
Sakata Seed America
Seedex
Seminis Vegetable Seed, Inc.
J.R. Simplot Co.
Syngenta
Valent
W-L Research

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

2007 WEATHER REPORT

Erik B. G. Feibert and Clinton C. Shock
Malheur Experiment Station
Oregon State University
Ontario, OR

Introduction

Air temperature and precipitation have been recorded daily at the Malheur Experiment Station since July 20, 1942. Installation of additional equipment in 1948 allowed for evaporation and wind measurements. A soil thermometer at 4-inch depth was added in 1967. A biophenometer, to monitor degree days, and pyranometers, to monitor total solar and photosynthetically active radiation, were added in 1985.

Since 1962, the Malheur Experiment Station has participated in the Cooperative Weather Station system of the National Weather Service. The daily readings from the station are reported to the National Weather Service forecast office in Boise, Idaho.

Starting in June 1997, the daily weather data and the monthly weather summaries have been posted on the Malheur Experiment Station web site on the internet at www.cropinfo.net.

On June 1, 1992, in cooperation with the U.S. Department of the Interior, Bureau of Reclamation, a fully automated weather station, linked by satellite to the Northwest Cooperative Agricultural Weather Network (AgriMet) computer in Boise, Idaho, began transmitting data from Malheur Experiment Station. The automated station continually monitors air temperature, relative humidity, dew point temperature, precipitation, wind run, wind speed, wind direction, solar radiation, and soil temperature at 8-inch and 20-inch depths. Data are transmitted via satellite to the Boise computer every 4 hours and are used to calculate daily Malheur County crop water-use estimates. The AgriMet database can be accessed through the internet at www.usbr.gov/pn/agrimet and from links on the Malheur Experiment Station web page at www.cropinfo.net.

Methods

The ground under and around the weather stations was bare until October 17, 1997, when it was covered with turfgrass. The grass is irrigated with subsurface drip irrigation. The weather data are recorded each day at 8:00 a.m. Consequently, the data in the tables of daily observations refer to the previous 24 hours.

Evaporation is measured from April through October as inches of water evaporated from a standard class A pan (10 inches deep by 4-ft diameter) over 24 hours. Evapotranspiration (ET_c) for each crop is calculated by the AgriMet computer using data from the AgriMet weather station and the Kimberly-Penman equation (Wright 1982). Reference evapotranspiration (ET_0) is calculated for a theoretical 12- to 20-inch-tall crop of alfalfa assuming full cover for the whole season. Evapotranspiration for all crops is calculated using ET_0 and crop coefficients for each crop. These crop coefficients vary throughout the growing season based on the plant growth stage. The crop coefficients are tied to the plant growth stage by three dates: start, full cover, and termination dates. Start dates are the beginning of vegetative growth in the spring for perennial crops or the emergence date for row crops. Full cover dates are typically when plants reach full foliage. Termination dates are defined by harvest, frost, or dormancy. Alfalfa mean ET_c is calculated for an alfalfa crop assuming a 15-percent reduction to account for cuttings.

Wind run is measured as total wind movement in miles over 24 hours at 24 inches above the ground. Weather data averages in the tables, except evapotranspiration, refer to the years preceding and up to, but not including, the current year.

2007 Weather

The total precipitation for 2007 (7.47 inches) was lower than the 10-year (10.41 inches) and 64-year (10.11 inches) averages (Table 1). Total snowfall for 2007 (3.8 inches) was lower than the 10-year (14.0 inches) and 64-year averages (18.2 inches) (Table 2).

The highest air temperature for 2007 was 105°F on July 7 (Table 3). The lowest temperature for the year was 6°F on January 15.

The months of February, March, May, June, and July had a higher number of growing degree days (50° to 86°F) than the 21-year average (Table 4, Fig. 1). Compared to 2003, which had the highest total growing degree days and compared to the average, the pattern of growing degree day accumulation in 2007 showed a higher accumulation earlier in the season (Fig. 1). The total number of degree days in the above-optimal range (86° to 104°F) in 2007 was higher than the average (Table 5).

Monthly total wind runs were close to the 10-year and 59-year averages (Table 6). Windy weather in late March had peak wind gusts of 34, 45, 37, and 42 mph on March 25, 26, 27, and 28, respectively. This windy weather event was associated with displacement of planted onion and sugar beet seed. Total pan-evaporation for April, May, June, and July was higher than the 10-year and 59-year averages (Table 7). Total accumulated reference ET and ET_c for onions and dry beans in 2007 were the highest since data collection started in 1992 (Table 8).

The average monthly maximum and minimum 4-inch soil temperatures in 2007 were close to the 10-year and 40-year averages (Table 9).

The last spring frost (≤32°F) occurred on May 4, 6 days later than the 31-year-average date of April 28; the first fall frost occurred on October 11, 5 days later than the 31-year-average date of October 6 (Table 10).

The year 2007 had the highest reference evapotranspiration since 1992, when the AgriMet station was installed at the Malheur Experiment Station (Table 11).

References

Wright, J.L. 1982. New evapotranspiration crop coefficients. Journal of Irrigation and Drainage Division, American Society of Civil Engineers 108:57-74.

Table 1. Monthly precipitation at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2007.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							inches						
1991	0.59	0.44	0.88	0.81	1.89	1.09	0.01	0.04	0.35	1.01	1.71	0.43	9.25
1992	0.58	1.36	0.25	0.74	0.21	1.43	0.36	0.01	0.09	0.95	1.15	1.51	8.64
1993	2.35	1.02	2.41	2.55	0.70	1.55	0.18	0.50	0.00	0.80	0.64	0.60	13.30
1994	1.20	0.57	0.05	1.02	1.62	0.07	0.19	0.00	0.15	1.23	2.46	1.49	10.05
1995	2.67	0.28	1.58	1.16	1.41	1.60	1.10	0.13	0.07	0.57	0.88	2.56	14.01
1996	0.97	0.86	1.03	1.19	2.39	0.12	0.32	0.31	0.59	0.97	1.18	2.76	12.69
1997	2.13	0.17	0.25	0.66	0.67	0.86	1.40	0.28	0.40	0.43	1.02	0.94	9.21
1998	2.26	1.45	0.95	1.43	4.55	0.36	1.06	0.00	1.00	0.04	1.07	1.11	15.28
1999	1.64	2.50	0.59	0.23	0.28	1.02	0.00	0.09	0.00	0.40	0.49	0.73	7.97
2000	2.01	2.14	0.97	0.72	0.28	0.26	0.03	0.06	0.39	1.74	0.38	0.66	9.64
2001	1.15	0.41	1.11	0.70	0.37	0.64	0.32	0.00	0.10	0.68	1.33.	1.00	7.78
2002	0.77	0.27	0.49	0.77	0.09	0.60	0.14	0.10	0.36	0.29	0.44	1.86	6.18
2003	1.46	0.48	0.99	1.12	1.52	0.24	0.36	0.11	0.15	0.02	0.86	1.47	8.78
2004	1.82	1.54	0.25	0.98	1.70	0.43	0.13	0.64	0.56	2.03	0.93	0.97	11.98
2005	0.41	0.12	1.66	0.80	2.94	1.02	0.22	0.06	0.14	1.38	1.58	3.92	14.25
2006	1.91	0.67	3.33	2.00	0.62	0.45	0.00	0.08	0.55	0.28	1.14	1.76	12.79
2007	0.07	0.95	0.12	0.82	0.47	0.63	0.03	0.15	0.92	0.68	1.07	1.56	7.47
10-yr avg	1.46	0.99	0.83	0.86	1.48	0.56	0.40	0.17	0.37	0.80	0.95	1.54	10.41
64-yr avg	1.29	0.96	0.93	0.78	1.08	0.80	0.23	0.34	0.44	0.74	1.16	1.32	10.11

Table 2. Annual snowfall totals at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2007.

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	10-yr avg	64-yr avg
								inches										
7.5	15.5	36.0	32.0	15.0	14.5	5.8	14.6	13.2	13.8	15.5	11.5	4.5	24.0	13.5	12.3	3.8	14.0	18.2

Table 3. Monthly air temperature, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	°F																							
Highest	48	29	59	37	73	47	85	50	90	56	98	65	105	70	99	63	96	62	82	48	65	47	60	44
Lowest	25	6	37	11	40	24	51	24	56	32	61	45	87	54	70	50	60	33	48	28	38	18	29	11
2007 avg	38	18	48	29	61	35	65	38	77	47	84	54	98	65	90	56	80	47	63	37	51	28	39	25
10-yr avg	38	25	45	27	56	33	64	38	73	46	82	52	93	60	91	56	81	47	67	38	49	30	38	25
64-yr avg	35	20	43	25	55	31	64	37	74	45	82	52	92	58	90	56	79	46	66	36	48	28	37	22

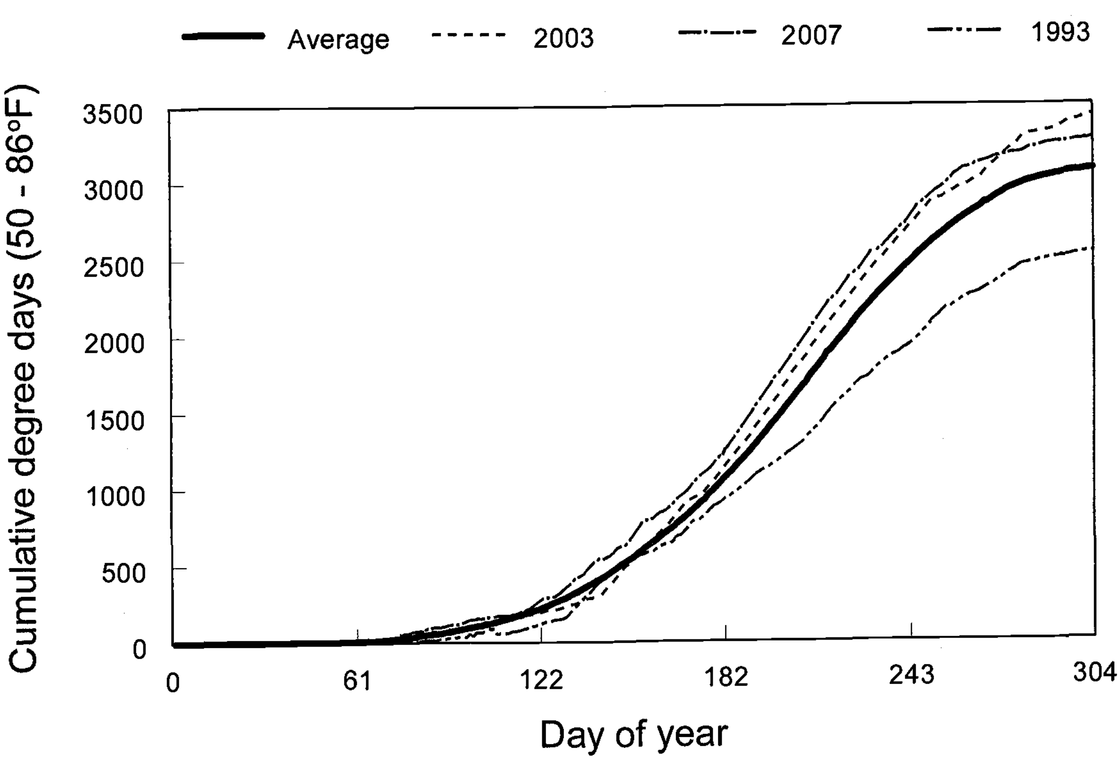


Figure 1. Cumulative growing degree days (50-86°F) over time for years with lowest (1993) and highest (2003) totals compared to 2007 and to 17-year average (1990-2006), Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 4. Monthly total growing degree days (50-86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2007.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	0	13	16	124	212	389	776	718	436	194	1	0	2,879
1992	0	13	106	202	482	574	639	704	385	174	4	0	3,283
1993	0	0	23	81	423	358	464	524	408	252	6	0	2,539
1994	0	2	92	189	369	523	794	774	509	144	2	0	3,398
1995	0	29	32	106	293	433	680	588	472	101	3	10	2,747
1996	0	5	53	135	243	446	805	658	364	194	18	2	2,923
1997	4	0	81	117	419	509	661	706	481	157	20	0	3,154
1998	0	2	52	112	68	571	802	749	515	151	16	4	3,042
1999	0	2	43	72	329	459	683	703	416	184	30	0	2,921
2000	0	4	36	194	342	536	751	743	368	133	2	0	3,109
2001	0	0	63	126	401	488	715	761	472	155	27	0	3,208
2002	0	2	32	137	319	562	805	621	437	142	14	2	3,073
2003	0	4	72	112	319	594	846	754	448	281	11	2	3,443
2004	0	0	115	187	311	607	776	680	365	180	4	0	3,225
2005	0	7	59	126	286	419	749	733	383	133	4	0	2,899
2006	0	4	22	131	364	599	866	668	394	151	31	0	3,230
2007	0	7	99	146	405	551	871	682	398	115	20	0	3,294
21-year avg	0	5	56	150	321	514	731	688	430	171	12	1	3,089

Table 5. Monthly total degree days in the above-ideal (86-104°F) range, Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2007.

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1991	0	0	2	41	36	4	0	83
1992	0	5	20	23	54	2	0	104
1993	0	4	4	2	11	5	0	26
1994	0	2	16	68	54	7	0	147
1995	0	0	4	23	22	7	0	56
1996	0	0	5	54	32	4	0	95
1997	0	4	0	27	31	5	0	67
1998	0	0	0	63	45	14	0	122
1999	0	1	2	21	16	1	0	41
2000	0	0	7	41	43	4	0	95
2001	0	5	7	25	45	4	0	86
2002	0	0	14	54	11	5	0	85
2003	0	5	9	74	36	5	0	130
2004	0	0	18	43	31	2	0	94
2005	0	0	4	43	36	4	0	86
2006	0	5	13	81	23	5	0	128
2007	0	0	14	79	29	5	0	128
17-yr avg	0	2	8	41	34	5	0	90

Table 6. Wind-run daily totals and monthly totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Daily	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						miles						
Mean	39	51	63	81	69	57	54	38	38	55	25	55
Max.	153	208	293	210	171	160	118	90	108	224	137	251
Min.	7	9	15	16	19	17	20	8	5	6	2	1
Annual total						miles						
2007	1,212	1,441	1,959	2,425	2,138	1,720	1,689	1,167	1,145	1,709	742	1,705
10-yr average	1,454	1,774	2,415	2,474	2,064	1,856	1,642	1,554	1,430	1,561	1,478	1,628
59-yr average				2,160	1,919	1,573	1,474	1,328	1,252	1,280		

Table 7. Pan-evaporation totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Totals	April	May	Jun	Jul	Aug	Sep	Oct	Total
Daily				inches				
Mean	0.22	0.32	0.35	0.42	0.34	0.23	0.14	
Max.	0.39	0.47	0.52	0.61	0.52	0.43	0.35	
Min.	0.03	0.13	0.06	0.26	0.07	0.06	0.00	
Annual				inches				
2007	6.54	10.04	10.49	13.13	10.47	6.91	4.23	61.8
10-yr avg	6.14	8.32	9.99	11.89	10.58	7.11	4.43	58.2
59-yr avg	5.65	7.73	9.01	11.23	9.68	6.35	3.32	51.8

Table 8. Total accumulated reference evapotranspiration (ET_0) and crop evapotranspiration (ET_c) (acre-inches/acre), Malheur Experiment Station, Oregon State University, Ontario, OR, 1992-2007.

										Poplar		
Year	ET_o	Alfalfa (mean)	Winter grain	Spring grain	Sugar beets	Onions	Potatoes	Dry beans	Field corn	1st year	2nd year	3rd year +
1992	53.7	44.4	26.9	27.9	36.1	30.3	28.8	21.3	29.8			
1993	51.9	36.4	21.3	22.7	29.3	24.1	22.8	17.9	23.7			
1994	57.6	40.6	21.3	22.6	34.5	29.5	28.2	21.1	27.7			
1995	49.6	37.1	18.9	22.2	29.0	26.7	23.6	16.7	23.7			
1996	52.8	39.8	22.3	24.1	32.9	27.2	26.3	19.5	25.7			
1997	55.2	41.5	23.8	25.3	33.4	28.0	26.6	19.7	25.1			
1998	55.0	40.7	21.3	23.9	32.4	28.2	26.2	21.0	27.9	23.9	37.1	44
1999	58.6	43.9	25.0	26.4	33.7	28.9	26.5	21.7	28.5	24.3	37.8	45.5
2000	58.7	45.5	26.0	25.7	38.3	32.0	29.5	24.1	30.6	24.9	38.9	47.1
2001	57.9	43.8	25.5	27.2	34.8	30.3	27.4	21.4	29.1	23.7	37.0	44.7
2002	58.8	41.7	25.9	28.7	35.2	30.4	27.7	21.9	27.8	23.6	36.7	44.4
2003	54.2	44.1	27.5	31.7	39.1	31.6	31.9	22.4	29.3	24.3	37.9	45.9
2004	52.8	43.5	27.8	30.6	34.3	30.2	27.9	22.1	28.4	23.3	36.3	44.1
2005	53.8	44.5	26.5	27.0	36.0	32.8	30.2	20.0	29.2	24.3	37.8	45.3
2006	57.7	47.8	24.3	30.2	38.4	32.4	30.9	22.4	29.6	26.2	40.8	49.3
2007	59.0	47.2	27.6	26.7	38.9	33.7	29.7	24.5	30.5	25.7	40.1	48.6
Average	55.2	42.4	24.3	26.5	34.5	29.6	27.5	21.0	27.8	24.3	37.8	45.6
mm	1,402.6	1,075.9	617.1	672.9	876.3	751.9	699.4	532.9	705.7	616.8	960.8	1,158.0

Table 9. Monthly soil temperature at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	°F																							
2007 avg	31	30	35	34	46	42	52	47	64	57	71	63	78	70	75	67	67	61	54	49	43	40	35	34
Highest	33	32	43	40	52	48	61	53	70	62	76	68	81	75	78	71	75	70	58	53	48	45	41	40
Lowest	29	28	29	29	36	35	47	43	54	48	62	56	74	64	67	61	56	51	49	44	35	34	31	31
10-yr avg	34	33	37	35	45	41	52	47	62	56	70	63	76	68	74	68	67	62	55	52	43	42	36	34
40-yr avg	33	32	37	34	50	41	60	47	72	58	80	66	88	74	86	73	75	63	60	51	44	39	34	33

Table 10. Last and first frost (≤32°F) dates and number of frost-free days, Malheur Experiment Station, Oregon State University, Ontario, OR, 1990-2007.

	Date of last frost	Date of first frost	Total frost-free days
	Spring	Fall	
1990	May 8	Oct 7	152
1991	Apr 30	Oct 4	157
1992	Apr 24	Sep 14	143
1993	Apr 20	Oct 11	174
1994	Apr 15	Oct 6	174
1995	Apr 16	Sep 22	159
1996	May 6	Sep 23	140
1997	May 3	Oct 8	158
1998	Apr 18	Oct 17	182
1999	May 11	Sep 28	140
2000	May 12	Sep 24	135
2001	Apr 29	Oct 10	164
2002	May 8	Oct 12	157
2003	May 19	Oct 11	145
2004	April 16	Oct 24	191
2005	April 15	Oct 6	174
2006	April 19	Oct 22	186
2007	May 4	Oct 11	160
1976-2006 Avg	April 28	October 6	161

Table 11. Record weather events at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Record event	Measurement	Date
---------- Since 1943 ----------		
Highest annual precipitation	16.87 inches	1983
Lowest annual precipitation	5.16 inches	1949
Highest monthly precipitation	4.55 inches	May 1998
Highest 24-hour precipitation	1.52 inches	Sep 14, 1959
Highest annual snowfall	40 inches	1955
Highest 24-hour snowfall	10 inches	Nov 30, 1975
Earliest snowfall	1 inch	Oct 25, 1970
Highest air temperature	110°F	July 22, 2003
Total days with maximum air temp. ≥100°F	17 days	1971
Lowest air temperature	-26°F	Jan 21 and 22, 1962
Total days with minimum air temp. ≤0°F	35 days	1985
---------- Since 1967 ----------		
Lowest soil temperature at 4-inch depth	12°F	Dec 24, 25, and 26, 1990
---------- Since 1986 ----------		
Highest yearly growing degree days	3,446 degree days	1988
Lowest yearly growing degree days	2,539 degree days	1993
---------- Since 1992 ----------		
Highest reference evapotranspiration	59.0 inches	2007

SECOND-YEAR RESULTS OF THE 2006-2011 FURROW-IRRIGATED ALFALFA FORAGE VARIETY TRIAL

Eric P. Eldredge, Clinton C. Shock, and Lamont D. Saunders
Oregon State University
Malheur Experiment Station
Ontario, OR, 2007

Introduction

The purpose of this trial is to compare the productivity and hay quality of alfalfa varieties in the Treasure Valley area of Malheur County. The trial also provides information about the adaptation of alfalfa varieties to furrow irrigation for hay production. In this 5-year trial, seven proprietary varieties and one seed treatment are being compared to two public check varieties.

Methods

The trial was established on Owyhee silt loam where winter wheat was the previous crop and alfalfa had not been grown for more than 10 years. Details of crop establishment are in last year's annual report, which is available at http://www.cropinfo.net/AnnualReports/2006/06AlfAnnReport.html. Seed of each proprietary entry was supplied by the company, and certified seed of the two public check varieties was obtained locally. The entry 'FC2055' was the same variety as 'FC1055' except FC2055 included a proprietary seed treatment. On November 16, 2006, the soil-active selective herbicides Kerb® 50WP at 1.5 lb/acre and Sinbar® 80WP at 1.5 lb/acre were applied. This trial was established and grown with furrow irrigation from gated pipe, with furrows spaced 30 inches apart. In 2007, the trial was irrigated twice after the first, second, and third cuttings and once following the last cutting. The first irrigation of the season followed immediately after the first harvest.

In 2007, the first cutting was taken on May 15. A 32-inch by 20-ft swath was cut from the center of each plot with a Lawn Genie flail mower, and the alfalfa was weighed. The alfalfa was harvested three more times, on June 22, July 19, and August 29. Ten samples of alfalfa were cut by hand from the edges of plots over the entire field at random on the same day just before each harvest. The samples were quickly weighed, then dried at 140°F for 48 hours, and reweighed to determine the average alfalfa moisture content at each cutting. Yield was reported as tons per acre of alfalfa hay at 88 percent dry matter.

Samples of alfalfa to measure forage quality were taken mid-morning before the third cutting from approximately 1 ft of row per plot. The forage quality samples were dried at 140°F for 48 hours, ground in a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass through a 1-mm screen, and sent to the Oregon State University Forage Quality Lab at

Klamath Falls, Oregon, where they were reground in a UDY mill (UDY Corp., Ft. Collins, CO) to pass through a 0.5-mm screen. Near infrared spectroscopy (NIRS) was used to estimate percent dry matter, percent crude protein, percent acid detergent fiber (ADF), percent neutral detergent fiber (NDF), percent fat, and percent ash.

Relationships for estimated dry matter intake for alfalfa hay (DMI), total digestible nutrients for alfalfa hay (TDNL), and relative forage quality (RFQ) were calculated using empirical formulas.

DMI (for alfalfa hay) was estimated by the equation
$DMI = (((0.120 * 1350) / (NDF/100)) + (NDFD - 45) * 0.374) / 1350 * 100$,
where $NDFD = dNDF48 / NDF * 100$ and dNDF48 is the digestible NDF as a percentage of dry matter, as determined by a 48-hour in vitro digestion test.

TDNL for alfalfa hay was estimated by the equation
$TDNL = (NFC * 0.98) + (protein * 0.93) + (fat * 0.97 * 2.25) + ((NDF-2) * (NDFD/100))$
where $NFC = 100 - ((NDF - 2) + protein + 2.5 + ash)$.

Relative forage quality was calculated by the formula:
$RFQ = (DMI * TDNL) / 1.23$
where: 1.23 is used as the denominator to adjust the scale to match the RFV (relative feed value) scale at 100 = full bloom alfalfa.

Quality standards for alfalfa hay based on RFQ are: Supreme, RFQ higher than 185; Premium, RFQ 170-184; Good, RFQ 150-169; Fair, RFQ 130-149, and Low, RFQ below 129. Relative forage quality is an estimate of voluntary energy intake when the alfalfa hay is the only source of energy and protein for ruminants. The higher the RFQ, the less grain or feed concentrate supplements are required to formulate dairy rations. For 2007 we have also reported RFV, the relative feed value.

Results and Discussion

Spring weather in 2007 was cool and dry, which slowed the alfalfa regrowth from winter dormancy. The average daytime high temperature in March was 61°F and rain totaled 0.11 inch. The average daytime high temperature in April was 65°F with a total of 0.82 inch of rain for the month. A total of 0.35 inch rain fell before May 15, when the first cutting was taken, and most of the varieties were in the late bud to early bloom stage. The second cutting was taken June 22 at mid-bud stage. Third cutting, when forage quality samples were taken, was on July 19, at late bud stage. The fourth cutting was taken on August 29, at late bud to early bloom stage.

The average second-year total hay yield was 7.7 ton/acre, with 'WL 357 HQ' at 8.3 ton/acre, 'Masterpiece' at 8.0 ton/acre, and 'WL 319 HQ' at 8.0 ton/acre among the highest in hay yield (Table 1). The first-cutting average yield was 2.3 ton/acre. In the second cutting the average yield was 2.0 ton/acre. In the third cutting, the average yield was 1.5 ton/acre. In the fourth cutting the average yield was 1.9 ton/acre.

Crude protein averaged 23.5 percent in the third cutting, and ranged from 24.2 percent for 'DKA-42-15' to 22.2 percent for 'Lahontan'. Acid detergent fiber averaged 32.1 percent, and ranged from 33.2 percent for Lahontan to 30.4 percent for DKA-42-15. Neutral detergent fiber averaged 36.7 percent, and ranged from 38.2 percent for 'FC 1045' to 34.8 percent for WL 319 HQ. Relative forage quality averaged 191, in the "Supreme" quality category, and ranged from RFQ = 203, "Supreme" for DKA-42-15 to RFQ = 178, "Good" for Lahontan.

After 2 years, among the highest yielding varieties were WL 357 HQ, Masterpiece, WL 319 HQ, DKA-42-15, FC 2055, and 'Rustler II', which produced 15 ton/acre cumulative total hay yield for 2006 and 2007 (Table 2).

Information on the disease, nematode, and insect resistance of the varieties in this trial was provided by the participating seed companies and/or the North American Alfalfa Improvement Council (Table 3). Most alfalfa varieties have some resistance to the diseases and pests that could limit hay production. Growers should choose varieties that have stronger resistance ratings for disease or pest problems known to be present in their fields. The yield potential of a variety should be evaluated based on performance in replicated trials at multiple sites over multiple years.

Table 1. Alfalfa variety hay yield and third-cutting crude protein, ADF, NDF, and relative forage quality for 2007, Oregon State University, Malheur Experiment Station, Ontario, OR.

Variety	Cutting date 5/15	6/22	7/19	8/29	2007 total	Crude protein	ADF[a]	NDF[b]	RFQ[c]	RFV[d]	TDNL[e]
	ton/acre[f]					% of DW[g]					
WL 357 HQ	2.5	2.2	1.7	2.0	8.3	23.4	32.4	37.4	185.0	158.5	63.9
Masterpiece	2.5	2.0	1.5	2.0	8.0	23.8	31.6	36.2	196.8	165.8	64.8
WL 319 HQ	2.4	2.1	1.6	1.9	8.0	24.0	30.8	34.8	202.0	173.2	65.6
FC 2055	2.4	2.0	1.6	2.0	7.9	23.6	32.8	37.2	187.4	158.3	63.5
DKA-42-15	2.2	2.1	1.6	2.0	7.8	24.2	30.4	35.0	202.6	174.7	66.1
FC 1045	2.4	2.0	1.4	1.9	7.6	23.4	33.0	38.2	182.2	154.7	63.2
Rustler II	2.3	1.9	1.4	2.0	7.6	23.6	32.2	36.4	192.2	163.1	64.3
FC 1055	2.3	2.0	1.5	1.8	7.6	23.2	32.8	37.2	189.6	159.9	63.8
Wrangler	2.4	1.8	1.2	1.9	7.3	23.6	32.2	36.4	194.8	163.4	64.4
Lahontan	2.1	1.9	1.4	1.7	7.1	22.2	33.2	38.0	177.8	154.5	63.2
Mean	2.3	2.0	1.5	1.9	7.7	23.5	32.1	36.7	191.0	162.6	64.3
LSD (0.05)	0.2	0.1	0.1	0.1	0.4	NS[h]	1.4	1.6	13.4	10.1	1.5

[a]ADF: acid detergent fiber. [b]NDF: neutral detergent fiber. [c]RFQ: relative forage quality. [d]RFV: relative feed value. [e]TDNL: total digestable nutrients for legumes. [f]Yield at 88 percent dry matter. [g]DW: dry weight. [h]NS: Not significant at the alpha = 0.05 level.

Table 2. Alfalfa variety hay yield in the first and second years and cumulative total yield in the 2006-2011 furrow-irrigated forage variety trial, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

Variety	2006 total	2007 total	Cumulative total
	-------------	ton/acre[a]	------------
WL 357 HQ	6.9	8.3	15.2
Masterpiece	7.0	8.0	15.1
WL 319 HQ	7.0	8.0	15.0
DKA-42-15	7.1	7.8	14.9
FC 2055	6.9	7.9	14.9
Rustler II	7.1	7.6	14.7
FC 1045	6.9	7.6	14.5
FC 1055	6.7	7.6	14.3
Lahontan	6.8	7.1	13.9
Wrangler	6.5	7.3	13.8
Mean	6.9	7.7	14.6
LSD (0.05)	NS[b]	0.36	0.60

[a]Yield at 88 percent dry matter. [b]NS: Not significant at the alpha = 0.05 level.

Table 3. Variety source, year of release, fall dormancy, and level of resistance to pests and diseases for alfalfa varieties in the 2006-2011 furrow-irrigated forage variety trial, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

Variety	Source	Release year	FD[a]	Pest resistance rating[b]									
				BW	FW	VW	PRR	AN	SAA	PA	SN	AP	RKN
Lahontan	public	1954	6[c]	MR	LR	-	LR	-	MR	LR	R	-	-
Wrangler	public	1984	2	MR	R	LR	HR	LR	HR	HR	LR	LR	LR
Rustler II	Andrews Seed	1995	4	HR	HR	HR	HR	HR	R	HR	MR	R	-
Masterpiece	Simplot	2000	4	HR	HR	R	HR	HR	R	-	HR	R	R
DKA-42-15	Monsanto	2001	4	HR	HR	HR	HR	HR	R	HR	R	HR	-
WL 319 HQ	W-L Research	2002	3	HR	HR	HR	HR	HR	R	HR	MR	HR	LR
WL 357 HQ	W-L Research	2003	5	HR	HR	HR	HR	HR	R	R	MR	HR	LR
FC 1045	Andrews Seed	2005	4	HR	HR	HR	HR	HR	MR	R	R	R	MR
FC 1055	Andrews Seed	2006	5	HR	HR	HR	HR	R	R	R	HR	R	HR
FC 2055	Andrews Seed	2006	5	HR	HR	HR	HR	R	R	R	HR	R	HR

[a]FD: fall dormancy, BW: bacterial Wilt, FW: Fusarium wilt, VW: Verticillium wilt, PRR: Phytophthora root rot, AN: Anthracnose, SAA: spotted alfalfa aphid, PA: pea aphid, SN: stem nematode, AP: Aphanomyces, RKN: Northern root knot nematode.
[b]Pest Resistance Rating: >50 percent = HR (high resistance), 31-50 percent = R (resistant), 15-30 percent = MR (moderate resistance), 6-14 percent = LR (low resistance).
[c]Fall dormancy: 1 = Norseman, 2 = Vernal, 3 = Ranger, 4 = Saranac, 5 = DuPuits, 6 = Lahontan.

YUKON® RATES FOR CONTROL OF YELLOW NUTSEDGE IN CORN GROWN IN ROTATIONS FOLLOWED BY ONION

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Yellow nutsedge has become a major crop production threat in many agricultural fields in the Treasure Valley of eastern Oregon. The gravity of this problem is especially noticeable when the land is planted to onions. Thus, development of effective yellow nutsedge control strategies is viewed by many as priority number one for researchers. Control of yellow nutsedge presents a challenge because of its ability to reproduce by rhizomes and tubers that can survive in the soil for 2-3 years. Research results at the Malheur Experiment Station indicate that millions of tubers are produced per acre each season in heavily infested fields (Shock et al. 2006). Successful control of yellow nutsedge will partly require development of elaborate crop rotation schemes that include multiple tactics including tillage, fumigation, and herbicides to destroy those pesky tubers. It has been reported that farming activities play a significant role in yellow nutsedge distribution in infested fields (Schippers et al. 1993). This study is a first step in testing products that will enhance yellow nutsedge control in rotations that include onions.

Materials and Methods

A field study was conducted during 2007 in a field heavily infested with yellow nutsedge along Hwy 201 near the Malheur Experiment Station, Ontario, Oregon. The study was laid out in a randomized complete block design with four replications. The study area was moldboard plowed during spring and disked twice before forming beds to facilitate furrow irrigation. Following soil analysis, a compound fertilizer to provide 120 lbs nitrogen (N), 30 lbs phosphorus (P), and 13 lbs sulfate (SO_4), 2 lbs zinc (Zn), and 1 lb boron (B) per acre was applied on May 4, 2007. The entire study was planted to Dekalb Roundup Ready® corn hybrid 'DKC-51-39' at 26,000 plants/acre in 2007. After harvesting, the study area was planted to winter wheat as a strategy to provide competition to yellow nutsedge during 2008, and in the process reduce yellow nutsedge tubers. Herbicide treatments tested in 2007 are listed in Table 1.

Pre-emergence treatments (PRE) were applied on May 9, early post-emergence (EPOST) on May 29, and post-emergence (POST) on June 8, 2007 using a CO_2-pressurized sprayer fitted with EVS 8002 nozzles. The sprayer was calibrated to deliver 20 gal/acre at 40 psi. Plots were evaluated for yellow nutsedge control using a visual scale of 0-100 percent (0 = no control and 100 percent = complete control) on June 15 and 22, 2007.

Soil sampling for initial tuber quantification was done by taking five cores from each plot, each measuring 4.25 inches in diameter and 12 inches deep on May 14, after bed formation and application of the first irrigation. The soil cores were processed to recover yellow nutsedge tubers using the washing and sieving procedure. Fall soil sampling was done on October 4 and processed to recover tubers on October 17, 2007. The tubers from each plot were placed in a ziplock plastic bag and stored in a dark cooler at 40°F until they were counted and weighed. The study was furrow irrigated as needed to maintain moisture in the top 12 inches of the soil profile. The corn was harvested for yield on September 28 from 20 ft along the two center rows in each (2.5-ft by 40-ft total) plot.

Results and Discussion

The study area had a relatively uniform distribution of yellow nutsedge tubers/ft^2 at the initiation of the study (Table 2). There was no difference in corn yield between treatments except for the untreated control that had very low yield due to excessive weed competition (Table 3). However, there was a significant difference among treatments for the number of yellow nutsedge tubers at the end of the season. Sequential application of Yukon® at 4 oz/acre EPOST followed by 4 oz/acre POST when corn was at 5-6 leaf collars provided the best yellow nutsedge control in this study. Not surprising, the untreated control had the highest number of tubers per plot whereas the plots treated with herbicides had lower densities. The final corn yield followed a similar trend, with the untreated control producing the lowest yield. There was no difference in yield among herbicide treatments.

References

Schippers, P., S.J. Ter Borg, J.M. Van Groenendael, and B. Habekotte. 1993. What makes *Cyperus esculentus* (yellow nutsedge) an invasive species? A spatial model approach. Proc. Brighton Crop Prot. Conf.: 495–504.

Shock, C.C., J. Ishida, and E. Feibert. 2006. Yellow nutsedge nutlet production in response to nutlet planting depth. Oregon State University Agricultural Experiment Station Special Report 1075:160-162.

Table 1. Herbicide treatments for yellow nutsedge control in corn, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Rate	Application timing
1. Untreated check		
2. Eradicane 6.7E	5 lb ai/acre	POST
Yukon	0.253 lb ai/acre	
+ NIS[a]	0.25 % v/v	
3. Yukon	0.338 lb ai/acre	POST
+ NIS	0.25 % v/v	
4. Yukon	0.169 lb ai/acre	EPOST
+ NIS	0.25 % v/v	
Yukon	0.169 lb ai/acre	POST
+NIS	0.25 % v/v	
5. Yukon	0.169 lb ai/acre	POST
+ Roundup OriginalMax	22 fl oz/acre	
+ NIS	0.25 % v/v	
6. Sandea	1 oz ai/acre	POST
7. Dual II Magnum	1.27 lb ai/acre	PRE
8. Sandea	0.495 oz ai/acre	PRE
Sandea	0.495 oz ai/acre	POST

[a]NIS = nonionic surfactant.

Table 2. Number of yellow nutsedge tubers on May 14 and October 4 (initiation and conclusion of the study), crop injury, chlorosis, crop growth reduction, and yellow nutsedge control, corn evaluations on June 15 and 22, 2007, and final yield, Malheur Experiment Station, Oregon State University, Ontario, OR, summer 2007.

Treatment	Rate	Timing	Tuber number at study initiation	Tuber weight, study initiation	Tuber number at end of study	Tuber weight, end of study	Crop injury	Chlorosis	Crop growth reduction	Yellow nutsedge control
				grams	per ft^2	grams	%			
Untreated check			845	14.6	351.0	35.7	0.0	0.0	0.0	0.0
Eradicane 6.7E	6 oz/acre	POST	800	14.1	112.0	10.1	5.0	0.0	0.0	25.0
+ Yukon	6 oz/acre	POST								
+ NIS	0.25% V/V									
Yukon	8 oz/acre	POST	815	14.2	109.5	8.8	0.0	0.0	0.0	28.8
+ NIS	0.25% V/V									
Yukon	4 oz/acre	EPOST	767	13.2	114.3	9.6	0.0	0.0	0.0	83.8
+ NIS	0.25% V/V									
Yukon +	4 oz/acre	POST								
+ NIS	0.25% V/V									
Yukon	4 oz/acre	POST	863	13.6	162.0	11.7	0.0	0.0	0.0	28.8
+ Roundup OriginalMax	22 oz/acre	POST								
+ NIS	0.25% V/V									
Sandea	1.33 oz/acre		440	7.8	157.0	11.8	0.0	0.0	0.0	17.5
Dual II Magnum	1.33 pt/acre	PRE	1,038	16.6	446.8	39.2	0.0	0.0	0.0	35.0
Sandea;	0.66 oz/acre	PRE	1,214	19.3	234.8	17.5	0.0	0.0	0.0	26.3
Sandea	0.66 oz/acre	POST								
LSD (P = 0.05)			837	13.8	204.2	17.3	NS	NS	NS	23.5

Table 3. Yellow nutsedge control on June 22, 2007 and corn response to Yukon® herbicide at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Timing	Crop injury	Chlorosis	Crop growth reduction	YNS control	# of plants	Corn yield
			%				#/40 ft	Bu/acre
Untreated check			0.0	0.0	0.0	0.0	55.5	115.6
Eradicane 6.7E	6 oz/acre	POST	0.0	0.0	0.0	72.5	53.0	225.6
+ Yukon	6 oz/acre							
+ NIS	0.25% V/V							
Yukon +	8 oz/acre	POST	0.0	0.0	0.0	78.8	54.5	205.0
+ NIS	0.25% V/V							
Yukon +	4 oz/acre	EPOST	0.0	0.0	0.0	87.5	52.5	217.0
+ NIS	0.25% V/V							
Yukon +	4 oz/acre	POST						
+ NIS	0.25% V/V							
Yukon +	4 oz/acre	POST	0.0	0.0	0.0	68.8	56.3	219.3
+ Roundup OriginalMax	22 oz/acre	POST						
+ NIS	0.25% V/V							
Sandea	1.33 oz/acre		0.0	0.0	0.0	58.8	52.0	206.6
Dual II Magnum	1.33 pt/acre	PRE	0.0	0.0	0.0	47.5	56.0	218.9
Sandea;	0.66 oz/acre	PRE	0.0	0.0	0.0	56.3	53.5	216.3
Sandea	0.66 oz/acre	POST						
LSD P = 0.05			NS	NS	NS	11.2	NS	28.0
Standard Deviation			--	--	--	7.6	3.1	19.0

Means followed by same letter do not significantly differ (P = .05, Student-Newman-Keuls)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

2007 ONION VARIETY TRIALS

Clinton C. Shock, Erik B. G. Feibert, and Lamont D. Saunders
Malheur Experiment Station, Oregon State University, Ontario, OR

Lynn Jensen
Malheur County Extension Service, Oregon State University, Ontario, OR

Krishna Mohan
University of Idaho, Parma, ID

Hanu Pappu
Washington State University, Pullman, WA

Introduction

The objective of the onion variety trials was to evaluate yellow, white, and red onion varieties for bulb yield, quality, and single centers. Five early-season varieties (four yellow, one red) were planted in March and were harvested and graded at the end of August. Fifty-four full-season varieties (42 yellow, 8 red, and 4 white) were planted in March, harvested in September 2007, and graded out of storage in January 2008. Each year, growers and seed industry representatives have the opportunity to examine the varieties at our annual Onion Variety Field Day in late August and during onion grading in early January. Varieties are evaluated for yield, grade, internal quality, and storability.

Methods

The onions were grown on an Owyhee silt loam previously planted to wheat. In the fall of 2006 the wheat stubble was shredded and the field was irrigated and disked. Soil analysis indicated the need for 172 lb phosphate (P_2O_5)/acre, 100 lb sulfur (S)/acre, 5 lb iron (Fe)/acre, 5 lb manganese (Mn)/acre, 2 lb copper (Cu)/acre, and 2 lb/acre of boron (B), which were broadcast in the fall of 2006 after disking. The field was then moldboard-plowed, groundhogged, roller-harrowed, fumigated with Telone® C-17 at 20 gal/acre, and bedded.

The full-season trial and the early maturing trial were planted adjacent to each other, on March 13, and in plots four double rows wide and 27 ft long. The early maturing trial had 5 varieties from 2 seed companies (Table 1) and the full-season trial had 54 varieties from 8 seed companies (Table 3). The experimental designs for both trials were randomized complete blocks with five replicates. A sixth nonrandomized replicate was planted for demonstrating onion variety performance to growers and seed company representatives.

Seed was planted in double rows spaced 3 inches apart at 9 seeds/ft of single row. Each double row was planted on beds spaced 22 inches apart. Planting was done with customized John Deere Flexi Planter units equipped with disc openers. The onion rows received 3.7 oz of Lorsban 15G® per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled on March 14. Onion emergence started on March 30. On May 4, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 7 through May 9, the seedlings were hand thinned to a plant population of 2 plants/ft of single row (6-inch spacing between individual onion plants, or 95,000 plants/acre).

The onions were managed to minimize yield reductions from weeds, pests, diseases, water stress, and nutrient deficiencies. Weeds were controlled with an application of Prowl® at 1 lb ai/acre on April 13. On May 18, Aza-Direct® at 0.0062 lb ai/acre and Success® at 0.25 lb ai/acre were applied for thrips control, and Select® at 0.25 lb ai/acre and Prowl at 0.24 lb ai/acre were applied for weed control. On June 1, Aza-Direct at 0.0062 lb ai/acre and Success at 0.25 lb ai/acre were applied for thrips control. Subsequent insecticide applications for thrips control were done aerially: June 16, Lannate® at 0.9 lb ai/acre; July 6, Carzol® at 1.15 lb ai/acre; July 15, Lannate at 0.9 lb ai/acre and Poast® at 0.28 lb ai/acre (grass control); and August 3, Lannate at 0.9 lb ai/acre.

The trial was furrow irrigated when the soil water tension at 8-inch depth reached 25 cb (1 cb = 1 kPa) (Shock et al. 2005). Starting in mid-June, soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) centered at 8-inch depth below the onion row. The sensors were automatically read three times a day with an AM-400 meter (Mike Hansen Co., East Wenatchee, WA). The last irrigation was on August 28.

The field was sidedressed with urea at 120 lb nitrogen (N)/acre on May 11. On June 11, the field was sidedressed with 100 lb N/acre as urea.

Onions in each plot were evaluated subjectively for maturity by visually rating the percentage of onions with the tops down and the percent dryness of the foliage. The percent maturity was calculated as the average percentage of onions with tops down and the percent dryness. The early maturing trial was evaluated for maturity on August 7 and 21, and the full-season trial was evaluated on August 23. The number of bolted onion plants in each plot was counted.

Onions in each plot of the full-season trial were evaluated subjectively for severity of symptoms of iris yellow spot virus (IYSV) and powdery mildew (*Leveillula taurica*) on August 22. Each plot was rated for both diseases on a scale of 0 to 5, where 0 = no symptoms, 1 = 1 to 25 percent of foliage diseased, 2 = 26 to 50 percent of foliage diseased, 3 = 51 to 75 percent of foliage diseased, 4 = 76 to 99 percent of foliage diseased, and 5 = 100 percent of foliage diseased.

At harvest, bulbs from one of the border rows in each plot of both trials were rated for single centers. Twenty-five consecutive onions ranging in diameter from 3.5 to 4.25 inches were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: small had diameters less than 1.5 inches, medium had diameters from 1.5 to 2.25 inches, and large had diameters greater than 2.25 inches. Onions were considered functionally single centered for processing if they were single centered or had a small multiple center.

Onions from the middle two double rows in each plot in the early maturity trial were lifted, topped by hand, and bagged on August 21. On August 23 the onions were graded.

During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

The onions in the full-season trial were lifted on September 10 to field cure. Onions from the middle two rows in each plot of the full-season trial were topped by hand and bagged on September 17. The bags were put in storage on September 26. The storage shed was ventilated to maintain air temperature as close to 34°F as possible. Onions from the full-season trial were graded out of storage on January 14 and 15, 2008.

Varietal differences were compared using analysis of variance. Means separation was determined using Fisher's least significant difference test at the 5 percent probability level, LSD (0.05). The varieties from each of the early maturity and full-season trials were compared for yield, grade, internal quality, and disease expression. Results are listed in tables 1-4 in alphabetical order by company. The LSD (0.05) values in each table should be considered when comparisons are made between varieties for significant differences in performance characteristics. Differences between varieties equal to or greater than the LSD value for a characteristic should exist before any variety is considered different from any other variety in that characteristic. Variety performance will vary by year. Growers are encouraged to review performance over a number of years before choosing a variety to plant.

Results

Early Maturing Trial

The percentage of single-centered bulbs averaged 18.4 percent and ranged from 0.8 percent for 'Renegade', to 44 percent for 'Montero' (Table 1). The percentage of onions that were functionally single centered averaged 27.5 percent and ranged from 1.6 percent for Renegade to 60 percent for Montero.

Total yield averaged 1,082 cwt/acre and ranged from 700.5 cwt/acre for 'XON-216' to 1,263 cwt/acre for 'Ovation' (Table 2). Ovation and 'Spanish Medallion' were among the varieties with the highest total yield, marketable yield, and supercolossal yield.

Full Season Trial

The percentage of single-centered bulbs averaged 32.3 percent and ranged from 1.6 percent for 'Frontier', to 81.6 percent for 'Ringleader' (Table 3). The percentage of onions that were functionally single centered averaged 40.7 percent and ranged from 3.2 percent for 'Peso' to 87.2 percent for 'Generation X'. Generation X, 'Arcero', Ringleader, 'Joaquin', 'Cometa', 'Harmony', and 'Evolution' had 80 percent or higher functionally single-centered bulbs.

Total yield out of storage averaged 1,030 cwt/acre and ranged from 484.5 cwt/acre for 'DPS 1415' to 1,379.4 cwt/acre for 'Charismatic' (Table 4). Charismatic, 'OLYS05N5', Harmony, 'Ranchero', and 'Vaquero' were among the varieties with the highest total yield. Charismatic, OLYS05N5, Vaquero, Ranchero, and Evolution were among the varieties with the highest marketable yield. Supercolossal yield averaged 203 cwt/acre and ranged from zero for Frontier, 'DPS 1413', 'DPS 1414', 'DPS 1418' and 'DPS 1419' to 687.7 cwt/acre for Charismatic. Charismatic had the highest supercolossal yield followed by 'Maverick', Ranchero, Ringleader, and OLYS05N5.

Iris Yellow Spot Virus (IYSV)

Iris yellow spot virus severity in 2007 was substantially lower than in 2005 and 2006. The average IYSV severity rating (0-5) for Vaquero in the variety trial was 1.1, 2.9, and 0.6 in 2005, 2006, and 2007, respectively. Onion yields were much higher in 2007 than in 2005 and 2006 (Shock et al. 2006, 2007). The average total yield of Vaquero was 666, 644, and 1,331 cwt/acre in 2005, 2006, and 2007, respectively. In 2007, the subjective ratings of IYSV symptom severity for the full-season varieties (scale of 0-5) ranged from 0.4 for 'Milestone' to 1 for 'Sedona' (Table 3).

Powdery Mildew

Powdery mildew is a relatively recently discovered onion disease caused by the fungus *Leveillula taurica*. The symptoms are necrotic lesions on the leaf surface with occasional white powdery patches with irregular margins. Powdery mildew is not currently thought to result in economic losses because infestations are occurring very late in the season. At the Malheur Experiment Station, powdery mildew on onions was first noticed in late August of 2006 at very low levels on a few varieties. In 2007, the disease was first observed in mid-August. Subjective ratings of powdery mildew symptom severity for the full-season varieties, on a scale from 0 to 5, ranged from 0 for many varieties to 3.2 for Evolution. Evolution and Joaquin had the most severe powdery mildew symptoms.

References

Shock, C.C., R. Flock, E. Feibert, C.A. Shock, A. Pereira, and L. Jensen. 2005. Irrigation monitoring using soil water tension. Oregon State University Extension Service EM 8900.

Shock, C.C., E.B.G. Feibert, L.D. Saunders, L. Jensen, and K. Mohan. 2006. 2005 Onion Variety Trials. Oregon State University Agricultural Experiment Station Special Report 1070:42-53.

Shock, C.C., E.B.G. Feibert, L.D. Saunders, L. Jensen, and K. Mohan. 2007. 2006 Onion Variety Trials. Oregon State University Agricultural Experiment Station Special Report 1075:33-42.

Table 1. Maturity and bulb multiple-center ratings for early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Seed company	Variety	Bulb color	Maturity Aug. 21	Multiple center large	Multiple center medium	Multiple center small	Single center functional[a]	Single center single
			%	%				
Nunhems	Renegade	Y	64.0	88.8	9.6	0.8	1.6	0.8
	Montero	Y	51.0	22.4	17.6	16.0	60.0	44.0
Sakata	Ovation	Y	50.0	54.4	13.6	9.6	32.0	22.4
	Spanish Medallion	Y	51.0	54.4	21.6	8.0	24.0	16.0
	XON-216	R	74.0	61.6	18.4	11.2	20.0	8.8
LSD (0.05)			5.4	27.7	NS	NS	21.3	17.9

[a]bullet + small double.

Table 2. Yield and grade performance of early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade: Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Non-marketable yield: No. 2s	Small	Total rot	Bulb counts >4¼ in
			cwt/acre								%	#/50 lb
Nunhems	Renegade	Y	1144.6	1064.5	255.7	539.9	265.1	3.8	77.8	1.1	0.1	29.3
	Montero	Y	1072.8	1068.8	221.3	541.8	302.6	3.1	3.2	0.7	0.0	31.7
Sakata	Ovation	Y	1263.1	1248.1	492.5	526.8	225.1	3.8	12.0	1.7	0.1	28.8
	Spanish Medallion	Y	1226.5	1196.3	544.0	475.6	174.5	2.2	26.3	1.5	0.2	28.5
	XON-216	R	700.5	686.7	8.5	113.4	534.5	30.2	7.4	3.6	0.5	28.6
	LSD (0.05)		83.4	90.8	8.4	98.6	84.3	8.7	19.4	1.7	NS	NS

Table 3. Bulb multiple-center rating, iris yellow spot virus (IYSV), powdery mildew (PM) rating, maturity, and bolting for full-season varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007. Continued on next page.

			Multiple center			Single center		Disease severity rating[b]		Maturity	
Seed company	Variety	Bulb color	large	medium	small	functional[a]	single	IYSV	PM	August 23	Bolting
			---- % ----					----- 0-5 -----		----- % -----	
A. Takii	Centerstone	Y	41.6	34.4	8.8	24.0	15.2	0.5	0.0	69.0	0.0
	Frontier	Y	47.2	38.4	12.8	14.4	1.6	na[c]	na	86.0	0.0
	T-433	Y	61.6	28.0	8.0	10.4	2.4	0.5	0.7	60.0	0.0
	Milestone	Y	28.8	42.4	12.8	28.8	16.0	0.4	0.0	77.0	0.0
	Ruby Ring	R	10.4	38.7	15.7	50.9	35.2	0.5	0.0	76.0	0.0
Bejo	Calibra	Y	71.2	23.2	1.6	5.6	4.0	0.5	0.0	70.0	0.0
	Crocket	Y	40.8	46.4	8.8	12.8	4.0	0.5	0.0	49.0	0.2
	Desperado	Y	52.8	31.2	8.0	16.0	8.0	0.5	0.1	61.0	0.1
	Delgado	Y	59.2	27.2	4.0	13.6	9.6	0.6	0.1	56.0	0.0
	Peso	Y	80.0	16.8	0.8	3.2	2.4	0.5	0.3	53.0	0.4
	Red Bull	R	36.0	43.2	7.2	20.8	13.6	0.8	0.0	65.0	0.0
	Sedona	Y	39.2	34.4	9.6	26.4	16.8	1.0	0.5	59.0	0.8
	Derby F1	Y	91.2	4.8	0.8	4.0	3.2	0.5	0.0	72.0	0.0
	BGS 231	Y	72.8	23.2	0.8	4.0	3.2	0.5	0.0	48.0	0.2
Crookham	Harmony	Y	10.4	8.8	0.8	80.8	80.0	0.5	0.5	51.0	1.5
	Sweet Perfection	Y	34.4	20.8	3.2	44.8	41.6	0.6	0.0	53.0	0.7
	OLYS03-207	Y	16.0	11.2	1.6	72.8	71.2	0.6	0.7	39.0	0.0
	OLYS05N5	Y	16.8	12.0	2.4	71.2	68.8	0.6	0.4	38.0	1.3
	OLYX00-23	Y	20.8	21.6	5.6	57.6	52.0	0.6	0.2	57.0	0.3
D. Palmer	Mesquite06	Y	53.6	21.6	2.4	24.8	22.4	0.5	0.2	37.5	1.1
	Tequila06	Y	40.8	20.8	4.8	38.4	33.6	0.5	0.0	51.0	1.3
	Evolution	Y	9.6	10.4	4.8	80.0	75.2	0.7	3.2	22.0	0.3
	Generation X	Y	2.4	10.4	10.4	87.2	76.8	0.9	1.5	44.0	0.0
	DPS1413	Y	39.2	20.0	23.2	40.8	17.6	na	na	89.0	0.0
	DPS1414	Y	20.9	30.6	27.6	48.5	20.9	na	na	85.0	0.0
	DPS1415	Y	42.4	24.0	11.2	33.6	22.4	na	na	87.0	0.0
	DPS1416	Y	33.6	36.0	15.2	30.4	15.2	na	na	89.0	0.0
	DPS1417	Y	46.4	28.0	9.6	25.6	16.0	0.5	0.0	77.0	0.0
	DPS1418	Y	15.2	38.4	25.6	46.4	20.8	na	na	85.0	0.0

Seed company	Variety	Bulb color	Multiple center large	Multiple center medium	Multiple center small	Single center functional[a]	Single center single	Disease severity rating[b] IYSV	Disease severity rating[b] PM	Maturity August 23	Bolting
			%					0-5		%	
D. Palmer	DPS1419	Y	30.4	33.6	19.2	36.0	16.8	0.5	0.0	80.0	0.0
	DPS3052	R	68.0	12.8	8.8	19.2	10.4	0.6	0.1	61.0	0.0
	DPS3055	R	80.8	14.4	3.2	4.8	1.6	0.6	0.0	61.0	0.0
	DPS3058	R	48.0	20.8	16.8	31.2	14.4	0.5	0.0	63.0	0.0
	DPS3062	R	56.7	22.8	4.6	20.4	15.8	0.5	0.0	60.0	0.1
Global Genetics	Maverick	Y	48.8	19.2	4.8	32.0	27.2	0.7	0.6	40.0	0.4
	Ringleader	Y	9.6	6.4	2.4	84.0	81.6	0.5	0.1	50.0	0.2
	Outlaw	Y	28.0	36.8	12.8	35.2	22.4	0.5	0.0	62.0	0.0
	6093	Y	19.2	9.6	6.4	71.2	64.8	0.7	0.8	29.0	1.1
Nunhems	Granero	Y	14.4	19.2	1.6	66.4	64.8	0.9	1.0	39.0	0.4
	Montero	Y	13.6	24.8	14.4	61.6	47.2	0.5	0.0	64.0	0.2
	Pandero	Y	25.6	29.6	6.4	44.8	38.4	0.6	0.1	42.0	0.7
	Ranchero	Y	20.8	26.4	9.6	52.8	43.2	0.5	0.0	52.0	0.2
	Salsa	R	52.0	32.0	7.0	16.0	9.0	0.6	0.0	68.0	0.0
	Vaquero	Y	12.8	19.2	8.0	68.0	60.0	0.6	0.1	57.0	0.1
	Arcero	Y	5.6	8.8	8.8	85.6	76.8	0.8	0.0	49.0	0.0
	Joaquin	Y	8.8	8.0	4.8	83.2	78.4	0.7	2.2	20.0	0.4
	Cometa	W	6.4	11.2	10.4	82.4	72.0	0.5	0.2	50.0	1.2
Sakata	XON-670W	W	16.0	26.4	10.4	57.6	47.2	0.5	0.0	53.0	2.7
Seminis	Affirmed	Y	17.6	30.4	9.6	52.0	42.4	0.5	0.1	43.0	0.6
	Charismatic	Y	21.6	31.2	3.2	47.2	44.0	0.5	0.7	41.0	0.4
	Monarchos	Y	13.6	22.4	4.8	64.0	59.2	0.5	0.1	42.0	0.0
	Mercury	R	58.4	30.4	8.8	11.2	2.4	0.5	0.0	77.0	0.0
	Toluca	W	38.4	32.0	8.0	29.6	21.6	0.5	0.0	39.0	0.0
	Orizaba	W	44.8	30.4	11.2	24.8	13.6	0.5	0.0	51.0	0.6
LSD (0.05)			14.0	12.6	9.4	14.4	11.2	0.3	0.4	8.3	0.7

[a] single + small double

[b] IYSV = iris yellow spot virus; PM = powdery mildew. 0 = no symptoms, 1 = 1-25% of foliage diseased, 2 = 26-50% of foliage diseased, 3 = 51-75% of foliage diseased, 4 = 76-99% of foliage diseased, and 5 = 100% of foliage diseased.

[c]na = data not available due to variety being fully mature at rating.

Table 4. Yield and grade of full-season experimental and commercial onion varieties graded out of storage in January 2008, Malheur Experiment Station, Oregon State University, Ontario, OR. Continued on next page.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade					Non-marketable yield					Bulb counts >4¼ in	Thrips damage[a]
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	No. 2s	Small	Total rot	Neck rot	Plate rot		
			cwt/acre								% of total yield			#/50 lb	0-10
A. Takii	Centerstone	Y	1083.8	1034.0	111.6	457.4	439.2	25.9	17.1	8.3	2.3	1.1	1.1	29.5	
	Frontier	Y	600.6	566.1	0.0	21.0	490.9	54.2	9.0	14.6	1.8	0.0	1.8		
	T-433	Y	1094.2	967.3	321.0	278.6	331.4	36.3	78.8	6.2	3.2	1.0	2.3	28.5	
	Milestone	Y	806.3	788.7	5.7	160.4	598.4	24.3	1.1	12.6	0.5	0.2	0.2	36.3	
	Ruby Ring	R	758.8	713.4	1.7	55.0	610.9	45.8	21.2	21.1	0.4	0.0	0.4	30.2	1.0
Bejo	Calibra	Y	950.9	890.6	28.5	332.3	515.7	14.0	39.0	10.0	1.2	0.0	1.2	28.7	
	Crocket	Y	1052.3	1010.1	73.1	390.9	512.3	33.8	27.8	10.5	0.4	0.0	0.4	29.0	
	Desperado	Y	1184.3	1083.0	223.5	495.2	348.7	15.6	72.8	11.8	1.4	0.7	0.7	27.9	
	Delgado	Y	1101.1	1024.0	139.6	462.4	400.9	21.1	60.0	5.2	1.1	0.5	0.6	31.5	
	Peso	Y	1176.2	998.7	270.2	469.2	245.6	13.8	140.1	2.5	3.0	2.4	0.6	27.2	
	Red Bull	R	755.0	724.2	16.6	151.7	527.6	28.4	11.6	16.2	0.4	0.1	0.3	30.8	0.0
	Sedona	Y	1148.3	1081.3	150.3	528.5	378.4	24.1	39.6	11.6	1.3	1.2	0.2	27.4	
	Derby F1	Y	1119.2	765.9	92.3	311.4	350.8	11.5	187.9	5.2	14.5	4.5	10.0	26.8	
	BGS 231	Y	1034.9	927.5	87.9	400.0	411.8	27.7	89.7	8.1	0.9	0.3	0.7	28.9	
Crookham	Harmony	Y	1321.2	1228.3	444.6	535.0	213.2	35.5	43.3	15.3	2.6	2.6	0.0	29.3	
	Sweet Perfection	Y	1226.7	1076.2	437.1	456.3	171.5	11.3	96.1	1.7	4.2	2.7	1.5	27.8	
	OLYS03-207	Y	1204.4	1117.0	315.3	505.2	284.1	12.4	27.4	11.0	4.3	2.9	1.4	31.4	
	OLYS05N5	Y	1371.7	1303.2	502.3	524.1	254.7	22.1	26.0	8.4	2.5	1.6	0.9	30.1	
	OLYX00-23	Y	1083.7	1042.0	106.6	510.0	397.3	28.2	23.5	10.6	0.7	0.5	0.3	31.1	
D. Palmer	Mesquite06	Y	1240.5	1110.3	468.1	419.6	217.5	5.1	95.6	6.8	2.2	1.6	0.7	28.5	
	Tequila06	Y	1257.7	1147.7	311.8	525.3	292.3	18.3	71.4	13.6	2.0	0.8	1.2	28.3	
	Evolution	Y	1283.7	1239.6	425.3	584.0	214.8	15.5	21.9	5.6	1.3	0.5	0.7	29.6	
	Generation X	Y	1180.6	1160.1	103.1	622.8	419.4	14.9	6.8	5.1	0.7	0.1	0.6	29.0	
	DPS1413	Y	641.6	606.9	0.0	41.1	509.6	56.3	14.6	15.4	0.7	0.0	0.7		
	DPS1414	Y	656.9	625.3	0.0	35.1	546.0	44.2	13.3	13.0	0.8	0.1	0.7		
	DPS1415	Y	484.5	431.1	2.3	34.4	314.3	80.1	24.8	23.3	1.1	0.5	0.7	22.7	
	DPS1416	Y	606.3	545.3	4.2	19.2	469.2	52.6	36.0	17.1	1.3	0.5	0.8	24.5	
D. Palmer	DPS1417	Y	708.0	641.8	28.9	141.5	423.0	48.4	37.2	19.0	1.2	0.4	0.8	29.1	

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade: Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Non-marketable yield: No. 2s	Small	Total rot	Neck rot	Plate rot	Bulb counts >4¼ in	Thrips damage[a]
			cwt/acre								-- % of total yield --			#/50 lb	0-10
	DPS1418	Y	594.2	568.7	0.0	25.2	490.9	52.6	6.8	17.0	0.4	0.1	0.2		
	DPS1419	Y	680.5	655.3	0.0	43.5	562.6	49.2	12.4	8.2	0.7	0.0	0.7		
	DPS3052	R	797.6	572.9	7.5	101.8	400.2	63.3	173.6	36.2	1.9	0.1	1.7	27.8	0.0
	DPS3055	R	802.0	501.5	1.4	65.8	387.2	47.0	266.7	17.7	2.0	0.7	1.2	37.8	0.0
	DPS3058	R	737.9	563.0	2.3	63.8	448.5	48.4	149.9	18.9	0.8	0.3	0.5	22.7	0.0
	DPS3062	R	722.9	540.8	5.0	95.9	403.9	36.0	156.5	15.9	1.4	1.0	0.3	30.2	0.3
Global Genetics	Maverick	Y	1254.9	1122.4	543.7	425.7	142.8	10.1	105.0	4.0	1.8	0.9	0.9	28.4	
	Ringleader	Y	1050.6	971.9	508.2	317.1	134.8	11.7	63.1	1.8	1.3	0.5	0.9	28.3	
	Outlaw	Y	958.4	913.3	96.1	362.9	428.7	25.6	25.5	8.9	1.1	0.2	0.9	28.9	
	6093	Y	1219.8	1146.1	317.5	533.2	277.9	17.4	34.4	8.0	2.6	1.3	1.3	31.2	
Nunhems	Granero	Y	1240.2	1199.6	270.6	634.4	282.7	12.0	20.6	9.4	0.9	0.6	0.3	29.6	
	Montero	Y	1140.0	1102.9	163.1	490.0	426.6	23.2	23.2	7.7	0.5	0.4	0.2	27.9	
	Pandero	Y	1174.8	1120.1	269.5	546.1	288.7	15.7	31.3	8.5	1.3	0.6	0.7	28.0	
	Ranchero	Y	1310.0	1260.8	531.9	528.7	181.8	18.5	19.0	4.7	1.9	1.2	0.7	28.1	
	Salsa	R	881.6	796.5	36.7	280.0	437.6	42.3	62.0	16.9	0.7	0.2	0.5	30.7	0.5
	Vaquero	Y	1309.1	1268.5	437.1	571.3	234.4	25.7	19.9	12.6	0.6	0.4	0.2	28.6	
	Arcero	Y	1107.5	1081.0	145.3	553.1	364.9	17.7	11.5	8.9	0.6	0.1	0.4	28.8	
	Joaquin	Y	1238.0	1189.4	371.5	534.6	267.4	15.8	18.9	8.2	1.7	0.8	1.0	29.5	
	Cometa	W	1255.4	1204.0	329.8	601.1	262.6	10.4	12.3	10.0	2.4	1.2	1.2	29.8	
Sakata	XON-670W	W	1166.4	1077.1	263.3	473.3	317.8	22.7	45.9	8.8	3.0	0.7	2.4	29.9	
Seminis	Affirmed	Y	1194.2	1147.0	495.2	475.4	164.0	12.4	23.5	4.6	1.6	0.5	1.1	27.8	
	Charismatic	Y	1379.4	1316.2	687.7	438.0	177.2	13.2	24.9	2.8	2.6	1.7	0.9	28.5	
	Monarchos	Y	1131.9	1108.5	314.0	578.6	205.7	10.3	3.4	2.4	1.6	0.3	1.2	28.5	
	Mercury	R	850.6	780.6	25.2	259.4	467.6	28.4	47.9	9.0	1.5	0.6	0.9	30.4	0.8
	Toluca	W	1177.1	1019.8	266.5	511.8	230.1	11.4	87.5	5.9	5.5	2.6	2.9	28.6	
	Orizaba	W	1130.5	942.2	186.6	470.2	270.7	14.8	62.1	4.5	11.0	7.5	3.5	27.5	
LSD (0.05)			115.4	108.7	87.1	84.4	102.6	21.1	40.3	11.5	2.7	1.7	1.8	3.3	

[a] Thrips damage on the surface of red onions at the end of the storage January 14 and 15: 0 = least damage, 10 = most damage.

ONION PRODUCTION FROM TRANSPLANTS GROWN IN A LOW TUNNEL COLD FRAME AND IN A GREENHOUSE

Clinton C. Shock, Erik Feibert, and Lamont Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Bob Simerly
McCain Foods
Fruitland, ID

Introduction

Increased interest in an earlier start for the onion harvest season has led to interest in transplanting. Our earlier research showed that onions can be harvested in July when grown from transplants started in the winter in a greenhouse (Shock et al. 2004). Transplants must be grown locally as required by the local onion white rot quarantine that prohibits importation of onion transplants from areas outside the Treasure Valley. Onion transplant production in the Treasure Valley is expensive due to the need for heated greenhouse production during the winter. Transplants produced from field-grown overwintering varieties have performed inconsistently and the available overwintering varieties do not have adequate bulb quality and appearance (Shock et al. 2006, 2007). Another alternative would be to plant seed in the winter and grow transplants in unheated "low tunnel" cold frames. This trial evaluated the performance of onion transplants produced in low tunnels and in a heated greenhouse.

Materials and Methods

Two 44-inch beds were made in a field of Nyssa silt loam on January 8, 2007. On January 9, 50 lb phosphate (P_2O_5)/acre, 0.5 lb zinc (Zn)/acre, and 100 sulfur (S)/acre were broadcast on the bed surface. Onion seed of variety 'Ranchero' (Nunhems, Parma, ID) was broadcast on the bed surface at 1 seed/inch^2 on January 16. The onion seed was covered with 0.25 to 0.5 inch of shredded bark mulch. Two drip tapes were laid 11 inches to each side of the bed center. On January 17, low tunnel cold frames were assembled over each bed. A 6-ft-wide plastic sheet was laid over wire hoops leaving about 6 inches of plastic on the outside of each bed side. The excess plastic was covered with soil to secure the plastic. The 76-inch-long hoops were made of number 10 gauge smooth galvanized steel wire. The hoops were inserted about 6 inches in the ground at the bed edges. The low tunnel was about 20 inches tall at the center. One bed was covered with perforated plastic and the other with solid plastic.

The beds were irrigated after planting as required to wet the bed surface. Emergence in both low tunnels started on February 12. Thereafter, the beds were irrigated when the soil water tension at 4-inch depth in the bed center reached 20 cb (1 cb = 1 kPa) (Shock et al. 2000). Soil water tension in each low tunnel was monitored by 6 granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) centered at 4-inch depth below the bed center. The sensors were automatically read three times a day with two AM-400 meters (Mike Hansen Co., East Wenatchee, WA).

Temperature sensors were installed in the soil and air in each low tunnel. Three sets of four sensors were installed in each low tunnel in the bed center. Each set had a sensor 4 inches above the soil surface and one at 1-inch, 2-inch, and 4-inch depths. The temperature was read hourly by a datalogger (CR10, Campbell Scientific, Logan, UT).

In addition to the low tunnel cold frames, transplants were also grown in a heated greenhouse (65°F day, 45°F night air temperatures). Onion seed of variety Ranchero was planted in flats with a vacuum seeder at 72 seeds/flat on January 18, 2007. The seed was sowed on a 1-inch layer of Sunshine general purpose potting mix. The seed was then covered with 1 inch of potting mix. The flats were watered immediately after planting and were kept moist until emergence on February 1.

On March 29, the 1- to 2-leaf onions from each low tunnel and the 2- to 3-leaf onions from the greenhouse were transplanted to a field of Owyhee silt loam. The seedlings were planted in double rows on 22-inch beds. The spacing between plants in each single row was 6 inches (every 3 inches in the double row), equivalent to 95,000 plants per acre. Plots of each treatment were 20 ft long by 4 double rows wide arranged in a randomized complete block design with 5 replicates.

The onions were managed to minimize yield reductions from weeds, pests, diseases, water stress, and nutrient deficiencies. Weeds were controlled with an application of Prowl® at 1 lb ai/acre on April 13. On May 18, Aza-Direct® at 0.0062 lb ai/acre and Success® at 0.25 lb ai/acre were applied for thrips control, and Select® at 0.25 lb ai/acre and Prowl at 0.24 lb ai/acre were applied for weed control. On June 1, Aza-Direct at 0.0062 lb ai/acre and Success at 0.25 lb ai/acre were applied for thrips control. Subsequent insecticide applications for thrips control were done aerially: June 16, Lannate® at 0.9 lb ai/acre; July 6, Carzol® at 1.15 lb ai/acre; July 15, Lannate at 0.9 lb ai/acre and Poast® at 0.28 lb ai/acre (grass control); and August 3, Lannate at 0.9 lb ai/acre. Not all of these late treatments were necessary for these onions, but they were planted in a field to be harvested in September and received all treatments appropriate for these full season trials.

The field was sidedressed with urea at 120 lb N/acre on May 11. On June 11, the field was sidedressed with 100 lb N/acre as urea.

On July 12, July 30, and August 14, 6.7 ft of the middle two rows in each plot were topped and bagged. Decomposed bulbs were not bagged. Following each harvest the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), and bulbs infected with neck rot (*Botrytis allii*) in the neck or side, plate rot (*Fusarium oxysporum*), or black mold (*Aspergillus niger*). The

No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

Onion bulbs from all harvests were rated for single centers. Twenty-five onions ranging in diameter from 3.5 to 4.25 inches from each plot were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: "small" had diameters less than 1½ inch, "medium" had diameters from 1½ to 2¼ inches, and "large" had diameters over 2¼ inches. Onions were considered "functionally single centered" for processing if they were single centered or had a small multiple center.

Treatment differences were compared using ANOVA and protected least significant differences at the 5 percent probability level, LSD (0.05).

Results and Discussion

Onion seed in the greenhouse emerged on February 1 (14 days to emergence) and onion seed in the low tunnels emerged on February 12 (27 days to emergence). Air temperature in the greenhouse oscillated within a narrower range than air temperature in the low tunnels (Figs. 1 and 2). A heater malfunction on the night of January 31 allowed air temperature in the greenhouse to drop to 24°F. At the time of transplanting, the greenhouse transplants had two to three true leaves and the low tunnel transplants had one to two true leaves. The greenhouse transplants were substantially larger than the low tunnel transplants.

At the first two harvests (July 12 and July 30) the greenhouse transplants had significantly higher total yield and colossal bulb yield than either solid or perforated-plastic low tunnel transplants (Table 1). At the last harvest (August 14) the greenhouse transplants had significantly higher total yield and supercolossal bulb yield than either low tunnel transplants. At the last harvest the low tunnel solid plastic transplants had a higher yield of supercolossal bulbs than the low tunnel perforated-plastic transplants. There was a constant increase in marketable yield between the first and last harvest (Table 1, Fig. 3). Supercolossal bulb yield showed a large increase between the second and third harvest compared to the first and second harvest.

Averaged over harvest dates, the greenhouse transplants had higher total and marketable yield and yield of supercolossal and colossal bulbs.

At the first harvest there was no significant difference in bulb single centeredness between transplant types (Table 2). At the second harvest the greenhouse transplants had a significantly lower percentage of functionally single-centered bulbs than the low tunnel solid-plastic transplants. At the third harvest the greenhouse transplants had signifcantly lower percentage of functionally single-centered bulbs than the low tunnel transplants. The greenhouse transplants had 20 percent bolted bulbs on July 30 and 19 percent bolted bulbs on August 14 compared to no bolting for the low tunnel transplants. At the time of transplanting, the greenhouse transplants had one to two leaves more than the low tunnel transplants and were substantially larger. The higher bolting with the greenhouse transplants could be related to their being more susceptible to vernalization than the low tunnel transplants. The last killing frost (≤ 32°F) was on May 4, with numerous killing frosts in April. Onion variety Ranchero, direct seeded in the same field and with emergence on March 30, showed only 0.2 percent bolting.

In 2007, the greenhouse transplants resulted in higher yield and grade, but lower percentage of single-centered bulbs than the low tunnel transplants. The performance of the greenhouse transplants simply in terms of yield and grade in 2007 was consistent with performance of greenhouse transplants in 2002 and 2003 (Table 3). Yields of onions grown from greenhouse transplants in 2006 were reduced by excessive thrips and iris yellow spot virus infestations. The lower number of single-centered bulbs with the greenhouse transplants in 2007 compared to previous years is not known. In 2006, the transplants were at the same stage as in 2007 (2-3 leaves), but transplanting occurred later in 2006.

The results suggest that transplants from the low tunnel cold frames were too small and might perform better in future trials if the seed had been planted earlier.

References

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2000. Irrigation criteria for drip-irrigated onions. HortScience 35:63-66.

Shock, C.C., E. B. G. Feibert, and L.D. Saunders. 2004. Onion production from transplants in the Treasure Valley. Oregon State University Agricultural Experiment Station Special Report 1055:47-52.

Shock, C.C., E. B. G. Feibert, and L.D. Saunders. 2006. Onion production from transplants. Oregon State University Agricultural Experiment Station Special Report 1075:45-50.

Shock, C.C., E. B. G. Feibert, and L.D. Saunders. 2007. Evaluation of overwintering onion for production in the Treasure Valley, 2005-2006 trial. Oregon State University Agricultural Experiment Station Special Report 1075:43-44.

Table 1. Performance data from three harvest dates for onion variety Ranchero grown from transplants. Transplants were produced in unheated low tunnel cold frames and in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR.

Transplant source	Total yield	Marketable yield by grade					Bulb counts >4¼ in	Small	No. 2	Rot
		Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in				
	---------- cwt/acre ----------						#/50 lb	-- cwt/acre --		%
12 July										
Greenhouse	671.6	664.6	4.7	147.0	467.7	45.2	37.8	7.1	0.0	0.0
Low tunnel perforated[a]	351.7	305.8	0.0	2.8	196.1	106.9	na	46.0	0.0	0.0
Low tunnel solid[b]	328.5	294.4	0.0	0.0	187.7	106.8	na	34.1	0.0	0.0
average	455.5	425.9	1.6	49.9	286.4	88.0	37.8	29.6	0.0	0.0
30 July										
Greenhouse	944.0	944.0	89.2	442.5	404.0	8.3	31.5	0.0	0.0	0.0
Low tunnel perforated	737.0	734.1	20.8	169.0	519.9	24.4	34.6	2.8	0.0	0.0
Low tunnel solid	685.8	683.2	20.9	154.9	478.2	29.2	35.1	2.6	0.0	0.0
average	796.0	794.3	45.1	259.4	469.0	20.8	33.2	1.7	0.0	0.0
14 August										
Greenhouse	1,341.3	1,332.7	716.0	455.1	160.7	0.8	27.2	2.0	0.0	6.7
Low tunnel perforated	1,035.2	1,026.5	178.5	418.8	315.0	19.1	28.9	4.2	6.7	0.0
Low tunnel solid	1,064.6	1,016.2	315.9	423.7	297.9	9.1	29.9	5.7	8.7	0.0
average	1,139.7	1,136.4	451.3	454.6	220.3	10.2	28.7	3.3	5.1	0.2
Average										
Greenhouse	985.6	980.4	270.0	348.2	344.1	18.1	30.1	3.0	0.0	0.2
Low tunnel perforated	708.0	688.8	90.3	220.2	326.9	51.5	31.0	16.9	2.2	0.0
Low tunnel solid	704.9	687.4	137.7	195.5	304.7	49.5	31.4	14.7	2.9	0.0
LSD (0.05) transplant source	87.4	90.6	72.7	66.4	NS	24.6	1.8	7.1	NS	NS
LSD (0.05) date	41.1	42.6	58.2	46.9	62.9	19.3	1.9	5.3	NS	NS
LSD (0.05) date X transpl.source	71.3	NS	100.8	81.1	108.9	NS	NS	9.1	NS	NS

[a]perforated plastic.
[b]solid plastic.

Table 2. Bulb single centeredness and bolting from three harvest dates for onion variety Ranchero grown from transplants. Transplants were produced in unheated low tunnel cold frames and in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR.

Transplant source	Multiple center: Large >2¼ inches[a]	Multiple center: Medium 1½ to 2¼ inches	Multiple center: Small <1½ inch	Single center	Functional single center[b]	Bolting
	%					
12 Jul						
Greenhouse	0.0	0.8	11.2	88.0	99.2	0.0
Low tunnel perforated	2.3	0.6	9.1	88.0	97.1	0.0
Low tunnel solid	3.5	1.0	4.0	91.5	95.5	0.0
Average	1.6	1.1	9.3	88.0	97.3	0.0
30 Jul						
Greenhouse	9.1	14.4	11.7	64.8	76.5	20.0
Low tunnel perforated	7.2	4.0	5.6	83.2	88.8	0.0
Low tunnel solid	7.3	2.7	4.7	85.3	90.0	0.0
Average	7.8	6.7	7.4	78.2	85.5	6.8
14 Aug						
Greenhouse	6.0	26.0	11.0	57.0	68.0	19.0
Low tunnel perforated	4.0	8.0	15.0	73.0	88.0	0.0
Low tunnel solid	4.0	8.0	14.0	74.0	88.0	0.0
Average	4.8	13.9	12.8	68.5	81.3	6.3
Average						
Greenhouse	5.2	13.6	11.4	69.9	81.3	13.0
Low tunnel perforated	4.3	4.3	10.9	80.5	91.5	0.0
Low tunnel solid	4.8	3.7	7.2	84.3	91.5	0.0
LSD (0.05) transplant source	NS	3.7	NS	9.2	5.7	5.3
LSD (0.05) date	3.6	5.1	NS	9.3	7.2	2.6
LSD (0.05) date X transplant source	NS	8.8	NS	NS	12.5	4.5

[a]diameter of the first continuous ring.
[b]single center plus small multiple center.

Table 3. Onion yield for variety Ranchero grown from transplants produced in a heated greenhouse over 4 years compared to low tunnels in 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Year	Transplant date	Transplant source	Stage at transplanting	Harvest date	Total yield	Marketable yield by grade: Total	Marketable yield by grade: >4¼ in	Marketable yield by grade: 4-4¼ in	Bulb counts >4¼ in	Functional single center[a]
			No. of true leaves		cwt/acre				#/50 lb	%
2002	15 March	greenhouse	1-2	July 23	921.4	921.4	102.4	327.9	29.1	100.0
2003	19 March	greenhouse	1-2	July 22	944.9	942.4	70.7	459.3	32.0	82.0
2006	12 April	greenhouse	2-3	July 19	579.8	560.5	0.0	42.5		98.4
2006	12 April	greenhouse	2-3	August 3	693.3	690.5	0.0	132.7		92.0
2007	29 March	greenhouse	2-3	July 30	944.0	944.0	89.2	442.5	31.5	77.0
2007	29 March	low tunnel perforated	1-2	July 30	737.0	734.1	20.8	169.0	34.6	89.0
2007	29 March	low tunnel solid	1-2	July 30	685.8	683.2	20.9	154.9	35.1	90.0

[a]single center plus small multiple center.

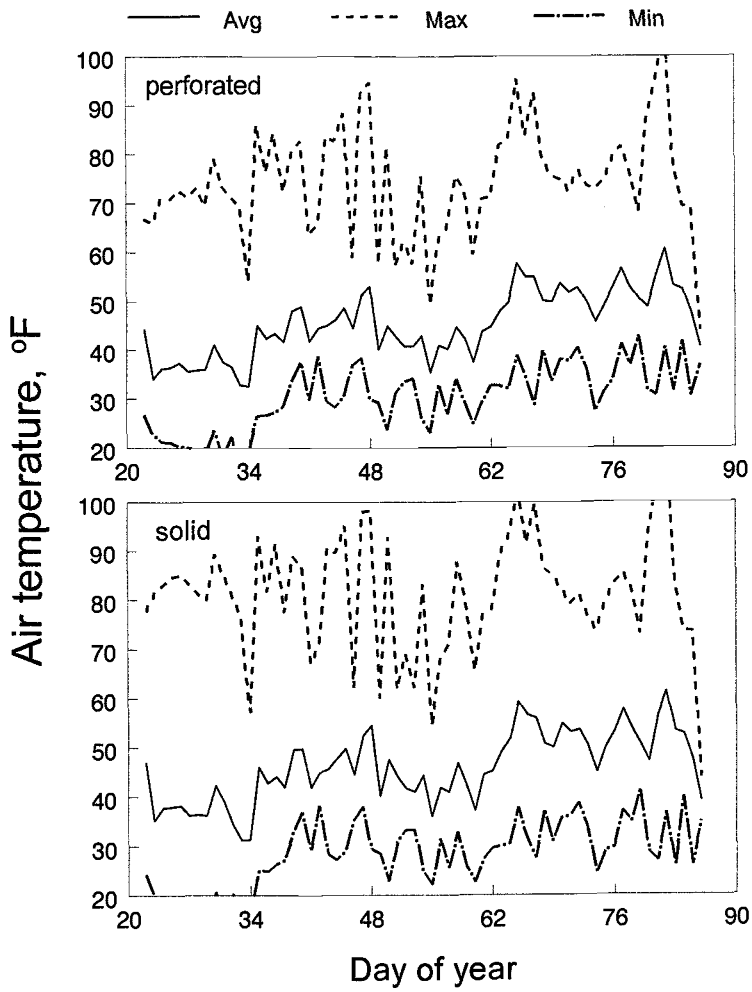


Figure 1. Daily average, maximum, and minimum air temperature in unheated low tunnels covered with perforated and solid plastic, Malheur Experiment Station, Oregon State University, Ontario, OR.

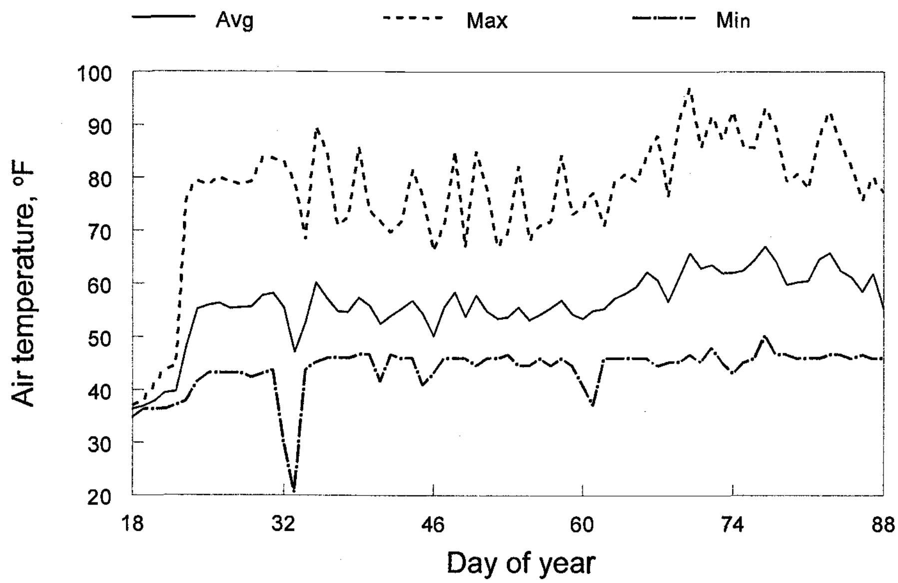


Figure 2. Daily average, maximum, and minimum air temperature in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR.

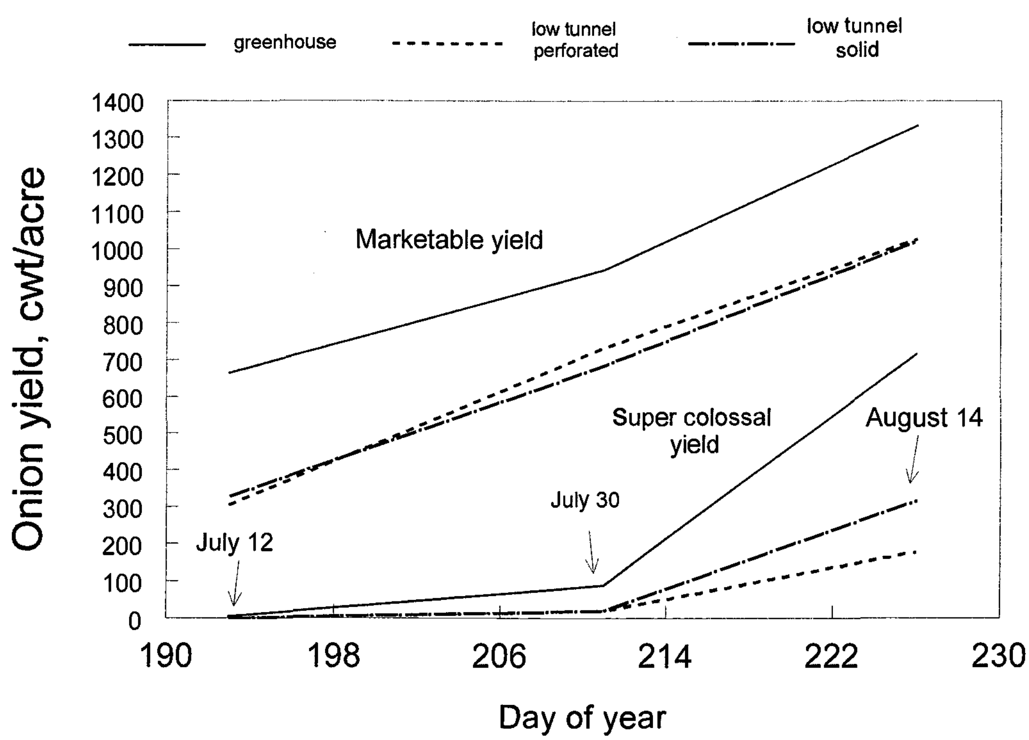


Figure 3. Marketable and supercolossal bulb yield at three harvest dates for onion variety Ranchero grown from transplants. Transplants were produced in unheated low tunnel cold frames covered with solid or perforated plastic and in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR.

MANAGEMENT OF ONION CULTURAL PRACTICES AS A MEANS TO CONTROL THE EXPRESSION OF IRIS YELLOW SPOT VIRUS

Clinton C. Shock, Erik B. G. Feibert, and Lamont D. Saunders
Malheur Experiment Station, Oregon State University, Ontario, OR

Lynn Jensen
Malheur County Extension Service, Oregon State University, Ontario, OR

Krishna Mohan
University of Idaho, Parma, ID

Introduction

Onion plants infected with iris yellow spot virus (IYSV) can progressively lose leaf area, resulting in reduced yield and reduced bulb size. The virus is transmitted by onion thrips (*Thrips tabaci*). The incidence of IYSV can be increased by inadequate control of onion thrips, which have become increasingly resistant to pyrethroid and organophosphate insecticides. A certain degree of varietal tolerance to thrips and IYSV has been determined (Shock et al. 2007). However, management factors such as irrigation, fertilization, and straw mulching that reduce plant stress might reduce the intensity of thrips and IYSV infestations. This trial tested the response of four onion varieties to water stress level, irrigation system, nitrogen fertilizer rate, and straw mulching.

Materials and Methods

The onions were grown on an Owyhee silt loam previously planted to wheat. In the fall of 2006, the wheat stubble was shredded and the field was irrigated and disked. Soil analysis indicated the need for 127 lb phosphate (P_2O_5)/acre, 80 lb sulfur (S)/acre, 7 lb maganese (Mn)/acre, 3 lb zinc (Zn)/acre, and 1 lb/acre of boron (B), which were broadcast in the fall of 2006 after disking. The field was then moldboard-plowed, groundhogged, roller-harrowed, fumigated with Telone® C-17 at 20 gal/acre, and bedded.

Onion seed of four varieties ('Evolution', D. Palmer Seed Co., Yuma AZ; 'Vaquero' and 'Joaquin', Nunhems, Parma ID; 'Charismatic', Seminis Seed Co., Saint Louis, MO) was planted on March 22 at 260,000 seeds/acre in double rows spaced 3 inches apart. Each double row was planted on beds spaced 22 inches apart with a customized planter using John Deere Flexi Planter units equipped with disc openers. Drip tape (Toro Micro-Irrigation, El Cajon, CA) was laid at 4-inch depth between the 2 double onion rows at the same time as planting. The distance between the tape and the center of each double row was 11 inches. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft.

The onion rows received 3.7 oz of Lorsban 15G® per 1,000 ft of row (0.82 lb ai/acre) and the soil surface was rolled on March 23. Onion emergence started on April 8. On May 4, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 9 through May 10, the seedlings were hand thinned to a plant population of two plants/ft of single row (6-inch spacing between individual onion plants, or 95,000 plants/acre).

The experimental design was a split-split plot randomized complete block with four replicates. The main plots were the irrigation treatment (Table 1). Each irrigation plot was split into two nitrogen (N) rates (100 or 200 lb N/acre). Each N rate split plot was split into the four varieties. Each variety split-split plot was 4 double onion rows wide and 23 ft long.

Table 1. Irrigation treatment specifications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Irrigation system	Irrigation criterion[a]	Irrigation intensity
		cb	inches per irrigation
1	Drip	10	0.12
2	Drip	15	0.24
3	Drip	20	0.48
4	Drip	30	0.48
5	Drip	15/25[b]	0.24/0.48[c]
6	Sprinkler	20	0.48
7	Drip/optional sprinkler	20	0.48
8	Furrow	20-25	16.0[d]
9	Furrow/optional sprinkler	20-25	16.0

[a]soil water tension at 8-inch depth.
[b]15 cb until July 31, then 25 cb thereafter.
[c]0.24 inch/irrigation until July 31, then 0.48 inch/irrigation thereafter.
[d]total water applied based on limited furrow inflow measurements.

Wheat straw was applied to one plot of each irrigation treatment in replicate one or two at random, leaving the remaining replicate untreated. Similarly, wheat straw was applied to one plot of each irrigation treatment in replicate three or four at random, leaving the remaining replicate untreated. Straw was applied to the center bed (area between middle two double rows) of each split-split plot on June 26. Straw was applied at 1,300 lb/acre. Soil temperature was measured with four temperature probes installed at 2-inch depth in the bed center in each irrigation plot in replicates one and two. Soil temperature measurements were recorded hourly using a datalogger.

The sprinkler- and furrow-irrigated plots (treatments 6,8, and 9) had the drip tape removed in late May. The sprinkler plots (treatments 6,7, and 9) had four sprinklers at the plot top and another four at the plot bottom. The risers were 3 ft tall and spaced 14.7 ft apart. The first riser was located at the plot corner. Each riser had a guard preventing the nozzle from applying water to the adjacent plots. The sprinklers were R10 turbos

(Nelson Irrigation, Walla Walla, WA) with 0.75-gal/min flow control nozzles. The sprinkler water application rate was 0.16 inch/hour at a pressure of 35 psi.

Each furrow-irrigated plot (treatments 8 and 9) had a gated pipe and tail ditch. At each irrigation, the onions were irrigated for 12 hours until July 1, 24 hours until August 15, and 12 hours until the last irrigation on August 31.

Onions in each drip- and sprinkler-irrigated plot (treatments 1-7) were irrigated automatically and independently according to the irrigation criterion and intensity predetermined for each treatment (Table 1). The irrigation duration for each treatment was adjusted so that when irrigated the maximum number of times, all irrigation systems had the capacity to deliver up to a maximum of 0.48 inch of water per day. The furrow-irrigated onions were irrigated manually when the soil water tension (SWT) at 8-inch depth reached 20 to 25 cb. The drip- and furrow-irrigated onions with optional sprinkler irrigation (treatments 7 and 9) received sprinkler irrigation of 0.48 inch of water once a week during the hottest part of the growing season starting on July 5 and ending on August 15.

The datalogger made irrigation decisions for each drip- and sprinkler-irrigated plot every 6 hours. The irrigation decisions for each plot were based on the average SWT. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to solenoid valves in each plot. The water for the drip and sprinkler plots was supplied by a well that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The amount of water applied to each plot was recorded daily at 8:00 a.m. from a water meter installed between the solenoid valve and the drip tape. The automated irrigation system was started on June 4. Irrigations were terminated on August 31.

The amount of water applied and the amount of water infiltrated to the furrow-irrigated plots was estimated from measurements of furrow inflow and outflow. The difference between inflow and outflow is the amount of water infiltrated. The inflow and outflow measurements were taken every 2 hours on 4 furrows in each of 2 plots during 3 irrigations. Inflow was determined by measuring the volume of water coming out of the gate in 15 seconds. To measure outflow, trapezoidal flumes were installed at the furrow ends. Outflow was determined by measuring the level of the water in the flume. Flume water level measurements were converted to flow rate using an equation developed by measurements of flume water height and outflow.

Soil water tension was measured in each plot with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors had been calibrated to SWT (Shock et al. 1998a). The GMS were connected to the datalogger via four multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the SWT every hour.

Onion evapotranspiration (ET_c) was calculated with a modified Penman equation (Wright 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station. Onion ET_c was estimated and recorded from crop emergence on April 8 until the final irrigation.

Starting on May 29, the high N split plots in each irrigation main plot received 40 lb N/acre and the adequate N split plots received 20 lb N/acre weekly until the last application on June 25. The N fertilizer for the drip plots was injected through the drip tape as uran. The N fertilizer for the sprinkler plots was applied as urea broadcast on the surface of the onion beds. The N fertilizer for the furrow plots was applied as urea to the top half of each furrow. The total amount of N applied was 200 lb N/acre to the high N treatment and 100 lb N/acre to the adequate N treatment.

The onions were managed to minimize yield reductions from weeds, pests, diseases, and nutrient deficiencies. Weeds were controlled with an application of Roundup® at 1 qt/acre on April 6, Prowl® at 1 lb ai/acre on April 13, Goal® at 0.1 lb ai/acre, Buctril® at 0.3 lb ai/acre, and Select® at 0.25 lb ai/acre on May 11. On May 15, Aza-Direct® at 0.0062 lb ai/acre and Success® at 0.25 lb ai/acre were applied for thrips control. Starting on June 1 and ending August 7, the field was sprayed weekly with Aza-Direct at 0.0062 lb ai/acre and Success at 0.25 lb ai/acre with a backpack sprayer.

Thrips populations were measured weekly in each split-split plot starting May 23 and ending August 7. Thrips populations were measured by counting the total number of thrips on each of 15 plants per split-split plot.

Onion plant maturity was evaluated subjectively in each plot by visually rating the percentage of onions with the tops down and the percent dryness of the foliage. The percent maturity was calculated as the average percentage of onions with tops down and the percent dryness. All plots were evaluated for maturity on August 13 and August 29. The number of bolted onion plants in each plot was counted.

Onions in each plot were evaluated subjectively for severity of symptoms of iris yellow spot virus (IYSV) and powdery mildew (*Leveillula taurica*) on August 28. Each plot was given a rating on a scale of 0 to 5 of increasing severity of symptoms, where 0 = no symptoms, 1 = 1-25 percent of foliage diseased, 2 = 26-50 percent of foliage diseased, 3 = 51-75 percent of foliage diseased, 4 = 76-99 percent of foliage diseased, and 5 = 100 percent of foliage diseased.

The onions were lifted on September 13 to cure in the field. Onions from the middle two rows in each plot of the full season trial were topped by hand and bagged on September 17. The bags were put in storage on September 21. The storage shed was ventilated to maintain air temperature as close to 34°F as possible. Onions were graded out of storage on December 12-14, 2007.

During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

One sample from each plot was saved during grading for rating of single centers. After grading, 25 onions ranging in diameter from 3.5 to 4.25 inches were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: "small" had diameters less than 1.5 inches, "medium" had diameters of 1.5-2.25 inches, and "large" had diameters greater than 2.25 inches. Onions were considered functionally single centered for processing if they were single centered or had a small multiple center.

Treatment differences in yield, grade, maturity, single centeredness, thrips counts, and disease severity ratings were compared using three-way analysis of variance (ANOVA) where factor A was irrigation treatment, factor B was replicate, factor C was N rate, and factor D was variety. Treatment differences in water applied and water use efficiency were compared using one-way ANOVA, where factor A was irrigation treatment and factor B was replicate. Means separation was determined with Fisher's least significant difference test at the 5 percent probability level, LSD (0.05).

Results and Discussion

For plots without straw mulch, the average daily maximum soil temperature was higher for the drier treatments (Table 2). Straw mulching resulted in a reduction in average daily maximum soil temperature. Straw mulching did not have any effect on onion yield or grade (data not shown) in this trial.

The average season SWT increased with the increasing irrigation criteria for the drip-irrigated treatments (Table 3). The average SWT for the two furrow-irrigated treatments was not different than the wettest drip-irrigated treatment (10 cb). The two furrow-irrigated treatments were irrigated at a wetter criterion than had been planned. As expected, the furrow-irrigated treatments had a greater oscillation in soil water than the wetter drip-irrigated treatments, getting wetter during irrigations and drier between irrigations (Fig. 1).

The furrow-irrigated treatment with optional sprinkler irrigation had the highest total amount of water applied, followed by the other furrow-irrigated treatment (Table 3). The treatment drip irrigated at 30 cb had the lowest total water applied. The total ET_c for the season was 33.8 inches. All treatments applied more water than ET_c except the treatment drip irrigated at 30 cb. Water use efficiency increased with the reductions in water applied for the drip-irrigated treatments. The furrow-irrigated treatments had the lowest water use efficiency.

Thrips population reached a maximum in mid-June and then decreased (Fig. 2). The thrips population was low for all plots, only exceeding the recommended threshold for the initiation of control measures on June 14 at 17.7 thrips/plant, based on 15-25 thrips/plant (Jensen 2005). There were significant differences in thrips counts only between treatments on June 14, June 20, and for the weekly May 23 through August 7 season average (Table 3). On June 14 and on average, the two furrow-irrigated treatments had among the highest thrips counts. On June 20, the treatments drip irrigated at 20 and 30 cb had among the highest thrips counts. The sprinkler-irrigated treatment had among the lowest thrips counts on June 14, June 20, and on average.

Iris yellow spot virus symptoms in 2007 were extremely few (Table 3). There were statistically significant differences between treatments and varieties, but these differences were too small for meaningful conclusions to be drawn.

Powdery mildew symptoms were also very few, with the sprinkler-irrigated treatment having among the lowest symptom severity rating. The variety Evolution had the highest powdery mildew severity rating, followed by Joaquin. Charismatic and Vaquero had practically no powdery mildew (Table 4).

Averaged over varieties and N rates, the two furrow-irrigated treatments had the highest total yield, marketable yield, and supercolossal yield, followed by the treatments drip irrigated at 10, 15, 20, 15/25 cb, and the treatment drip irrigated at 20 cb with optional sprinkler irrigation (Table 5). The furrow-irrigated treatments were maintained wetter than intended, and wetter than is often desirable for furrow irrigation due to the risk of bulb decomposition. Drip irrigation at 30 cb and sprinkler irrigation at 20 cb resulted in the lowest total yield, marketable yield, and supercolossal yield. Drip or furrow irrigation with optional sprinkler irrigation did not significantly increase onion yield. Increasing the SWT irrigation criterion from 15 to 25 cb after August 1 did not affect onion yield in this trial.

The response of the varieties individually to the irrigation treatments was not different from the variety average, except for Evolution and Joaquin. Evolution had significantly lower total yield and marketable yield when furrow irrigated with optional sprinkler irrigation compared to furrow irrigation only. Joaquin had significantly higher total yield and marketable yield when furrow irrigated with optional sprinkler irrigation compared to furrow irrigation alone. Averaged over irrigation treatments and N rates, Charismatic had the highest and Vaquero had the lowest supercolossal bulb yield. Averaged over irrigation treatments and N rates, Vaquero had the highest marketable onion yield and Joaquin and Evolution had the lowest marketable onion yield.

There was no significant interaction of N rate with irrigation and variety. Averaged over irrigation treatments and varieties, the highest total yield, marketable yield, and supercolossal yield were obtained with the lower N rate of 100 lb N/acre.

The furrow-irrigated treatments and the treatment drip irrigated at 30 cb had among the lowest percentage of functionally single-centered bulbs (Table 6). Sprinkler irrigation resulted in among the highest percentage of single-centered bulbs for Vaquero and

Joaquin. Evolution and Joaquin had the highest and Charismatic had the lowest percentage of single-centered bulbs.

Drip irrigation at 10 cb and the furrow-irrigated treatments had among the lowest maturity on August 13 and August 29. Vaquero and Charismatic were the most mature and Evolution and Joaquin were the least mature on August 29 (Table 6). Sprinkler irrigation resulted in the highest amount of bolting.

Conclusions

As we noted above, differences that cultural practices might make on IYSV expression were negligible due to low thrips pressure and very low IYSV pressure observed in these studies in 2007. We expect that variety and irrigation treatment responses might be different with higher thrips and IYSV pressure. The results of this trial show that higher soil moisture achieved with the wetter treatments resulted in higher onion yield and grade. The higher yield and grade achieved with furrow irrigation compared to drip irrigation in this trial might not be realistic on a commercial scale. The plots in this trial were only 23 ft long, allowing extremely wet and uniform furrow irrigation. Such extremely wet and uniform furrow irrigation is difficult to achieve on a commercial scale without risk of over-irrigation and bulb decomposition in a considerable part of the field. In a year with higher thrips and IYSV pressure, furrow irrigation might not perform as well, as suggested by the higher thrips counts in the furrow-irrigated plots. Furrow irrigation also resulted in a lower percentage of functionally single-centered bulbs. Previous research at the Malheur Experiment Station has also shown that, with both furrow and drip irrigation, frequent irrigations to maintain high soil moisture can result in high yield and grade, but in years with rainfall, very wet conditions also result in higher losses to storage decomposition (Shock et al. 1998b, 2000).

The higher onion yield and grade achieved in this trial with the low N rate (100 lb N/acre) is in agreement with previous results showing that onion yields often show little response to N fertilizer in furrow or drip irrigations (Miller et al. 1993; Shock et al. 2001, 2004). High amounts of N can be provided to an onion crop by natural sources such as N mineralization and N in irrigation water (Shock et al. 2001, 2004). The only reason that the 200 lb N/acre was used in this trial was the possibility that higher N might help IYSV-infected plants to sustain leaf area and productivity. This idea could not be tested in 2007 due to low IYSV pressure.

The treatments tested in this trial need to be tested in other years with higher IYSV pressure.

References

Jensen, L. 2005. Controlling thrips in onions. Onion World December 2005 issue.

Miller, J.M., C. Shock, and M. Saunders. 1993. Efficiency of nitrogen fertilization on onions 1992 trials. Oregon State University Agricultural Experiment Station Special Report 924:79-90.

Shock, C.C., J.M. Barnum, and M. Seddigh. 1998a. Calibration of Watermark Soil Moisture Sensors for irrigation management. Pages 139-146 *in* Proceedings of the International Irrigation Show, Irrigation Association, San Diego, CA.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 1998b. Onion yield and quality affected by soil water potential as irrigation threshold. HortScience 33:1188-1191.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2000. Irrigation criteria for drip-irrigated onions. HortScience 35:63-66.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2001. Plant population and nitrogen fertilization for subsurface drip-irrigated onions. Oregon State University Agricultural Experiment Station Special Report 1029:52-60.

Shock, C.C., E.B.G Feibert, and L.D. Saunders. 2004. Plant population and nitrogen fertilization for subsurface drip-irrigated onion. HortScience 39:1722-1727.

Shock, C.C., E.B.G. Feibert, L.D. Saunders, L. Jensen, and K. Mohan. 2007. Onion variety trials. Oregon State University Agricultural Experiment Station Special Report 1075:33-42.

Wright, J.L. 1982. New evapotranspiration crop coefficients. Journal of Irrigation and Drainage Division, American Society of Civil Engineers 108:57-74.

Table 2. Average daily maximum soil temperature at 2-inch depth for onions with and without straw mulch and submitted to 9 irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Irrigation system	Irrigation criterion	Straw	No straw
	cb	°F	°F
Drip	10	74.0	75.8
Drip	15	73.7	80.6
Drip	20	77.8	85.5
Drip	30	77.0	88.2
Drip	15/25	73.9	75.2
Sprinkler	20	74.6	75.1
Drip/spr.	20	76.3	86.6
Furrow	20-25	76.0	75.4
Furrow/spr.	20-25	74.7	77.8
Average		75.4	80.0
LSD (0.05) average straw vs. no straw		3.4	

Table 3. Average hourly soil water tension, total water applied, marketable yield, and water use efficiency (cwt marketable yield per inch of water applied) for onions submitted to nine irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Irrigation system	Irrigation criterion	Average hourly soil water tension	Standard deviation	Total water applied[a]	Marketable yield	Water use efficiency
	cb	cb		inches	cwt/acre	cwt/inch
Drip	10	11.7	3.4	44.7	1001.5	22.8
Drip	15	15.1	2.7	42.4	1037.0	24.4
Drip	20	17.6	3.3	37.8	1002.4	26.6
Drip	30	24.1	5.5	30.4	951.3	31.3
Drip	15/25	17.2	4.4	38.0	1041.6	27.5
Sprinkler	20	17.8	5.2	37.9	912.9	24.8
Drip/spr.	20	17.3	3.2	37.3	1034.7	28.0
Furrow	20-25	13.5	6.8	273.7	1153.2	4.2
Furrow/spr.	20-25	13.8	5.3	286.1	1150.8	4.0
LSD (0.05)		2.3	2.3	6.3	56.2	4.1

[a]includes 2.1 inches of precipitation. For the furrow irrigated plots, the total water applied was estimated from limited furrow inflow measurements. Based on inflow and outflow measurements, the total amount of water infiltrated in the furrow plots was estimated to be 66.9 inches for the furrow treatment and 79.3 inches for the furrow with optional sprinkler irrigation treatment.

Table 4. Thrips counts, iris yellow spot virus (IYSV), and powdery mildew (PM) leaf damage severity ratings in response to irrigation system and variety, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007. Continued on next page.

Irrigation system	Irrigation criterion	Thrips counts			Disease severity rating[a]	
		6/14	6/20	5/7-8/23 average	IYSV	PM
	cb	No./plant			Scale of 0-5	
		Evolution				
Drip	10	15.7	7.7	5.3	0.50	1.44
Drip	15	19.1	6.4	6.1	0.50	1.81
Drip	20	16.9	8.1	6.0	0.50	1.00
Drip	30	15.2	10.8	5.0	0.50	0.56
Drip	15/25	17.5	6.2	5.5	0.50	1.19
Sprinkler	20	16.7	6.9	5.4	0.50	0.06
Drip/spr.	20	17.1	8.0	6.1	0.50	0.88
Furrow	20-25	23.6	7.1	6.2	0.44	0.88
Furrow/spr.	20-25	24.2	6.9	6.4	0.50	0.69
	average	18.4	7.6	5.8	0.49	0.94
		Vaquero				
Drip	10	18.8	7.8	5.8	0.56	0.13
Drip	15	16.5	6.6	6.3	0.56	0.06
Drip	20	19.7	9.1	6.3	0.56	0.06
Drip	30	21.4	9.5	5.9	0.50	0.00
Drip	15/25	17.8	5.7	5.6	0.50	0.00
Sprinkler	20	18.7	6.3	5.4	0.50	0.00
Drip/spr.	20	19.2	7.9	6.4	0.56	0.00
Furrow	20-25	23.7	7.1	7.0	0.50	0.00
Furrow/spr.	20-25	24.0	7.4	6.3	0.50	0.06
	average	19.9	7.5	6.1	0.53	0.03
		Joaquin				
Drip	10	17.3	5.8	4.7	0.50	0.94
Drip	15	17.0	6.5	5.8	0.50	1.13
Drip	20	20.4	8.4	5.7	0.50	0.69
Drip	30	17.6	9.4	5.4	0.63	0.44
Drip	15/25	17.8	5.9	5.3	0.50	0.63
Sprinkler	20	15.0	6.6	4.6	0.50	0.00
Drip/spr.	20	17.1	6.7	5.6	0.44	0.19
Furrow	20-25	21.3	7.0	5.8	0.50	0.44
Furrow/spr.	20-25	21.8	6.7	5.7	0.44	0.31
	average	18.4	7.0	5.4	0.50	0.53

Irrigation system	Irrigation criterion	Thrips counts			Disease severity rating[a]	
		6/14	6/20	5/7-8/23 average	IYSV	PM
	cb	---------- No./plant ----------			------ Scale of 0-5 ------	
		Charismatic				
Drip	10	12.6	6.1	4.5	0.50	0.06
Drip	15	12.2	5.3	4.9	0.50	0.13
Drip	20	15.6	6.7	5.2	0.50	0.06
Drip	30	13.3	8.0	4.7	0.50	0.00
Drip	15/25	13.5	5.3	4.3	0.50	0.06
Sprinkler	20	13.8	5.5	4.2	0.50	0.00
Drip/spr.	20	12.3	7.1	4.9	0.44	0.00
Furrow	20-25	18.5	5.4	5.7	0.44	0.00
Furrow/spr.	20-25	16.2	6.0	5.1	0.38	0.00
	average	14.2	6.2	4.8	0.47	0.03
		Average over varieties and N rates				
Drip	10	16.1	6.8	5.1	0.52	0.64
Drip	15	16.2	6.2	5.8	0.52	0.78
Drip	20	18.1	8.1	5.8	0.52	0.45
Drip	30	16.9	9.4	5.3	0.53	0.25
Drip	15/25	16.7	5.8	5.2	0.50	0.47
Sprinkler	20	16.0	6.3	4.9	0.50	0.02
Drip/spr.	20	16.4	7.4	5.7	0.48	0.27
Furrow	20-25	21.7	6.6	6.2	0.47	0.33
Furrow/spr.	20-25	21.5	6.7	5.9	0.45	0.27
	average	17.7	7.1	5.5	0.50	0.39
LSD (0.05)						
Irrigation		3.9	2.1	0.8	0.04	0.24
N rate		NS	NS	NS	NS	NS
Variety		1.2	NS	0.2	0.04	0.09
Irrig. X N rate		NS	NS	NS	NS	NS
Irrig. X Var.		NS	NS	NS	NS	0.28
N rate X Var.		NS	NS	NS	NS	NS
Irrig. X N rate X Var.		NS	NS	NS	NS	NS

[a]0 = no symptoms, 1 = 1-25% of foliage diseased, 2 = 26-50% of foliage diseased, 3 = 51-75% of foliage diseased, 4 = 76-99% of foliage diseased, and 5 = 100% of foliage diseased.

Table 5. Onion yield and grade in response to irrigation system, N rate, and variety, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007. Continued on next page.

Irrigation system	Irrigation criterion	Total yield	Marketable yield by grade					No. 2	Small	Rot	Bulb counts >4¼ in
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in				
	cb	cwt/acre								%	#/50 lb
				Evolution							
Drip	10	1030.9	935.5	484.2	333.8	114.7	2.7	37.7	2.8	5.4	28.9
Drip	15	1134.5	1032.9	365.7	491.2	170.0	6.1	46.1	2.0	4.6	30.3
Drip	20	1050.0	969.6	349.3	446.2	169.9	4.2	40.4	0.4	3.7	30.3
Drip	30	933.7	855.1	307.2	383.8	158.8	5.3	52.7	1.1	2.6	29.8
Drip	15/25	1066.4	998.2	368.8	447.9	180.5	0.9	32.7	0.0	3.3	29.4
Sprinkler	20	954.0	887.4	302.8	409.7	169.0	5.8	22.3	0.9	4.6	32.2
Drip/spr.	20	1075.3	1003.7	448.6	411.9	134.4	8.8	36.1	1.3	3.2	29.3
Furrow	20-25	1268.0	1209.3	697.9	386.0	123.1	2.3	14.8	0.2	3.4	28.5
Furrow/spr.	20-25	1114.8	1061.8	715.6	282.7	62.0	1.4	17.2	0.5	3.2	27.9
	average	1069.7	994.8	448.9	399.3	142.5	4.2	33.3	1.0	3.8	29.6
				Vaquero							
Drip	10	1148.1	1088.7	455.8	444.5	177.6	10.7	15.0	1.1	3.7	29.4
Drip	15	1109.2	1056.2	382.2	484.0	186.0	4.0	16.5	1.0	3.2	29.5
Drip	20	1061.6	1010.2	327.6	470.5	207.4	4.8	22.8	1.6	2.9	30.0
Drip	30	1042.2	995.5	253.3	476.6	259.4	6.2	20.8	1.7	2.3	29.1
Drip	15/25	1164.5	1100.4	338.5	531.4	228.2	2.2	14.1	2.0	4.1	29.7
Sprinkler	20	1041.6	985.7	234.4	466.8	275.8	8.7	15.4	2.0	3.7	29.7
Drip/spr.	20	1095.7	1047.2	381.7	482.5	179.0	3.9	17.7	1.2	2.7	28.5
Furrow	20-25	1263.1	1211.0	673.0	404.5	130.5	2.9	13.6	3.2	3.0	27.6
Furrow/spr.	20-25	1280.8	1222.9	698.9	386.6	134.3	3.0	15.6	0.2	3.3	27.6
	average	1134.1	1079.8	416.2	460.8	197.6	5.2	16.8	1.6	3.2	29.0
				Joaquin							
Drip	10	1091.4	1018.2	457.5	392.2	165.3	3.2	21.4	0.5	4.7	29.4
Drip	15	1081.9	1008.5	460.2	384.5	158.8	4.9	30.3	0.0	3.9	30.3
Drip	20	1059.5	1016.4	391.6	425.8	192.5	6.4	19.6	1.3	2.1	31.6
Drip	30	1005.8	956.1	347.8	424.2	180.0	4.1	28.2	0.2	2.2	29.4
Drip	15/25	1081.8	1040.5	395.1	448.7	192.9	3.8	16.0	1.3	2.1	30.2
Sprinkler	20	885.8	826.0	237.2	350.0	233.8	5.0	3.7	3.0	6.5	31.1
Drip/spr.	20	1057.6	1003.7	403.7	425.3	165.6	9.1	19.0	1.5	3.1	29.9
Furrow	20-25	1140.7	1053.4	627.5	318.9	101.8	5.1	16.3	0.8	6.3	28.3
Furrow/spr.	20-25	1220.2	1143.1	716.0	319.0	106.6	1.5	20.3	1.2	4.5	28.2
	average	1069.4	1007.3	448.5	387.6	166.4	4.8	19.4	1.1	4.0	29.8

Irrigation system	Irrigation criterion	Total yield	Marketable yield by grade					No. 2	Small	Rot	Bulb counts >4¼ in
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in				
	cb	cwt/acre								%	#/50 lb
					Charismatic						
Drip	10	1060.8	963.7	482.7	345.9	132.4	2.7	39.9	0.1	5.4	29.0
Drip	15	1125.5	1050.4	514.3	368.3	163.6	4.1	37.5	1.5	3.3	29.3
Drip	20	1070.9	991.9	443.0	371.1	172.4	5.4	40.2	1.7	3.5	28.7
Drip	30	1066.0	998.5	449.3	362.6	178.1	8.4	39.3	1.8	2.5	28.8
Drip	15/25	1150.3	1027.2	467.1	370.3	183.4	6.5	56.0	2.8	5.9	29.7
Sprinkler	20	1008.2	952.3	363.8	373.4	208.3	6.8	24.1	2.3	2.9	29.9
Drip/spr.	20	1156.1	1084.0	492.3	401.6	182.3	7.8	43.3	1.3	2.4	29.4
Furrow	20-25	1216.9	1139.3	724.9	267.1	143.3	4.1	36.69	1.5	3.2	27.1
Furrow/spr.	20-25	1233.4	1175.6	767.9	274.8	126.1	6.7	19.4	2.0	2.9	27.4
	average	1120.9	1042.5	522.8	348.4	165.6	5.8	37.4	1.7	3.6	28.8
					Average over variety and N rate						
Drip	10	1082.8	1001.5	470.0	379.1	147.5	4.8	28.5	1.1	4.8	29.2
Drip	15	1112.8	1037.0	430.6	432.0	169.6	4.8	32.6	1.1	3.8	29.9
Drip	20	1060.5	997.0	377.9	428.4	185.5	5.2	30.7	1.2	3.0	30.2
Drip	30	1011.9	951.3	339.4	411.8	194.1	6.0	35.2	1.2	2.4	29.3
Drip	15/25	1115.7	1041.6	392.4	449.6	196.2	3.4	29.7	1.5	3.9	29.7
Sprinkler	20	972.4	912.9	284.5	400.0	221.7	6.6	16.4	2.1	4.4	30.7
Drip/spr.	20	1096.2	1034.7	431.6	430.3	165.3	7.4	29.0	1.3	2.9	29.2
Furrow	20-25	1222.2	1153.2	680.8	344.1	124.7	3.6	20.3	1.4	3.9	27.9
Furrow/spr.	20-25	1212.3	1150.8	724.6	315.8	107.3	3.1	18.1	1.0	3.5	27.8
	average	1098.5	1031.1	459.1	399.0	168.0	5.0	26.7	1.3	3.6	29.3
	N rate lb N/acre										
	100	1118.2	1048.4	485.4	398.2	160.0	4.9	27.1	1.3	3.7	29.2
	200	1071.8	1006.8	420.1	403.0	178.5	5.2	26.7	1.3	3.5	29.5
LSD (0.05)											
Irrigation		55.3	53.6	97.9	71.4	48.3	NS	11.6	NS	NS	1.5
N rate		42.4	41.2	32.5	NS	18.8	NS	NS	NS	NS	NS
Variety		26.3	27.9	28.2	24.1	17.2	NS	5.4	NS	NS	0.5
Irrig. X N rate		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrig. X Var.		79.0	83.5	NS	NS	NS	NS	16.2	NS	NS	NS
N rate X Var.		NS	NS	NS	NS	24.3	NS	NS	NS	NS	NS
Irrig. X N rate X Var.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Maturity, bolting, and onion single centers for four onion varieties submitted to nine irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007. Continued on next page.

Irrigation system	Irrigation criterion	Maturity		Bolter	Multiple center			Single center	
		Aug. 13	Aug. 29		large	medium	small	functional	single
	cb	%							
Evolution									
Drip	10	9.7	29.4	0.2	2.0	3.5	4.8	94.5	89.7
Drip	15	10.3	27.5	0.5	1.5	4.0	11.5	94.5	83.0
Drip	20	14.4	33.1	0.3	5.1	2.9	2.9	92.0	89.1
Drip	30	20.0	43.1	0.0	8.0	4.0	5.0	88.1	83.1
Drip	15/25	11.7	30.0	0.4	4.0	2.5	13.5	93.5	80.0
Sprinkler	20	13.8	27.5	0.9	2.5	3.6	8.6	93.9	85.3
Drip/spr.	20	8.1	25.6	0.0	5.3	3.4	5.0	91.3	86.3
Furrow	20-25	5.3	23.8	0.3	4.5	5.0	9.0	90.5	81.5
Furrow/spr.	20-25	5.3	20.0	0.0	2.5	5.0	9.0	92.5	83.5
	average	11.0	28.9	0.3	3.9	3.8	7.8	92.3	84.5
Vaquero									
Drip	10	25.0	52.5	0.1	3.5	9.0	9.5	87.5	78.0
Drip	15	30.9	55.6	0.2	7.5	4.5	9.5	88.0	78.5
Drip	20	38.4	60.0	0.1	8.0	10.0	17.0	82.3	65.0
Drip	30	46.9	66.3	0.2	5.1	8.6	12.8	86.3	73.5
Drip	15/25	30.9	60.6	0.4	6.5	12.0	8.5	81.5	73.0
Sprinkler	20	27.2	53.8	0.4	6.5	6.0	8.5	88.0	79.0
Drip/spr.	20	26.9	50.6	0.2	9.5	10.0	6.5	80.5	74.0
Furrow	20-25	15.6	46.9	0.3	9.0	8.0	15.0	83.0	68.0
Furrow/spr.	20-25	12.8	38.1	0.1	11.4	9.7	8.6	76.7	67.3
	average	28.3	53.8	0.2	7.4	8.6	10.7	83.9	73.1
Joaquin									
Drip	10	8.8	26.9	0.5	2.5	2.5	8.5	95.0	86.5
Drip	15	10.9	30.0	0.3	1.5	3.0	13.0	95.5	82.5
Drip	20	13.4	36.9	0.3	2.0	3.5	8.5	94.5	86.0
Drip	30	21.6	41.3	0.2	4.0	2.0	8.0	94.0	86.0
Drip	15/25	17.5	31.9	0.7	2.0	1.5	9.0	96.5	87.5
Sprinkler	20	16.3	33.8	1.4	2.0	1.5	4.5	96.5	92.0
Drip/spr.	20	10.3	29.4	0.1	3.0	3.0	10.0	94.0	84.0
Furrow	20-25	7.2	23.1	0.7	4.5	7.5	9.0	88.0	79.0
Furrow/spr.	20-25	5.6	22.5	0.7	2.5	2.5	5.5	95.0	89.5
	average	12.4	30.6	0.5	2.7	3.0	8.4	94.3	85.9
Charismatic									
Drip	10	21.9	90.0	0.2	17.6	11.3	20.4	71.1	50.7
Drip	15	30.6	53.8	0.2	19.5	11.0	25.0	69.5	44.5
Drip	20	28.1	55.0	0.1	15.0	17.0	22.0	68.0	46.0
Drip	30	42.5	60.6	0.2	12.0	23.4	30.3	64.6	34.3
Drip	15/25	26.6	55.0	0.5	18.4	10.9	24.4	70.8	46.4
Sprinkler	20	20.9	44.4	1.4	19.5	16.5	20.0	64.0	44.0
Drip/spr.	20	19.4	46.9	0.1	21.5	14.0	24.5	64.5	40.0
Furrow	20-25	9.7	35.6	1.0	21.0	11.5	13.5	67.5	54.0
Furrow/spr.	20-25	6.6	31.3	0.5	20.0	14.0	19.0	66.0	47.0
	average	22.9	52.5	0.5	18.4	14.4	22.0	67.3	45.3

Irrigation system	Irrigation criterion	Maturity		Bolter	Multiple center			Single center	
		Aug. 13	Aug. 29		large	medium	small	functional	single
	cb	%							
		Average over variety and N rate							
Drip	10	16.3	49.7	0.2	6.0	6.4	10.5	87.5	77.0
Drip	15	20.7	41.7	0.3	7.5	5.6	14.8	86.9	72.1
Drip	20	23.6	46.3	0.2	7.6	8.5	12.9	84.0	71.0
Drip	30	32.7	52.8	0.1	7.2	9.1	13.5	83.8	70.2
Drip	15/25	21.7	44.4	0.5	7.4	6.6	13.5	86.0	72.5
Sprinkler	20	19.5	39.8	1.0	7.6	6.9	10.4	85.5	75.1
Drip/spr.	20	16.2	38.1	0.1	9.8	7.6	11.5	82.6	71.1
Furrow	20-25	9.5	32.3	0.6	9.8	8.0	11.6	82.3	70.6
Furrow/spr.	20-25	7.6	28.0	0.3	9.0	7.7	10.6	82.9	72.1
	average	18.6	41.5	0.4	8.0	7.4	12.1	84.6	72.4
LSD (0.05)									
Irrigation		7.1	11.4	0.4	NS	NS	NS	3.7	NS
N rate		NS	NS	NS	NS	NS	NS	NS	NS
Variety		2.2	6.3	0.2	NS	NS	NS	2.9	3.5
Irrig. X N rate		NS	NS	NS	NS	NS	NS	NS	NS
Irrig. X Var.		6.6	NS	NS	NS	NS	NS	NS	10.6
N rate X Var.		NS	NS	NS	NS	NS	NS	NS	NS
Irrig. X N rate X Var.		NS	NS	NS	NS	NS	NS	NS	NS

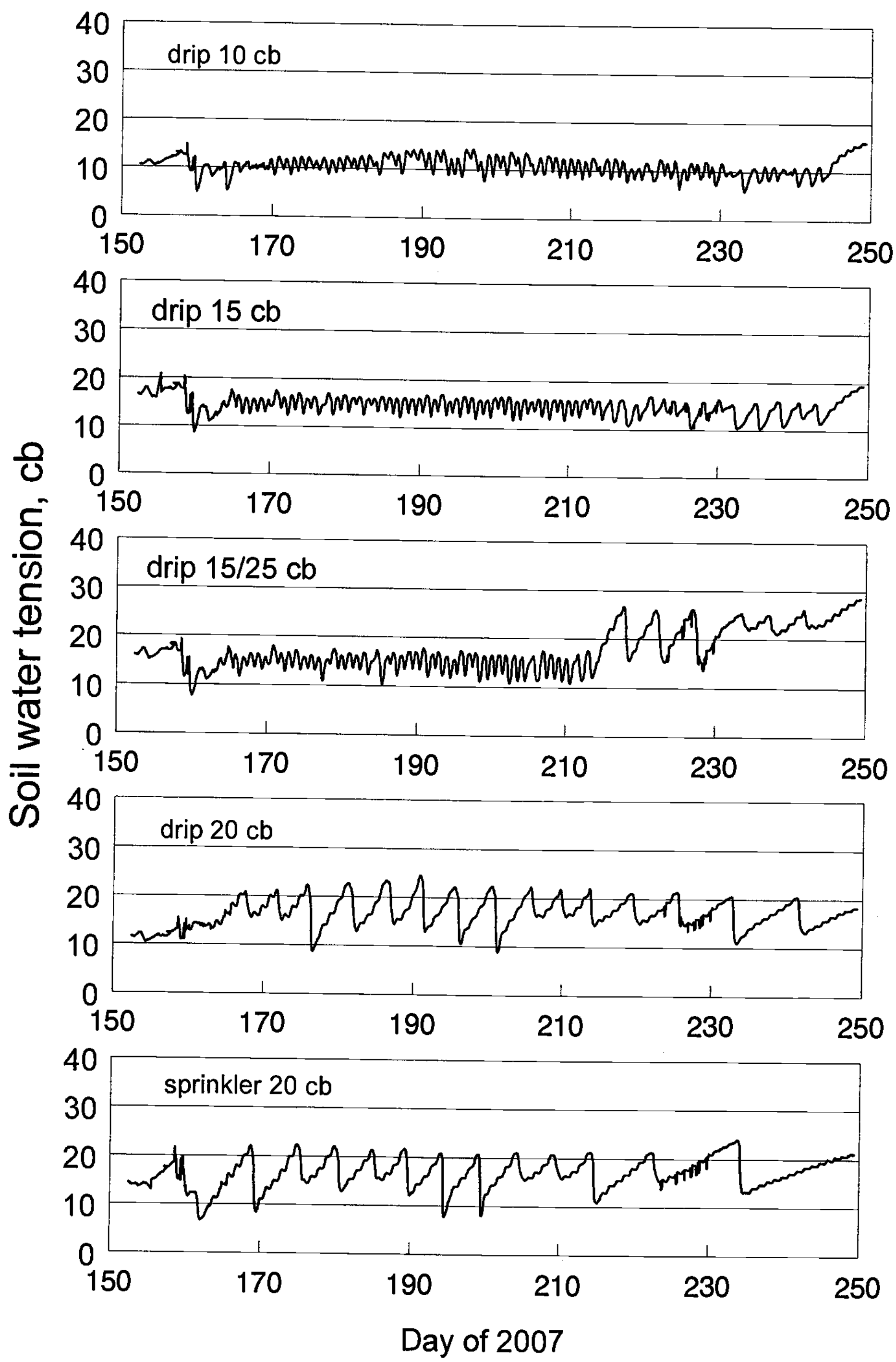


Figure 1a. Soil water tension at 8-inch depth over time for onions submitted to nine irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

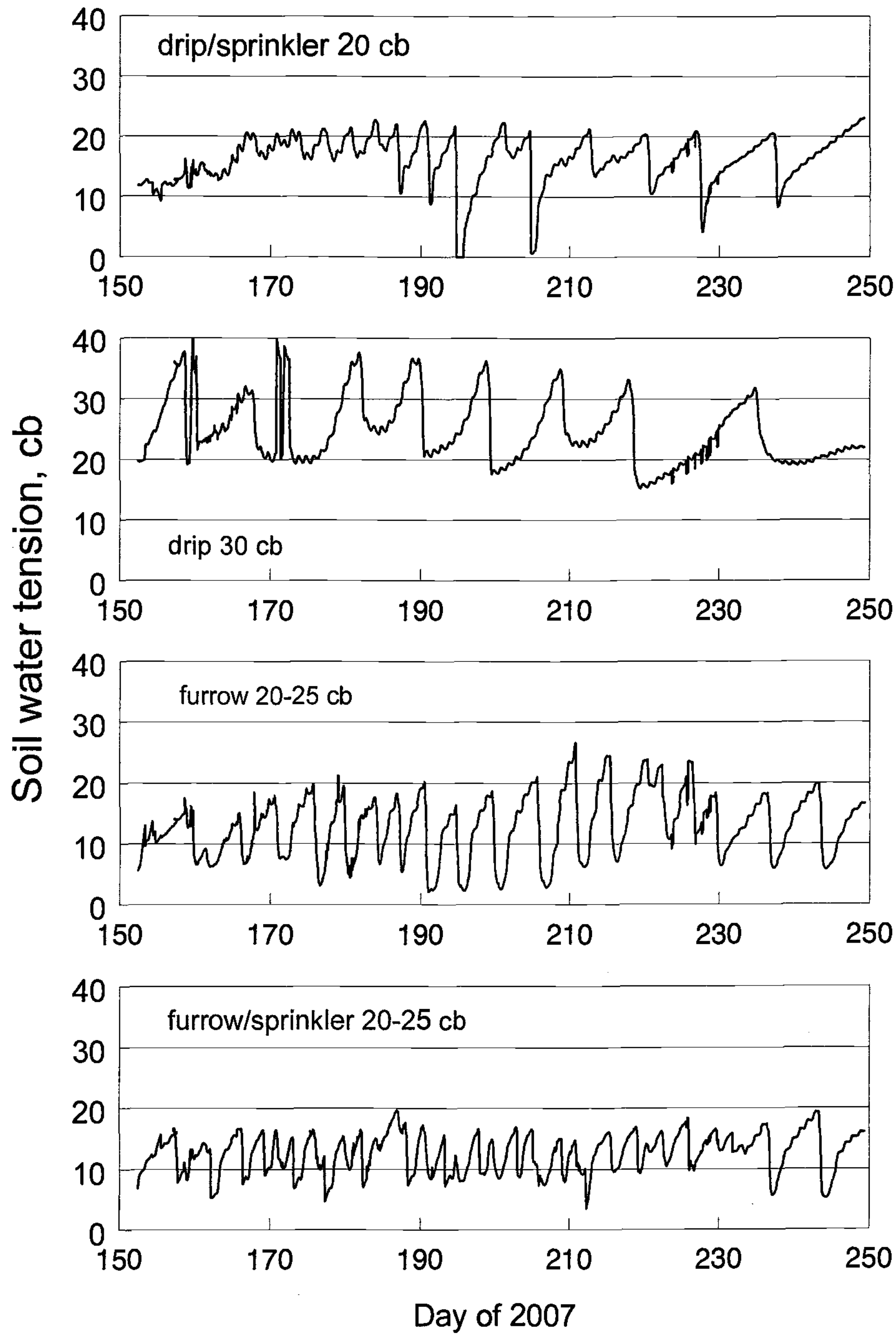


Figure 1b. Soil water tension at 8-inch depth over time for onions submitted to nine irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

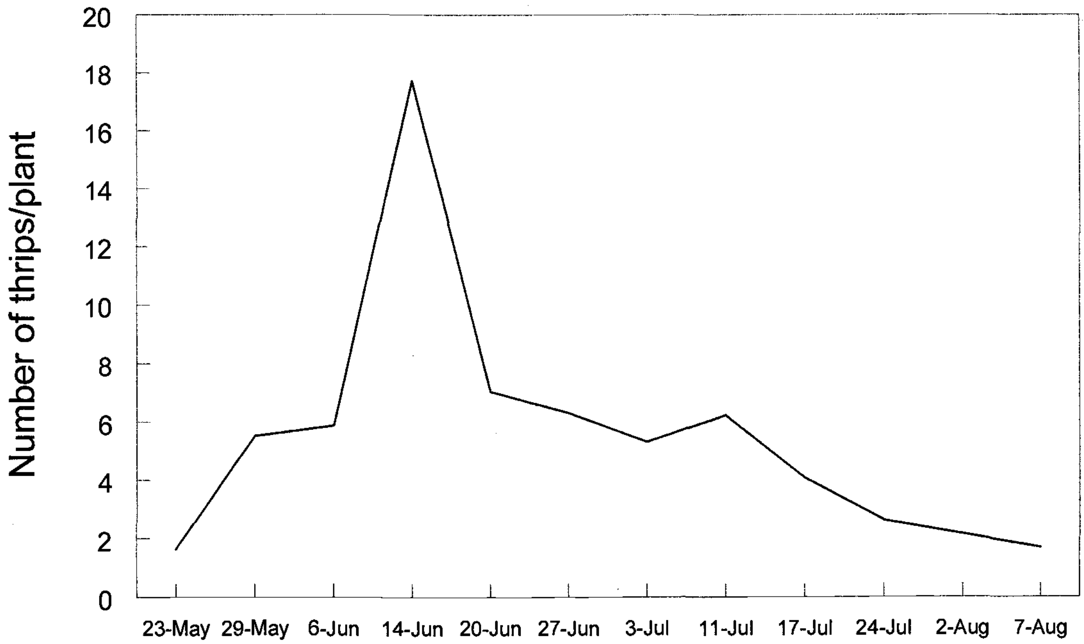


Figure 2. Thrips population counts per onion plant over time. Counts presented here were the average over irrigation treatments, N rates, and varieties (288 plots). On each date thrips on 15 onion plants/plot were counted. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

INSECTICIDE EFFICACY TRIAL FOR THRIPS CONTROL IN DRY BULB ONIONS - 2007

Lynn Jensen
Malheur County Extension Service
Oregon State University
Ontario, OR

Introduction

Thrips (onion and western flower) control is becoming increasingly difficult for commercial onion growers in the Treasure Valley. One of the problems is resistance to some of the commonly used insecticides. The objective of this trial was to screen registered and nonregistered insecticides to find those that have potential for use in thrips control programs. **Not all insecticides referred to in this report are registered for use on onions. Always obtain and read the insecticide label to ensure that the product is registered for the crop for which it is intended.**

Materials and Methods

A 1-acre field, soil type Nyssa silt loam, was planted with the onion variety 'Vaquero' (Nunhems, Parma, ID) on March 12, 2007. The onions were planted as two double rows on a 40-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 153,000 seeds/acre. Lorsban® 15G was applied in a 6-inch band over each row at planting at a rate of 3.7 oz/1,000 ft of row for onion maggot control. Water was applied by furrow irrigation.

Treatments were made by a CO_2-pressurized plot sprayer with 4 nozzles spaced 19 inches apart. It was set to apply 41.3 gal/acre, with water as the carrier. A silicone surfactant was added to all treatments, and Carzol®, Lorsban, Penncap M®, and Diazinon were buffered to pH 6.0. Treatments were applied on a weekly basis beginning on June 7. Thrips counts were also made on a weekly basis by visually counting the total number of thrips on 15 plants in each plot. The treatments are listed in Table 1.

Table 1. Treatments evaluated in the onion thrips insecticide efficacy trial, Oregon State University, Nyssa, OR, 2007.

Treatment	Rates/acre	Application date					
		6/7	6/13	6/21	6/28	7/7	7/12
1) Battalion	17.9 oz	X	X	X	X	X	X
2) Battalion + Malathion	17.9 oz + 2.0 qt	X	X	X	X	X	X
3) Knack + Success +	8.0 oz + 8.0 oz						
AzaDirect	+ 16.0 oz	X	X				
Knack + Lannate	8.0 oz + 3.0 pt			X		X	X
Knack + Carzol	8.0 oz + 20.0 oz				X		
4) Novaluron + Success +	12.0 oz + 8.0 oz	X	X				
AzaDirect	+ 16.0 oz						
Novuluron + Lannate	12.0 oz + 3.0 pt			X		X	X
Novuluron + Carzol	12.0 oz + 20.0 oz				X		
5) XDE 175 (GF1587)	8.0 oz	X	X	X	X	X	X
6) Assail	5.0 oz	X	X	X	X	X	X
7) Assail	8.0 oz	X	X	X	X	X	X
8) V-1017050 WG	3.0 oz	X	X	X	X	X	X
9) Success + AzaDirect +	8.0 oz + 16.0 oz						
Actigard	+ 0.76 oz	X	X				
Lannate	3.0 pt			X		X	X
Carzol + Actigard	20.0 oz + 0.76 oz				X		
10) Beyond	7.0 oz	X	X	X	X	X	X
11) Beyond	14.0 oz	X	X	X	X	X	X
12) Penncap M + MSR	2.0 qt + 3.0 qt	X	X	X	X	X	X
13) Pennecap M + Diazinon	2.0 qt + 1.0 pt	X	X	X	X	X	X
14) AgriMek	1.0 pt	X	X	X	X	X	X
15) Carzol	20.0 oz	X	X	X	X	X	X
16) Success + AzaDirect	8.0 oz + 16.0 oz	X	X				
Lannate	3.0 pt			X	X		X
Carzol	20.0 oz					X	
17) Untreated check	-						
18) Success + AzaDirect +	8.0 oz + 16.0 oz						
Field Enhancer	+ 5.0 qt	X	X				
Lannate + Field	3.0 pt +						
Enhancer	5.0 qt			X	X		X
Carzol + Field Enhancer	20.0 oz + 5.0 qt					X	
19) Venom SG	4.0 oz	X	X	X	X	X	X
20) Ecotrol	2.0 qt	X	X	X	X	X	X

Results and Discussion

There were significantly more thrips in the untreated check treatment (no. 17) than in the grower standard treatment (no. 16) (Fig. 1). The grower standard treatment consisted of two weekly applications of Success® + Aza Direct®, then a Lannate® treatment followed by a Carzol treatment, then two more Lannate applications. There were six treatments that were as effective as the grower standard (Fig. 2). Three of those treatments included the grower standard plus either Knack®, Novaluron, or Field Enhancer. None of them were significantly better than the grower standard alone. The insecticides Radiant™, AgriMek® and Carzol were all effective. Carzol has had a Section 18 for the past 2 years (2006-2007), and it is hoped that the Environmental Protection Agency will grant one for 2008. Radiant is a new insecticide closely related to Success and it has just recently received a label for use on onions. AgriMek is not currently registered for onions.

There were a number of products that were not significantly better than the untreated check. These included V-10170, Beyond®, Penncap M + Diazinon, Venom®, and EcoTrol® (Fig. 3). Two products had significantly more thrips than the untreated check: Battalion™, a synthetic pyrethroid, and Assail® at the 5.0-oz rate (Fig. 4). Synthetic pyrethroids in general have performed poorly on thrips during the past few years, very comparable with Battalion's performance. The addition of Malathion to the Battalion treatment slightly enhanced control, but only similar to the untreated check. The 8.0-oz rate of Assail gave slightly better thrips control than the 5.0-oz rate, but the difference was not significant.

Conclusions

The new insecticide Radiant could replace Success in a thrips spray program, but the products should not be applied together, with no more than two consecutive applications made without using another class of insecticide. It appears that Radiant will have aerial application on its label, but no tests have been done locally to determine its efficacy when applied by air. AgriMek shows efficacy and it is hoped the product will be registered sometime in the future. Carzol continues to be effective against thrips, and should be part of an insecticide rotation plan if it is approved for a Section 18 emergency registration again in 2008.

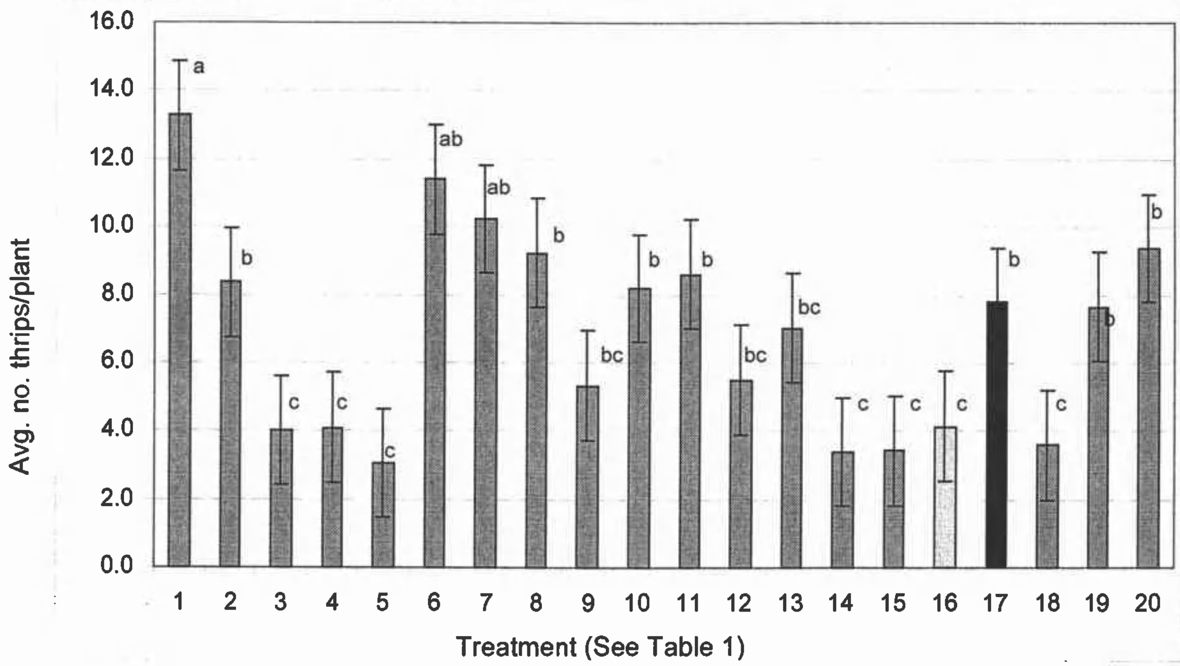


Figure 1. Season-average thrips population in dry bulb onion with different insecticide treatments, Oregon State University, Nyssa, OR, 2007.

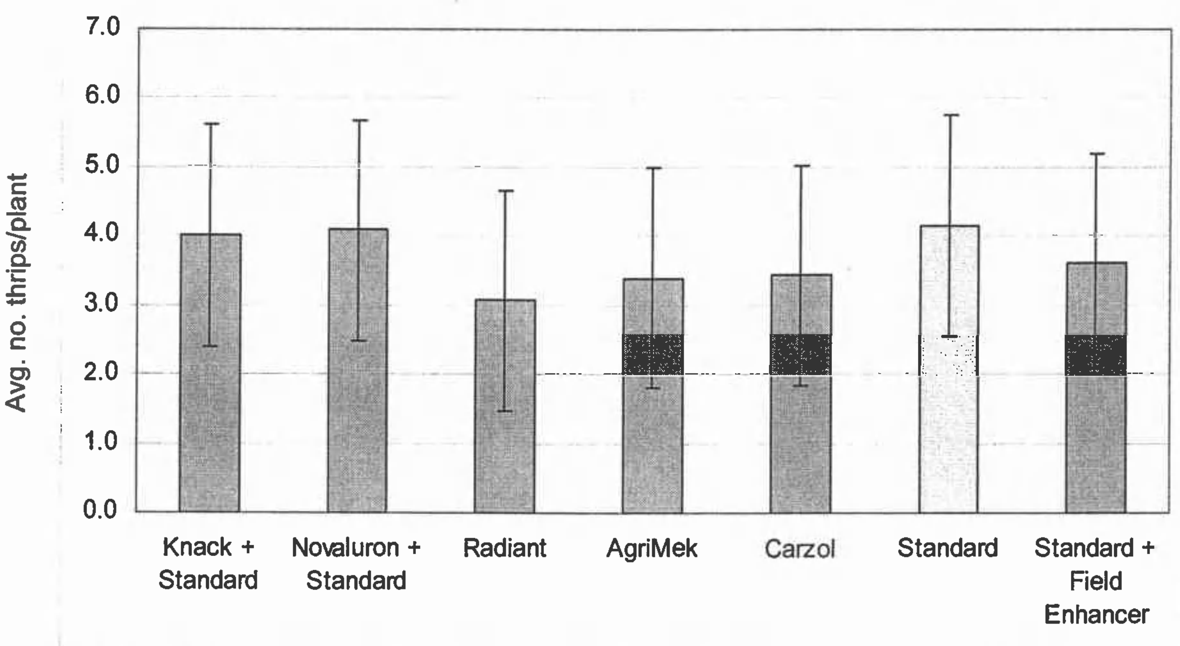


Figure 2. Season-average thrips population with some effective insecticide treatments, Oregon State University, Nyssa, OR, 2007.

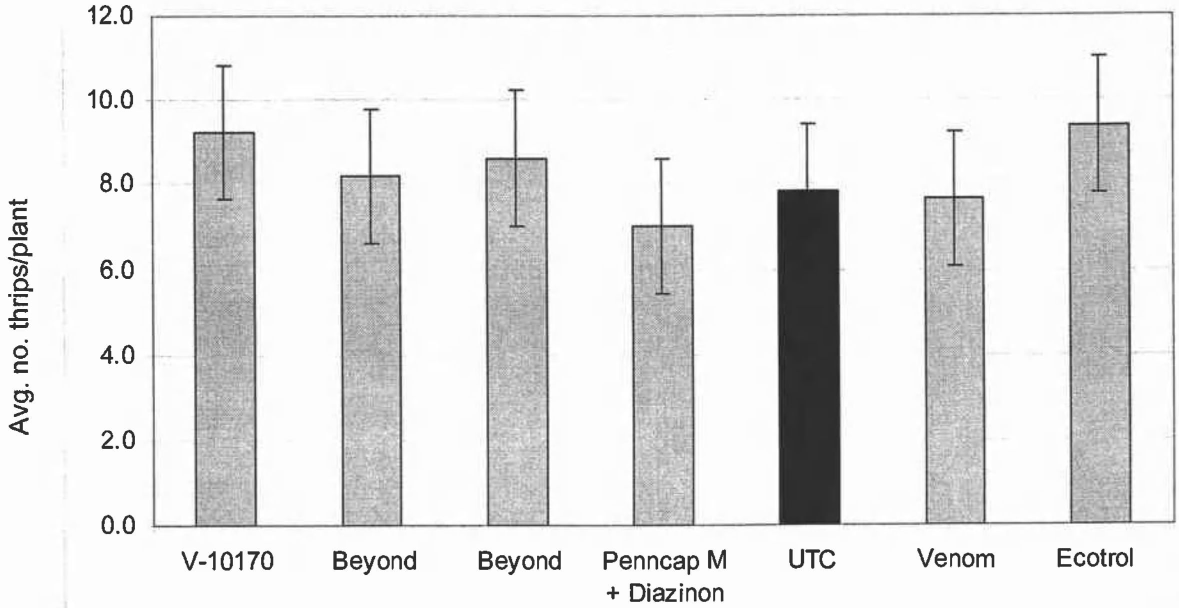


Figure 3. Season-average thrips population with insecticide treatments that did not give effective control, Oregon State University, Nyssa, OR, 2007.

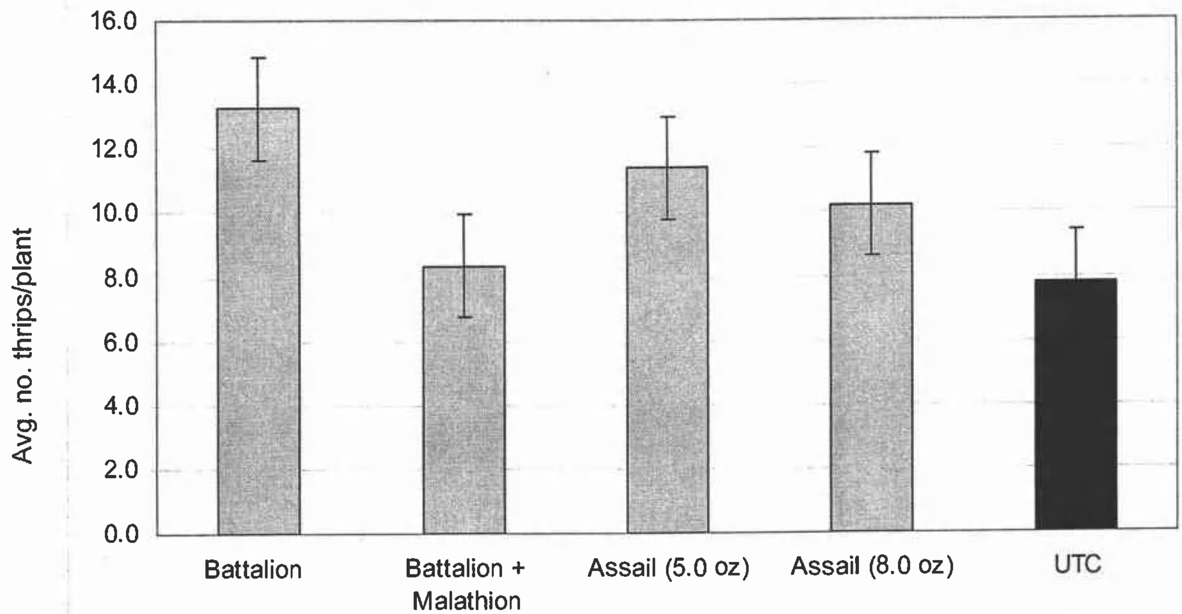


Figure 4. Season-average thrips population with ineffective insecticide treatments, Oregon State University, Nyssa, OR, 2007.

MANAGING CARZOL® FOR MAXIMUM EFFICACY AGAINST THRIPS - 2007

Lynn Jensen
Malheur County Extension Service
Clinton Shock and Lamont Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR

Objective

Our objective was to determine the most effective rates and combinations of insecticides to use with Carzol SP® to provide season-long thrips control and reduce the risk of resistance development. **Not all insecticides referred to in this report are registered for use on onions. Always obtain and read the insecticide label to ensure that the product is registered for the crop for which it is intended.**

Introduction

Oregon State University trials in 2005 showed that Carzol SP was effective in controlling thrips and reducing iris yellow spot virus (IYSV) incidence. The Environmental Protection Agency granted several states a Section 18 registration for Carzol SP use on onions for the 2006 and 2007 growing seasons, but at a lower rate than was considered effective. This project was designed to determine the optimum rate, timing, and rotation sequence with other insecticides to maximize thrips control within the parameters of the Section 18 label. The current label restricts the grower to a total of 24 oz/acre, with a maximum single application up to 20 oz.

Materials and Methods

Two trials were established at the OSU Malheur Experiment Station, one to look at the effectiveness of Carzol SP applied at different rates and spray intervals, the other to determine the most effective insecticides to rotate with Carzol SP in a complete thrips control program. The Carzol SP spray interval trial consisted of an untreated control and Carzol SP rates of 8, 12, 16, and 20 oz/acre, with application intervals of 1, 2, 3, and 4 weeks. The Carzol SP rotation trial consisted of 18 treatments of Carzol SP rotated with other insecticides (Table 1).

Table 1. Carzol SP rotation trial, insecticide treatments applied during the growing season, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

	Application		Application		Application		Application		Application		Application		Application	
	29-May	Rate/acre	8-Jun	Rate/acre	13-Jun	Rate/acre	20-Jun	Rate/acre	27-Jun	Rate/acre	3-Jul	Rate/acre	12-Jul	Rate/acre
1	UTC [a]		UTC		UTC		UTC		UTC		UTC		UTC	
2	Carzol	8.0 oz			Carzol	8.0 oz			Carzol	8.0 oz			Carzol	8.0 oz
3	Lannate	3.0 pt	Carzol	16.0 oz	Lannate	3.0 pt	Carzol	16.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
4[b]	UTC		UTC		UTC		UTC		UTC		UTC		UTC	
5	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	MSR	3.0 pt					MSR	3.0 pt						
6	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	MSR	3.0 pt	Warrior	3.84 oz	Warrior	3.84 oz	MSR	3.0 pt	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz
	Warrior	3.84 oz					Warrior	3.84 oz						
7[b]	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	MSR	3.0 pt					MSR	3.0 pt						
8[b]	Success	6.0 oz	Success	6.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Carzol	16.0 oz	Lannate	3.0 pt	Lannate	3.0 pt
	AzaDirect	16.0 oz	AzaDirect	16.0 oz										
9[c]	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz
	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz
10	Diazinon	1.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Carzol	20.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	MSR	3.0 pt												
11	Success	6.0 oz	Success	6.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Carzol	16.0 oz	Lannate	3.0 pt	Lannate	3.0 pt
	AzaDirect	16.0 oz	AzaDirect	16.0 oz										
12	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	Lannate	3.0 pt	Carzol	16.0 oz	Lannate	3.0 pt	Lannate	3.0 pt
	MSR	3.0 pt	MSR	3.0 pt	MSR	3.0 pt								
13	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz
	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz
14	Success	6.0 oz	Success	6.0 oz	Success	6.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	AzaDirect	16.0 oz	AzaDirect	16.0 oz	AzaDirect	16.0 oz	Carzol	8.0 oz	Carzol	8.0 oz	Carzol	8.0 oz	Carzol	8.0 oz
15	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
16	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt
	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz
17	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz	Warrior	3.84 oz
18	Lannate	3.0 pt	Carzol	12.0 oz	Lannate	3.0 pt	Carzol	12.0 oz	Lannate	3.0 pt	Lannate	3.0 pt	Lannate	3.0 pt

[a]UTC = Untreated check.
[b]Seed treated with Regent insecticide.
[c]Seed treated with Regent insecticide, straw mulch applied on June 15.

58

A block of onion 22 ft wide by 648 ft in length was planted to 'Joaquin' (Nunhems, Parma, ID) and a similar-sized block planted to 'Charismatic' (Seminis, Payette, ID) on March 21, 2007. The onions were planted as 2 double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 137,000 seeds per acre. Lorsban 15G® was applied at planting in a 6-inch band over each double row at a rate of 3.7 oz/1,000 ft of row for onion maggot control.

The rate and spray interval trial was conducted in the block planted to Joaquin and the insecticide rotation trial was in the block planted to Charismatic. The plots were 27 ft long by 3.67 ft wide. Insecticide applications were made with a CO_2-pressurized backpack sprayer. Materials were applied with water at 41.3 gal/acre. Each treatment was replicated four times. Thrips counts were made weekly by visually counting the total number of thrips on 15 plants in each plot. IYSV severity was evaluated in August. Yield and grade evaluation was completed in late September.

Results

Carzol SP Rate and Spray Interval Trial

Figure 1 shows the average thrips population for each treatment. The weekly application sequence was always significantly better than the 3- or 4-week spray intervals and there was a trend for better control with shorter spray intervals regardless of rate (Fig. 2). There was no significant increase in thrips control with higher rates, although there was a slight trend for better control with the 20-oz rate (Fig. 3). These data suggest that spray frequency is more important than application rate, with 1-week spray intervals being better than longer intervals. Four, 4-oz applications would be more effective than one 20-oz application.

Because of light thrips pressure during the growing season, there were not significant differences in total yield, but there were differences in the supercolossal size class, where the untreated check and some of the 3- and 4-week spray intervals had significantly lower supercolossal yields than the other treatments (Table 2).

Table 2. Onion yield response to different Carzol SP rates and application intervals, Malheur Experiment Station, Oregon State University, Ontario, OR. 2007

Treatment	Medium	Jumbo	Colossal	Super-colossal	Colossal + Supercol.	Total yield
	-cwt/acre-					
8 oz – 1 wk int	8.4	286.1	526.0	360.4	886.3	1180.8
8 oz – 2 wk int	6.3	265.7	480.6	438.2	918.9	1190.9
8 oz – 3 wk int	11.5	355.6	500.6	259.3	760.0	1126.8
8 oz – 4 wk int	2.1	246.3	540.8	336.3	877.1	1125.4
12 oz – 1 wk int	4.7	241.2	557.0	394.5	951.5	1197.4
12 oz – 2 wk int	5.5	177.0	461.6	462.8	924.4	1106.9
12 oz – 3 wk int	7.1	276.8	600.5	291.3	891.8	1175.7
12 oz – 4 wk int	1.9	309.7	567.0	284.8	851.8	1163.4
16 oz – 1 wk int	4.8	231.8	474.7	458.4	933.1	1169.7
16 oz – 2 wk int	2.9	172.1	515.2	457.1	972.3	1147.3
16 oz – 3 wk int	3.5	205.9	526.6	351.7	878.4	1087.7
16 oz – 4 wk int	6.5	276.1	561.5	355.8	917.3	1199.9
20 oz – 1 wk int	7.9	285.0	475.4	344.9	820.3	1113.1
20 oz – 2 wk int	12.0	305.2	469.9	341.0	810.9	1128.1
20 oz – 3 wk int	5.9	262.4	493.9	348.2	842.1	1110.4
20 oz – 4 wk int	5.6	262.4	525.5	303.9	829.4	1097.4
Untreated check	8.1	328.2	541.4	251.3	792.7	1129.0
LSD (0.05)	NS	NS	NS	124.4	NS	NS

Iris yellow spot virus evaluations were made during the first week of August. There was a trend for higher disease ratings with higher thrips populations (Fig. 4), but neither thrips pressure nor disease severity had any effect on total yield.

Carzol SP Rotation Trial

The weekly thrips counts are listed in Table 3, and the season total is shown graphically in Figure 5.

Treatments 1, 4, and 17 had significantly more thrips than the other treatments, with treatment 17 having significantly more thrips than treatments 1 or 4. Treatment 1 is the untreated check, and treatment 4 is an untreated check except for the seed-coat application of Regent®. Treatment 17 is a synthetic pyrethroid (Warrior®)-only treatment and illustrates the problem of thrips resistance to this class of insecticides in the Treasure Valley. Synthetic pyrethroid insecticides are not selective and are more harmful to beneficial insect populations than are other insecticides. This treatment had the lowest total yield of any of the treatments (Table 4). As a comparison, treatment 15 is weekly Lannate® applications, and treatment 16 is a combination of Lannate and Warrior. The addition of the synthetic pyrethroid did not improve thrips control over Lannate alone, and tended to decrease supercolossal and total yield (Fig. 6).

Table 3. Average weekly thrips counts on onions during the 2007 growing season, Malheur Experiment Station, Oregon State University, Ontario, OR. 2007.

Treatment	21-May	1-Jun	7-Jun	12-Jun	18-Jun	22-Jun	26-Jun	2-Jul	10-Jul	16-Jul	23-Jul	1-Aug
	Average thrips/plant											
1	0.3	18.1	39.7	22.8	31.9	15.2	30.9	37.3	10.5	30.8	9.8	27.4
2	0.7	3.1	14.5	14.1	17.8	15.0	23.6	11.4	18.9	16.0	9.2	17.5
3	0.5	3.1	15.2	6.7	14.8	5.0	8.7	7.7	10.1	14.5	10.6	10.2
4	0.5	10.5	25.0	15.4	32.4	14.6	28.3	30.6	16.2	38.0	9.3	28.2
5	0.5	4.8	20.4	10.0	13.9	6.1	13.9	9.6	12.4	13.3	14.5	12.3
6	0.3	7.5	35.7	10.2	13.3	4.6	7.9	9.7	16.7	15.7	11.6	12.5
7	0.5	6.7	21.8	8.8	17.3	4.7	10.6	11.1	8.5	11.2	9.4	10.3
8	0.6	6.0	17.5	9.8	15.7	5.5	11.1	3.6	8.9	11.3	11.6	8.7
9	0.4	6.7	20.3	11.9	15.9	6.2	13.6	7.6	10.8	9.3	12.1	10.3
10	0.9	6.1	22.4	11.6	15.8	5.3	7.3	5.7	10.7	12.0	12.8	8.9
11	0.7	6.2	15.6	12.4	14.1	4.4	9.3	4.4	5.5	13.1	13.5	8.1
12	0.4	7.7	23.8	15.7	28.4	3.2	11.8	5.0	8.2	13.2	12.6	9.5
13	0.6	4.3	17.9	13.2	19.1	4.1	9.4	10.1	12.5	8.4	10.9	10.1
14	0.3	3.3	20.8	12.9	17.5	5.5	5.4	3.6	5.5	10.4	10.2	6.2
15	0.7	1.8	12.0	10.0	14.4	3.8	7.0	8.5	16.4	12.7	17.8	11.1
16	0.6	3.1	12.0	11.3	11.1	4.7	7.4	8.7	16.9	15.6	14.3	12.1
17	0.9	3.5	25.3	15.3	33.1	19.3	34.4	76.9	40.7	58.0	17.7	52.5
18	0.6	2.5	12.9	12.8	16.2	3.4	6.5	7.2	16.0	14.5	10.8	11.1
LSD (0.05)	NS	5.5	9.4	5.3	6.9	3.5	11.6	22.5	12.2	12.8	6.4	NS

Regent was applied to the onion seed coat of treatments 4, 7, 8, and 9, with non-Regent treatments 1, 5, 11, and 13, respectively, as a comparison (Fig. 7). In addition, treatment 9 had straw applied as a mulch on June 15, at a rate of about 1,000 lb/acre. The Regent treatments had higher yields than the nontreated in 3 of the 4 treatments, but it was only significant in treatment 8 versus treatment 11, which was the grower standard treatment. The Regent treatments were made with seed treated in the spring of 2006, and may have lost some of its effectiveness during storage. The Regent plus straw mulch was not better than the comparison treatment (treatment 13).

Treatment 2 had 4 8-oz treatments of Carzol SP applied at 2-week intervals. It had significantly higher average thrips numbers compared to the best treatments, but provided high total yield in spite of the high thrips counts (Table 4). These data suggest that 3 8-oz applications (legal application rate of Carzol SP is 24 oz/acre under 2006 and 2007 Section 18 emergency registrations) might be better than the single 20-oz application that growers are currently using. They should be integrated into the grower standard practice of using spinosad insecticides (Success, Radiant) early, followed by Carzol SP, then finish the season with Lannate.

There was no relationship between average thrips population and IYSV disease incidence (Fig. 8), or between thrips population and total yield (Fig. 9). However, there was a good correlation between disease incidence and total yield (Fig. 10).

Table 4. Carzol SP rotation trial on onion yield, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Medium	Jumbo	Colossal	Super-colossal	Colossal + Supercol.	Total yield
	------------------------		-cwt/acre -		------------------------	
1	9.7	291.5	612.5	295.7	908.2	1209.4
2	12.3	305.3	629.2	357.4	986.6	1304.3
3	14.3	359.9	553.8	192.3	746.1	1120.3
4	28.0	680.8	481.5	76.7	558.2	1267.0
5	13.9	341.0	523.9	205.3	729.2	1084.1
6	5.9	351.8	521.4	152.6	674.0	1031.7
7	26.3	555.2	503.0	62.7	565.7	1147.3
8	32.3	609.9	543.7	142.3	686.1	1328.3
9	29.3	512.3	478.4	162.7	641.1	1182.8
10	6.0	374.6	554.8	261.6	816.4	1197.0
11	10.7	311.9	516.2	309.4	825.6	1148.2
12	13.0	394.7	558.3	221.2	779.4	1187.1
13	14.1	349.3	555.9	299.4	855.3	1218.8
14	19.1	367.5	492.2	380.1	872.3	1259.0
15	8.9	320.5	565.5	281.9	847.4	1176.9
16	13.8	375.9	587.1	154.2	741.3	1131.0
17	20.1	588.7	374.0	48.3	422.3	1031.2
18	5.0	337.7	500.5	293.3	793.8	1136.5
LSD (0.05)	12.7	119.4	N.S.	103.6	180.3	152.4

Conclusion

Carzol SP Rate and Spray Interval Trial

The results from 2007 were similar to those from 2006, and show that shorter spray intervals (7-14 days) are more important to both thrips control and yield than longer spray intervals. Rate was also important, but not as important as application interval.

Carzol SP Rotation Trial

Synthetic pyrethroid effect varied, depending on treatment, from no effect, to significantly less thrips control and lower yields. Growers are urged not to add this class of insecticides to their tank mixes unless they know they have had positive experiences with them on their farm.

Regent did not perform as well in 2007 as in 2006. This may be due to the use of seed treated for the 2006 crop. There was still a positive effect on yield in most of the treatments.

Multiple applications of Carzol SP at the 8-oz rate appear better than a single 20-oz application.

With Joaquin, there was no relationship between total yield and either thrips or IYSV, but there was with Charismatic, indicating that Joaquin may have more resistance to thrips, IYSV, or both.

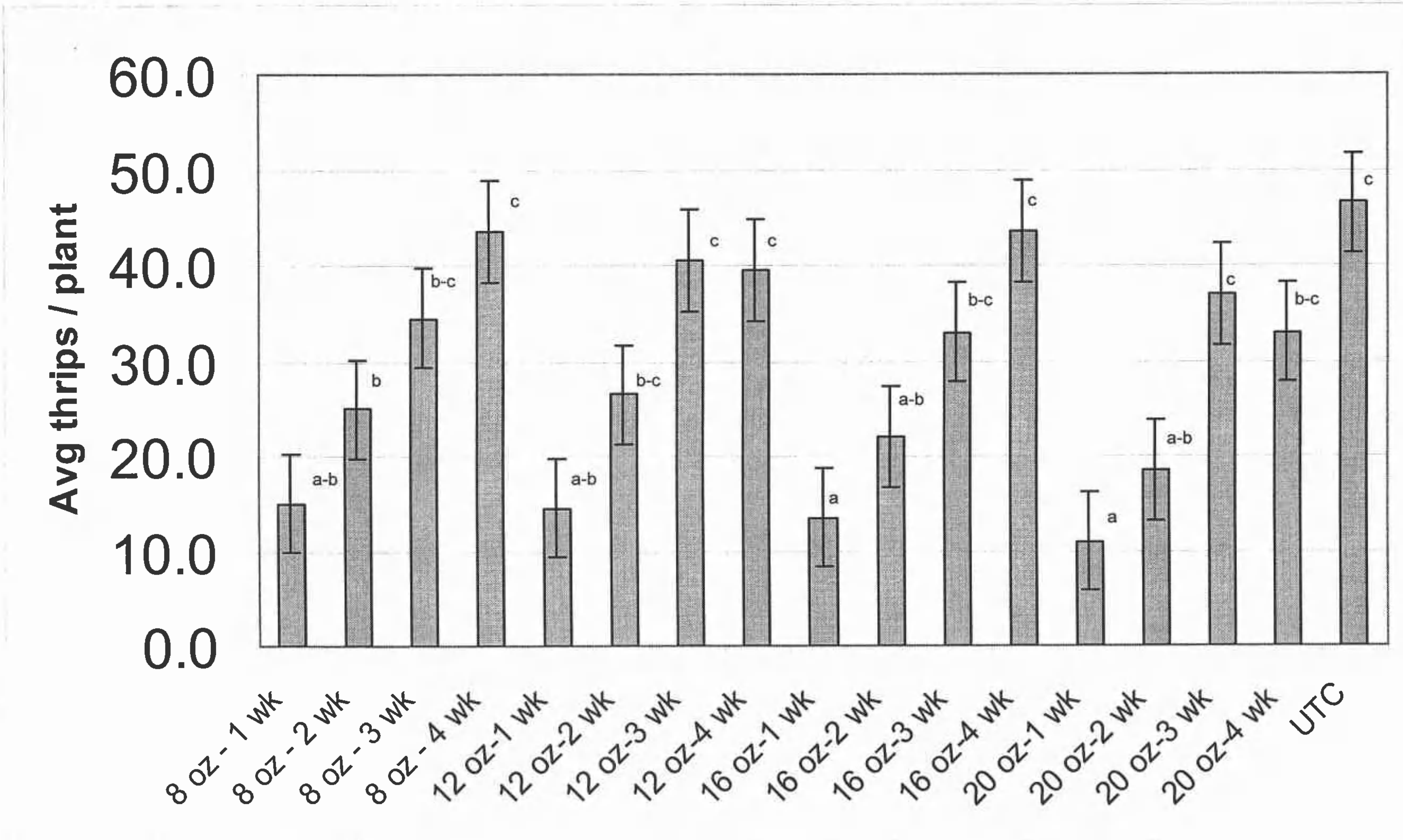


Figure 1. Carzol SP rate and spray interval trial in onions. Average season-long thrips populations at different Carzol rates and spray intervals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

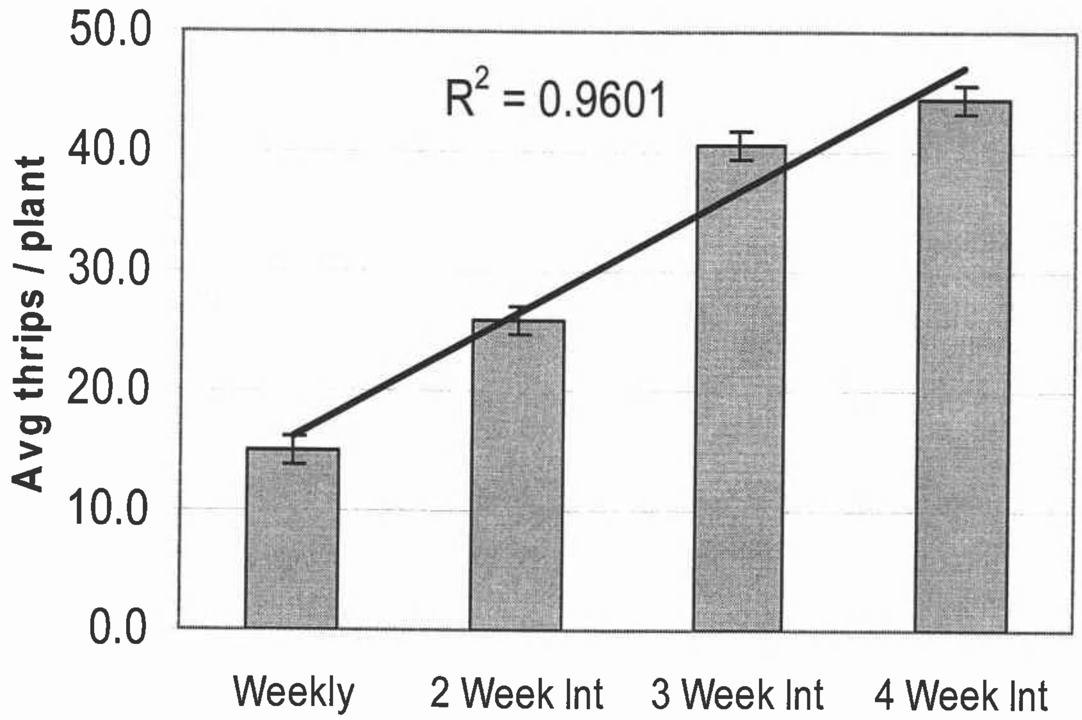


Figure 2. Carzol SP rate and spray interval trial in onions. Average season-long thrips populations with different spray intervals using the insecticide Carzol, averaged over the 8-, 12-, 16- and 20-oz rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

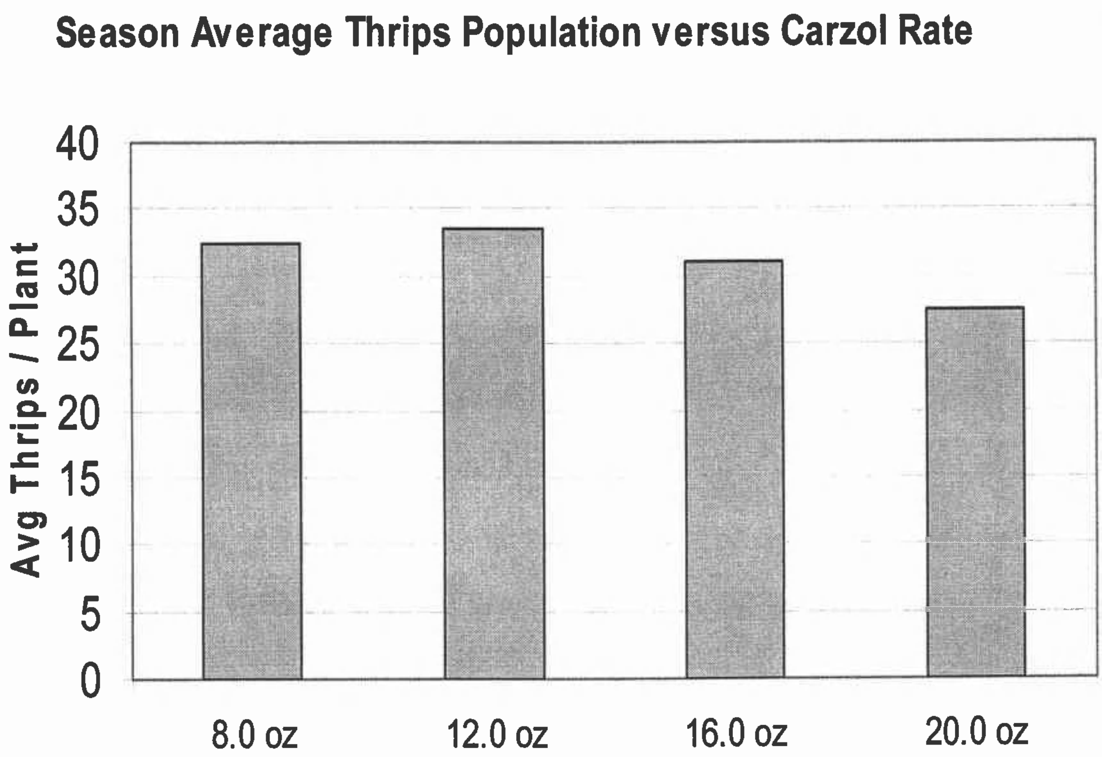


Figure 3. Carzol SP rate and spray interval trial in onions. Average season-long thrips populations at different Carzol application rates, averaging 1-, 2-, 3- and 4-week timing sequences, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

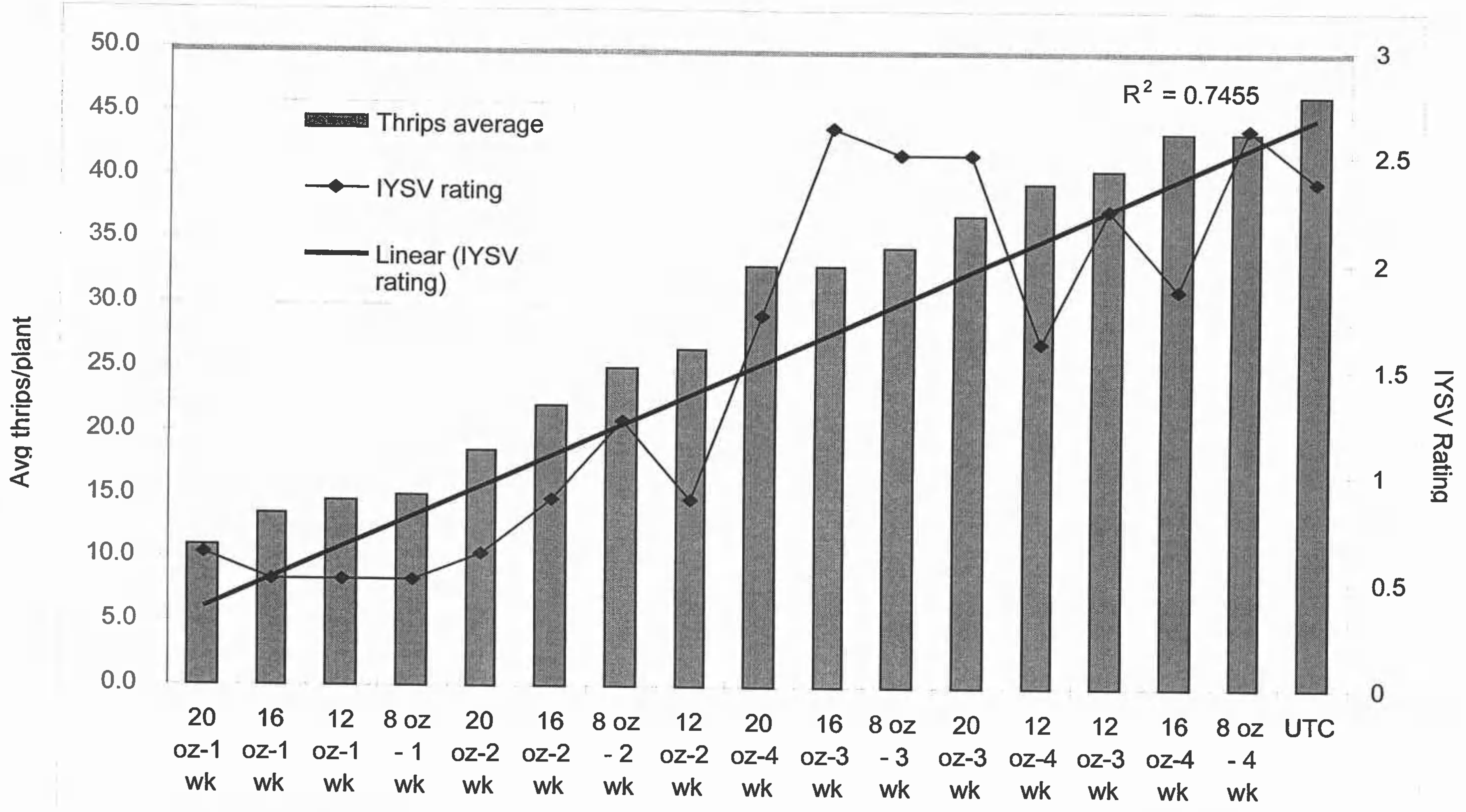


Figure 4. Carzol SP rate and spray interval trial in onions. Average seasonal thrips population relationship to iris yellow spot virus evaluation (0 = no damage, 5 = dead plant), Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

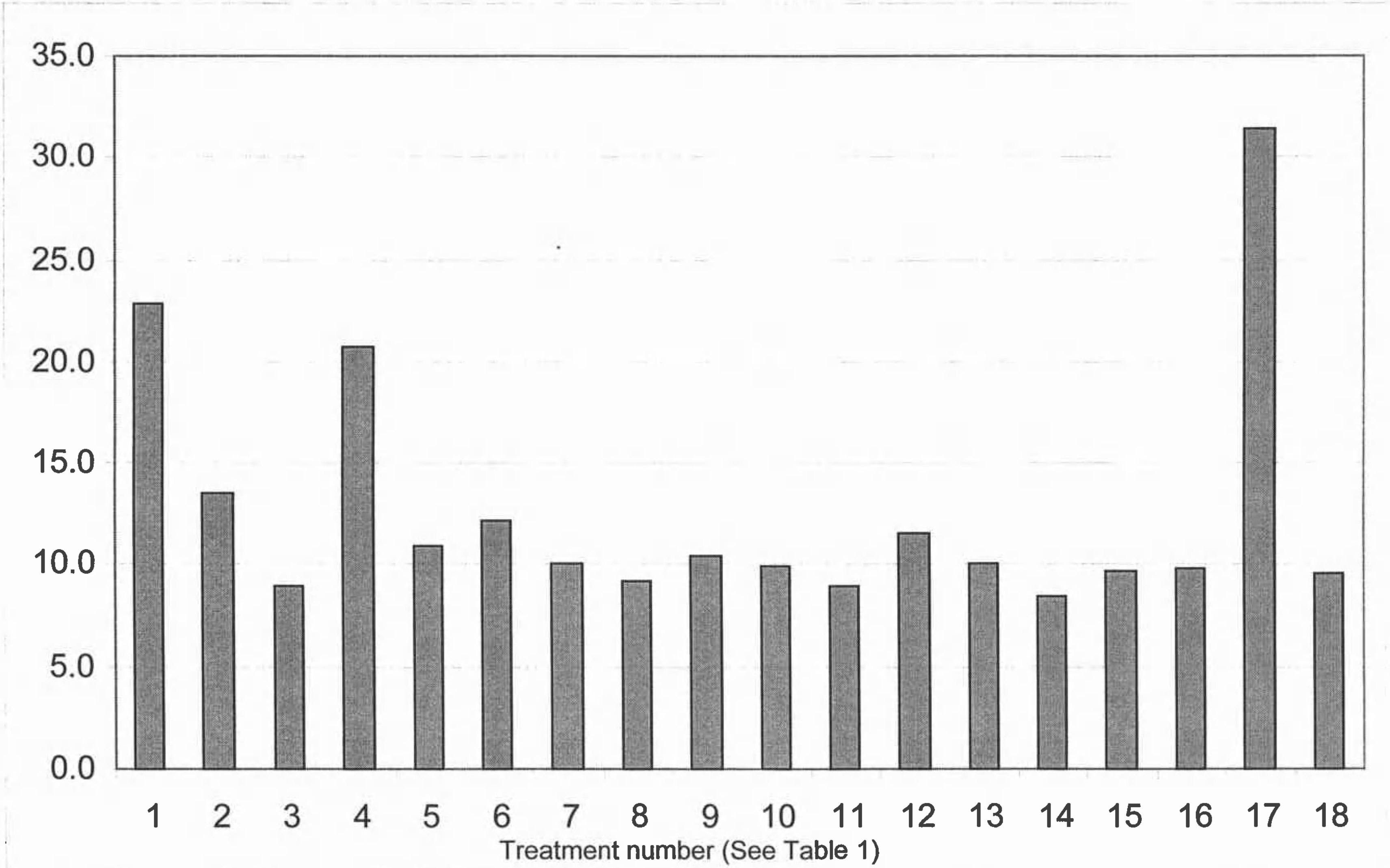


Figure 5. Carzol SP rotation trial in onions; seasonal thrips populations during the 2007 growing season, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

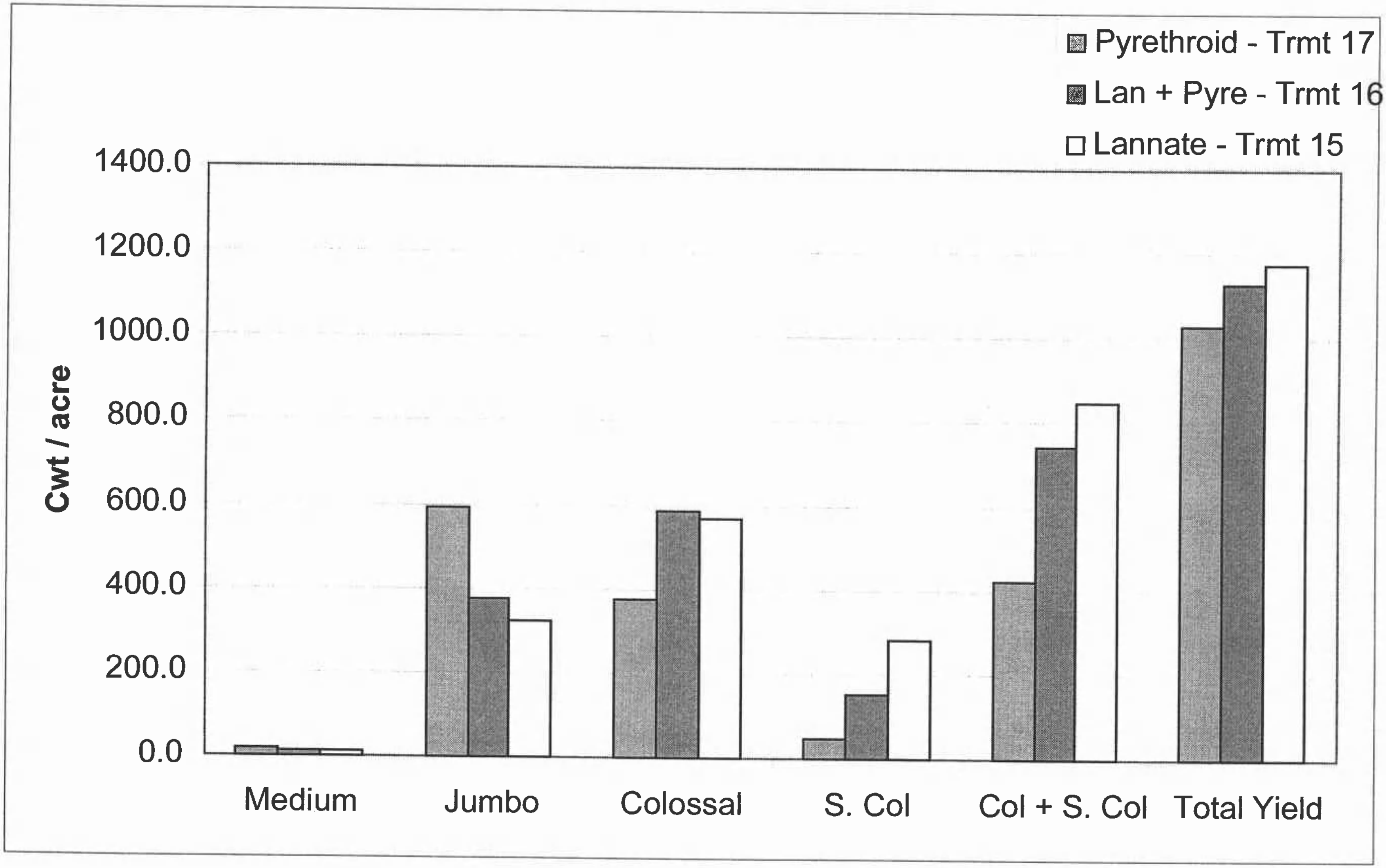


Figure 6. Carzol SP rotation trial: pyrethroid impact on onion yield, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

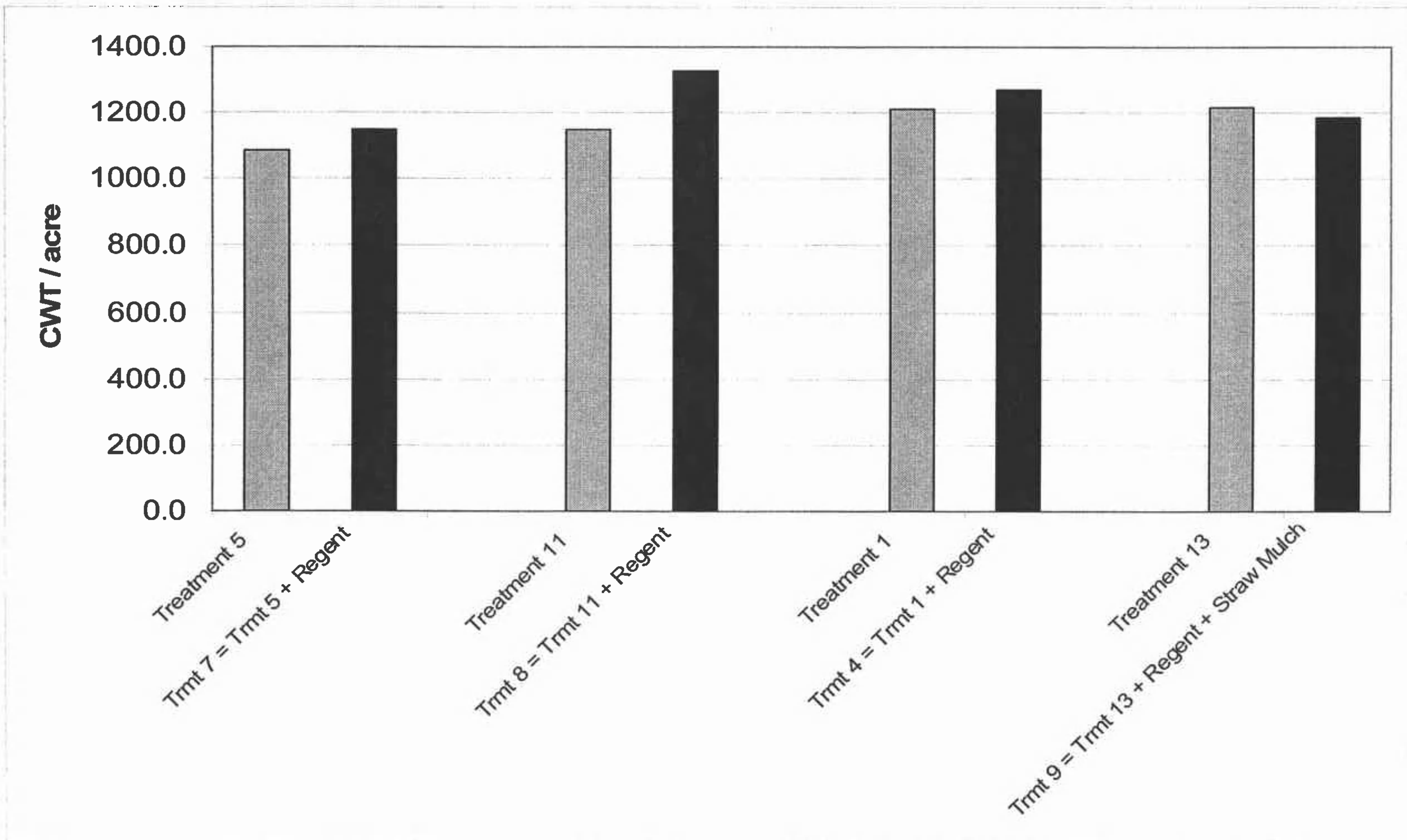


Figure 7. Carzol SP rotation trial: the effect of Regent insecticide treatments on total onion yield, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

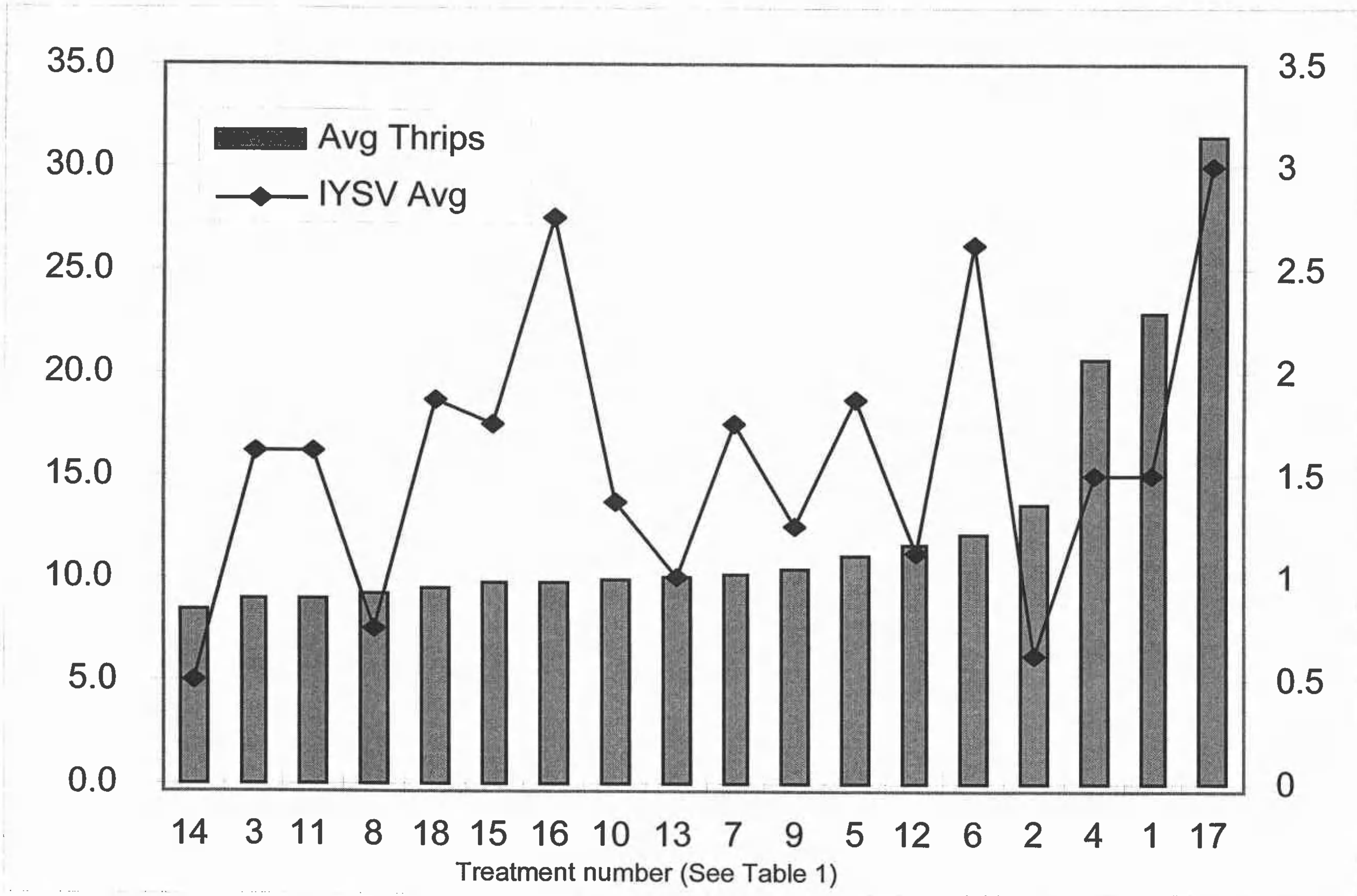


Figure 8. Carzol SP rotation trial in onions: a comparison of the relationship of seasonal thrips population to iris yellow spot virus disease incidence (0 = no damage, 5 = dead plants), Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

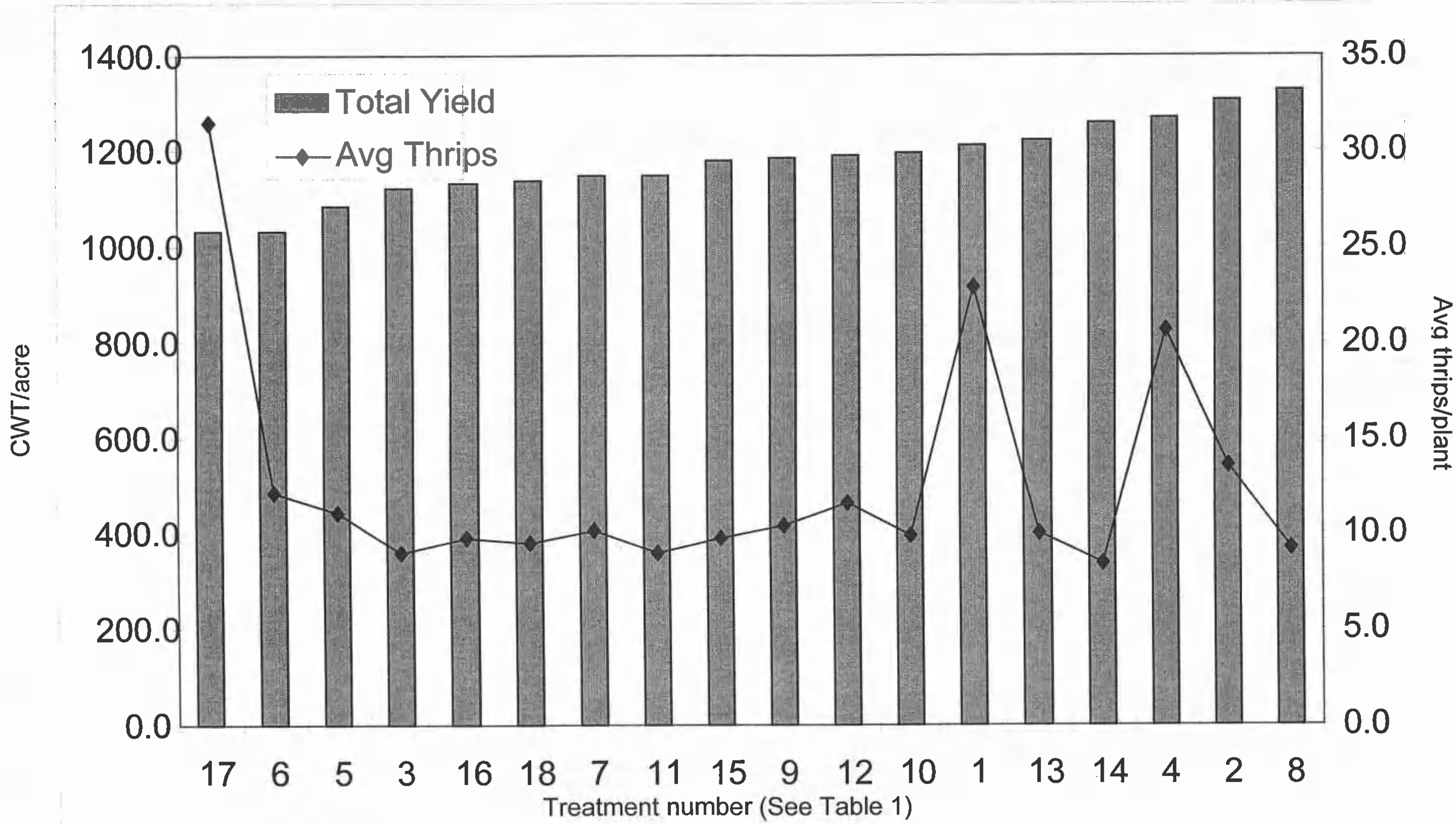


Figure 9. Carzol SP rotation trial: average thrips population compared to total onion yield, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

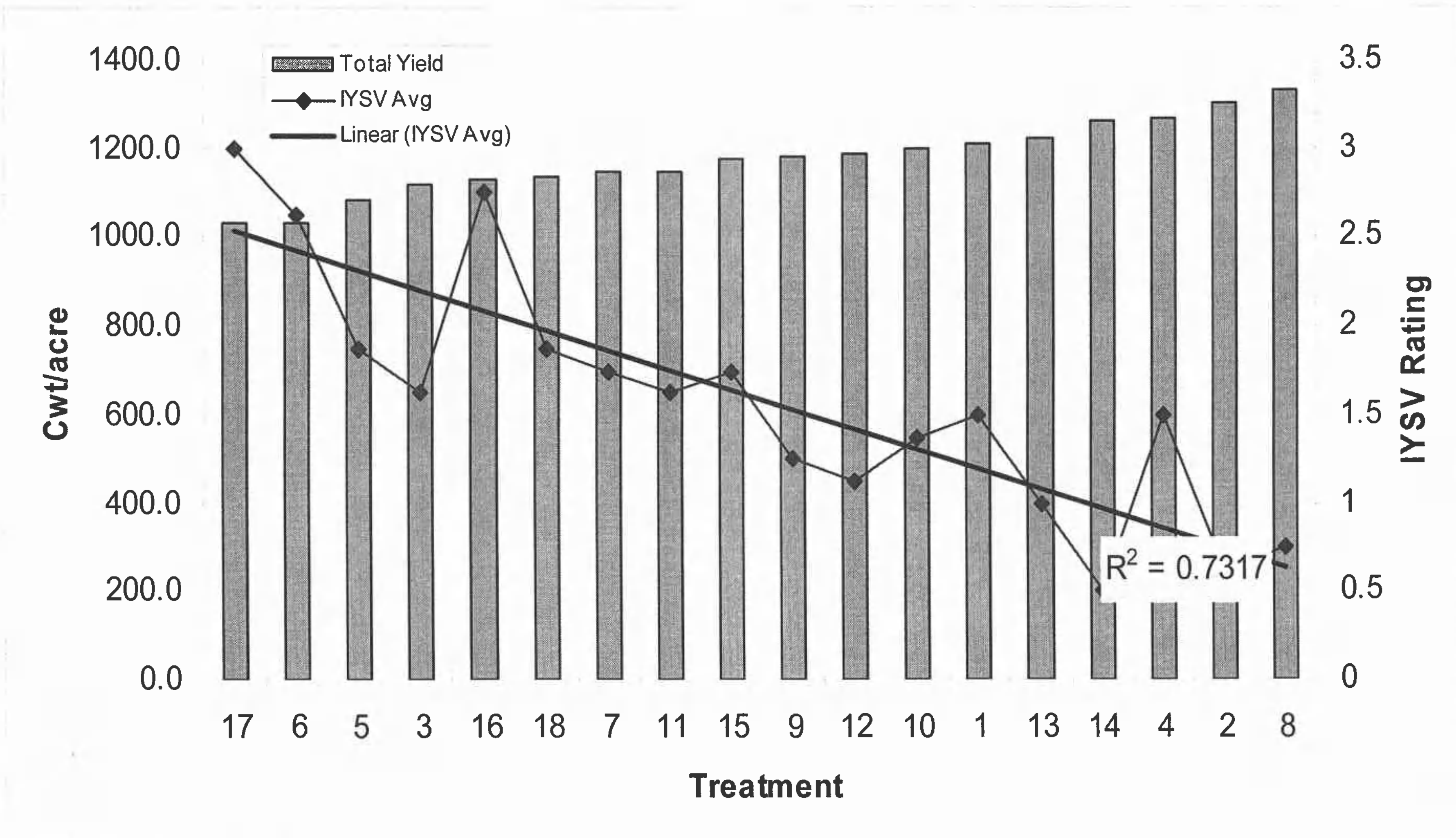


Figure 10. Carzol SP rotation trial: relationship between total onion yield and iris yellow spot disease severity (0 = no damage, 5 = dead plant), Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

ONION PRODUCTION SURVEY
FOR MALHEUR COUNTY, OREGON AND IDAHO - 2008

Lynn Jensen
Malheur County Extension Service
Oregon State University
Ontario, OR

Introduction

Growers in Malheur County, Oregon, and Idaho were surveyed regarding onion production. Resources were not available to survey growers for production practices on all crops, so onion was chosen as most representative of Malheur County agriculture. Previous studies identified onion production as one of the primary sources of nitrate and Dacthal (DCPA metabolite) movement into groundwater in Malheur County. Dacthal herbicide has since been replaced with an herbicide less likely to move through the soil profile into ground water. However, the question to be answered was whether growers have been able to better utilize nitrogen.

Results

All surveyed growers in Malheur County and most growers in Idaho were using soil testing to determine residual levels of nitrogen prior to planting onion (Table 1). This is up from 62 percent in 1989. The percent of growers using tissue (root) testing for nitrogen management during the growing season remained constant, but there was a trend for growers who are new to onion production to use the technique more than growers with a long history of onion production (Fig. 1).

Table 1. Onion crop survey for Malheur County, Oregon, and Idaho, February 2008, compared to 1989 Malheur County survey.

Survey area	Malheur Co.	Idaho	Malheur Co. 1989
Onion acreage represented	3,328	3,001	4,167
Average onion yield	789 cwt	783 cwt	621 cwt
Average number of years growing onions	28.7	26.8	25.8
Average onion acreage/grower	128	150	93
% of growers soil testing	100%	95.5%	62%
% of growers using tissue testing	34.6%	22.7%	33%
Number of insecticide applications for thrips/year	5.5	5.5	3.6
Number of fungicide applications/year	3.3	3.4	3.6

Fall-applied nitrogen was down by 17 percent in 2007 compared with1989 (Table 2). The number of side-dress nitrogen applications has increased in Oregon from 1.6 to 2.25 times as growers distribute nitrogen more uniformly throughout the growing season. The average amount of nitrogen applied at each side-dressing application has been reduced from 116 lbs N/acre in 1989 to 78 lbs N/acre in 2007. The total amount of applied nitrogen is 9.5 percent lower in 2007 vs. 1989, from 284 lbs N/acre to 257 lbs N/acre.

Table 2. Nitrogen use in furrow-irrigated onions for Malheur County, Oregon, and Idaho, February 2008, compared to 1989 Malheur County survey.

	Malheur Co.	Idaho	Malheur Co. 1989
Average onion yield (furrow)	769 cwt	782 cwt	621 cwt
Fall applied N (lb/acre)	81	105	98
Number of sidedress applications	2.25	1.6	1.6
Pounds N applied/sidedress application	78	97	116
Total sidedressed N	176	155	186
Total applied N	257	260	284

In addition, about 20 percent of the onion acreage in 2007 is irrigated by drip rather than the conventional furrow irrigation used by all growers in 1989 (Table 3). This system uses less water and other inputs. Growers using drip irrigation reported using 175 lbs N/acre versus furrow irrigators who were using 257 lbs N/acre.

Table 3. Nitrogen use in drip-irrigated onions for Malheur County, Oregon, and Idaho, February 2008.

	Malheur Co.	Idaho
Average onion yield (drip)	814 cwt	788 cwt
Fall applied N (lb/acre)	40	70
Number of N applications through system	9	9
Average pounds N injected/application	15	9.4
Total N applied through drip system	135	85
Total applied N	175	162

Onion productivity per applied N was 307 lbs of onions/lb of N for furrow-irrigated onion and 465 lbs of onions/lb of N for drip-irrigated onion (Table 4). This compares to 219 lbs of onions/lb of N in 1989. If nitrogen use on the drip-irrigated acreage in Malheur County is factored into overall nitrogen use, then total nitrogen use for onion production is reduced to 240.6 lbs N/acre. This is a 15 percent reduction in nitrogen use for onion growers in Malheur County. Growers using drip irrigation applied nitrogen 9 times through their drip system compared to 2.25 times as sidedressed nitrogen under furrow irrigation practices. The number of insecticide applications increased from 3.6 to 5.5, due to increased resistance to insecticide.

Table 4. N use efficiency of furrow- versus drip-irrigated onion production for Malheur County, Oregon, and Idaho, February 2008, compared to 1989 survey.

	Malheur Co.	Idaho	Malheur Co. 1989
Yield (cwt) – furrow	789	783	921
Total applied N – furrow	257	260	284
Yield (lbs onions/lb applied N)	307	301	219
Yield (cwt) – drip	814	788	-
Total applied N – drip	175	162	-
Yield (lbs onions/applied N)	465	486	-

Conclusions

The results of this survey suggest that while nitrogen use has decreased slightly (15%), nitrogen efficiency has increased dramatically from 219 lbs onions/lb of N to 307 lbs onions/lb of N for furrow-irrigated onions. It is even better for onions grown under drip irrigation. Some of this increase is probably due to higher yielding onion varieties, but some is due to better irrigation and nitrogen use practices.

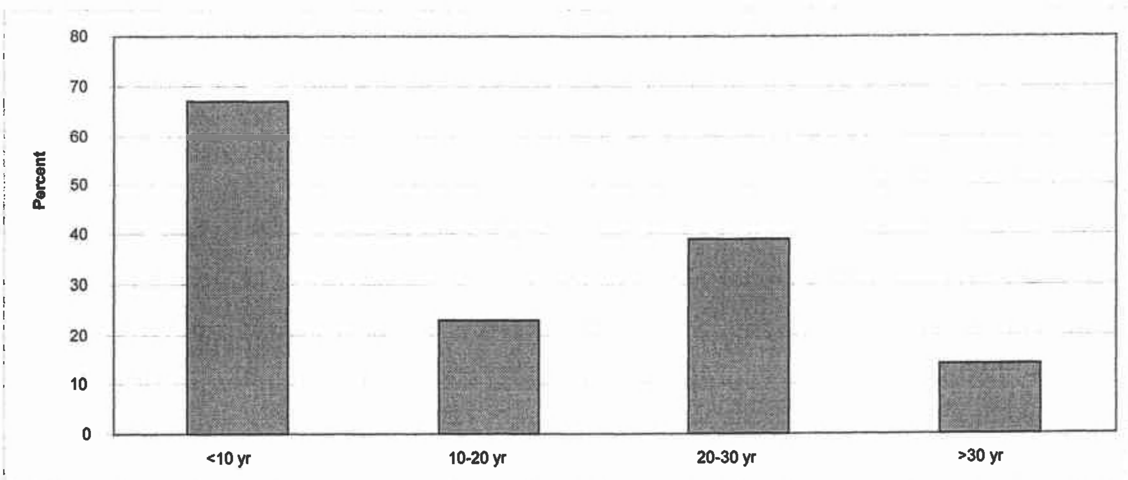


Figure 1. Percent of growers using tissue testing on onions, arranged by number of years they have produced onions in Malheur County, Oregon, and Idaho, 2008.

EVALUATION OF BASAGRAN® HERBICIDE FOR YELLOW NUTSEDGE CONTROL IN BULB ONION

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR 2007

Introduction

Yellow nutsedge continues to present a challenge to onion growers in the Treasure Valley of eastern Oregon. The herbicides registered for use in onion production that have activity on yellow nutsedge include Outlook®, Dual Magnum®, and Nortron®. This necessitates testing of other products that are known to control yellow nutsedge in other crops. Basagran® is a foliar-applied herbicide marketed by Arysta LifeScience Corp. and has been identified by several researchers as a candidate for use on onions to control yellow nutsedge if and when a label is granted by the Environmental Protection Agency. ***It is important to recognize that these tests are experimental only, and the use of Basagran in onion production is NOT recommended by researchers or its manufacturer.*** This study was part of a multistate effort to test the tolerance of different onion types to Basagran in different environments.

Materials and Methods

The study was laid out in a split-plot design with varieties ('Vaquero' and 'Ranchero') forming the main plots and herbicide treatments (Table 1) as subplots. The soil was conventionally tilled, disked, and 22-inch beds made during fall 2006. Each plot had 4 rows that were 7.33 ft wide and 30 ft long with 4 replications. Onions were seeded using a double row planter with 3.93-inch spacing within the row. Lorsban® 15G was applied immediately after planting at 3.7 oz/1,000 ft of row. Furrow irrigation began on April 2, 2007 and continued as needed based on soil moisture content. Prior to onion emergence, Roundup Original® Max was applied at 1 pt/acre on the entire study area to control emerged weeds.

Treatments including Prowl® H2O were applied on April 11, 2007 using a pressurized CO_2 sprayer. Treatments including Surround crop protectant were applied on April 30, 2007. Basagran was applied post-emergence (POST) at different timings starting when onions were at the two-leaf stage. Basagran application timing was as follows: POST 1 = onions at 2-leaf stage; POST 2 = onions at 3-leaf stage; POST 3 = 2 weeks after POST 2; POST 4 = 2 weeks after POST 3; and POST 5 = 2 weeks after POST 4. Treatments were applied with and without crop oil at 1 percent V/V.

Onions were sprayed for thrips and general insect control starting May 15 and continuing until July 16, 2007. Onion tops and weeds were flailed on September 7 and the two center rows in each plot were lifted later that day. Onions were harvested on September 12 and graded using standard categories; small (<2.25 inches diameter), medium (2.25 to 3 inches), jumbo (3 to 4 inches), colossal (4 to 4.25 inches), and supercolossal (>4.25 inches in diameter). Evaluation for single centers was done on September 21-24 on 20 onions from each plot.

Results and Discussion

Onion varieties responded similarly to herbicide treatments and therefore only averages for the two varieties are presented. No injury was observed on onions treated with Basagran at 0.5 pt/acre alone. However, addition of crop oil concentrate (COC) at 1 percent V/V resulted in 6 percent crop injury that was still visible 14 days after application. Evaluations done 24 days later indicated that injury had subsided and did not reduce marketable yield (Tables 1 and 2). Similarly, application of Basagran at 1 pt/acre plus COC starting when onions were at the 3-leaf stage and followed by 2 sequential applications every 2 weeks resulted in 11 percent onion injury that reduced marketable onion yield by 13 percent. When Basagran at 1 pt/acre was applied alone on onions bigger than the 3-leaf stage, the injury was as high as 20 percent and the yield was reduced by 16 percent. The greatest onion injury (26 and 36 percent with and without COC, respectively) was observed when Basagran was applied at 2 pt/acre starting when onions were at the 3-leaf stage followed by 2 sequential applications every 2 weeks thereafter. Marketable onion yield reduction was 21 and 28 percent when Basagran was applied at 2 pt/acre with and without COC, respectively, compared to the standard herbicides (treatment 2). Results indicate that a significantly high level of onion injury by Basagran was possibly exacerbated by the addition of COC. Tests will continue to identify safe rates and possible mixing adjuvants.

Table 1. Response of dry bulb onion (var. Ranchero and Vaquero) to Basagran herbicide application timing on June 25 and July 2, 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Rate/acre	Timing[a]	Crop injury on 6/25/07 17 days after 1st application	Crop injury 7/2/07 24 days after 1st application
			%	%
Untreated			0	0
Prowl H2O	2 pt	PRE	0	0
Buctril 4EC	21.3 fl oz	POST 1		
Goal 2XL	2 pt	POST 1		
Buctril 4EC	2 pt	POST 2		
Goal 2XL	0.5 pt	POST 2		
Goal 2XL	1 pt	5 Leaf		
Basagran	0.5 pt	POST 1; 2; 3	0	0
Basagran	0.5 pt	POST 2; 3; 4	6	1
COC	1% V/V			
Basagran	1 pt	POST 2; 3; 4	5	1
Basagran	1 pt	POST 2; 3; 4	11	1
COC	1% V/V			
Basagran	2 pt	POST 2; 3; 4	26	5
Basagran	2 pt	POST 2; 3; 4	36	6
COC	1% V/V			
Basagran	1 pt	POST 1; 2; 3	4	1
GoalTender	0.126 pt	POST 1; 3		
Basagran	1 pt	POST 2; 4	19	3
GoalTender	0.126 pt	POST 1; 2; 4		
NIS	0.25% V/V			
Buctril	0.5 pt	1st leaf	0	0
Surround	12.5 lb			
Buctril	1 pt	1st leaf	1	0
Surround	25 pt			
LSD P ≤ 0.05			6.8	1.3

[a]Herbicide application timing: PRE = Preemergence; POST 1 = Onion at 2-leaf stage; POST 2 = Onions at 3-leaf stage; POST 3 = 2 weeks after POST 2; POST 4 = 2 weeks after POST 3; POST 5 = 2 weeks after POST 4

Table 2. Dry bulb onion (var. Ranchero and Vaquero) yield in response to Basagran herbicide application, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety comparison across herbicides			Small <2.25"	Medium 2.25-3"	Jumbo 3-4"	Colossal 4-4.25	S. Col. >4.25"	Marketable
			Yield (cwt/acre)					
Ranchero			4.1	16.4	508.2	536.0	233.4	1294.0
Vaquero			4.0	20.1	626.5	415.1	114.1	1175.8
			NS	NS	NS	NS	NS	NS
Comparison across varieties								
Treatment	Rate/acre	Timing[a]						
Untreated			0.0	0.0	0.0	0.0	0.0	0.0
Prowl H2O	2 pt	PRE	4.1	17.2	571.3	635.6	294.2	1518.2
Buctril 4EC	21.3 fl oz	POST 1						
Goal 2XL	2 pt	POST 1						
Buctril 4EC	2 pt	POST 2						
Goal 2XL	0.5 pt	POST 2						
Goal 2XL	1 pt	5 Leaf						
Basagran	0.5 pt	POST 1; 2; 3	5.4	26.1	645.3	509.4	195.2	1376.1
Basagran	0.5 pt	POST 2; 3; 4	3.9	17.6	616.5	585.2	215.5	1434.9
COC	1% V/V							
Basagran	1 pt	POST 2; 3; 4	4.6	12.8	566.3	548.0	196.1	1323.2
Basagran	1 pt	POST 2; 3; 4	3.4	20.4	720.4	479.2	101.8	1321.8
COC	1% V/V							
Basagran	2 pt	POST 2; 3; 4	1.5	12.8	609.6	449.5	122.9	1194.9
Basagran	2 pt	POST 2; 3; 4	10.1	36.4	660.9	321.8	70.2	1089.3
COC	1% V/V							
Basagran	1 pt	POST 1; 2; 3	3.4	18.2	657.1	573.9	186.5	1435.8
GoalTender	0.126 pt	POST 1; 3						
Basagran	1 pt	POST 2; 4	7.1	26.0	628.4	464.3	157.0	1275.7
GoalTender	0.126 pt	POST 1; 2; 4						
NIS	0.25% V/V							
Buctril	0.5 pt	1st leaf	1.8	15.4	546.0	577.2	270.5	1409.2
Surround	12.5 lb							
Buctril	1 pt	1st leaf	3.3	16.1	586.5	562.5	275.0	1440.2
Surround	25 pt							
Least Significant Difference P = 0.05			3.7	13.0	93.8	103.8	71.5	119.7

[a]Herbicide application timing: PRE = Preemergence; POST 1 = Onion at 2-leaf stage; POST 2 = Onions at 3-leaf stage; POST 3 = 2 weeks after POST 2; POST 4 = 2 weeks after POST 3; POST 5 = 2 weeks after POST 4.

LONG TERM STORAGE OF ONION CULTIVARS
2007 REPORT

Mike Thornton and Deron Beck
University of Idaho

Clinton Shock
Oregon State University

Bob Simerly, McCain Foods

Background

The Treasure Valley of western Idaho and eastern Oregon supplies approximately 40 percent of the winter storage onions in the U.S. Processing accounts for a significant portion of crop usage. Extending the current storage season beyond May would increase the amount of locally produced onions that could be grown for processing. However, there is currently no information available on onion cultivars that have resistance to common onion decay pathogens over extended storage and thus potential for extended storage life. This study evaluated several new onion cultivars and pre-commercial varieties under cold storage conditions to see if they could be kept until mid-July.

Methods

Onion bulbs of thirteen yellow onion cultivars and pre-commercial varieties were collected from research trials and grower fields. Where enough bulbs were available, the samples were split into 3 fifty pound replicates. However, for several lines there was insufficient material, so only a single 50 lb sample was collected. Because these samples were collected from different locations, and may have been handled differently in terms of cultural practices, sprout inhibitor application, maturity, etc., it is important to note that the results of these storage evaluations may have been influenced by factors other than variety resistance to storage decay. The onions were brought to the Parma Research and Education Center after they were cured in a commercial storage. All of the samples were placed in a small controlled temperature room on March 6, 2007 and held at 36°F. Hobo recorders placed in the room indicated that temperatures fluctuated by no more than ½ degree, while relative humidity fluctuated between 70 and 90 percent. At no time was free moisture observed on the onions.

On June 12, June 29 and July 13 the samples were removed from storage and evaluated for external defects and sprouting. If a bulb had both sprouting and decay, it was scored for decay. Bulbs that were sprouted, but not decayed were considered usable. At the final sample date, all bulbs were sliced diagonally to detect internal decay. External decay was scored as "usable" if it only affected the outer rings that would normally be removed during processing. Bulbs scored as unusable had external decay that was too extensive to be removed during processing.

Data for the replicated samples were analyzed by ANOVA using the SAS statistical program. When the F-test was significant, means were separated using an LSD at the 5 percent level.

Results

There were significant differences in the level of usable decay, unusable decay and sprouting on both evaluation dates during June (Table 1). 'Vaquero', the current industry standard cultivar, was low to intermediate in terms of the proportion of unblemished bulbs. Cultivars such as 'Crocket', 'Grand Coulee', and 'Sabroso' had significantly more good bulbs by June 29th compared to Vaquero. 'RTC1462' stored best in the un-replicated evaluations.

Table 1. Incidence of external decay and sprouting of 13 yellow onion cultivars and non-commercial varieties on June 12 and June 29 after long term cold storage.

	12-Jun					29-Jun				
Onion Variety	% usable decay	% unusable decay	% good bulbs	% totals	% of total sprouted	% usable decay	% unusable decay	% good bulbs	% totals	% of total sprouted
Replicated										
EX16035	5.2	24.5	70.3	100	10.7	14.0	28.1	57.9	100	11.3
Joaquin	2.4	11.7	86.0	100	6.3	4.7	19.4	75.8	100	13.3
Monarchos	4.5	12.6	82.9	100	4.2	13.5	20.9	65.6	100	11.4
Sabroso	3.3	1.3	95.4	100	0.0	4.6	2.6	92.8	100	0.0
Ranchero	16.8	21.3	61.5	100	2.0	24.9	25.3	49.8	100	2.8
Granero	8.3	19.2	72.4	100	0.9	13.0	24.8	62.2	100	3.2
Vaquero	15.0	20.7	64.3	100	0.9	14.1	31.0	54.9	100	0.9
Crocket	0.0	0.0	100.0	100	0.0	0.0	0.0	100.0	100	0.0
Grand Coulee	0.0	2.1	97.9	100	0.0	4.2	1.0	94.8	100	0.0
LSD	**4.8**	**7.6**	**8.6**		**NS**	**7.7**	**10.7**	**14.8**		**9.3**
Non-replicated										
GC6603	3.2	38.7	58.1	100	32.3	12.9	58.1	29.0	100	51.6
RTC1462	0.0	0.0	100.0	100	0.0	0.0	0.0	100.0	100	0.0
Sedona	5.7	25.7	68.6	100	5.7	20.0	25.7	54.3	100	2.9
Evolution	0.0	0.0	100	100	0.0	16.7	0.0	83.3	100	0.0

By the final evaluation on July 13th, most of the onion cultivars and non-commercial varieties in this study had dropped below 50 percent unblemished bulbs (Table 2). Internal and external decay was present at high levels in most onion genotypes evaluated. However, Crocket, Grand Coulee, Sabroso and RTC1462 continued to store very well, and had a very high proportion of good bulbs.

Table 2. Incidence of internal and external decay and sprouting of 13 yellow onion cultivars and non-commercial varieties on July 13 after long term cold storage.

Onion Variety	% usable decay	% unusable decay	% good bulbs	% totals	% of total sprouted	% of total w/ internal decay
Replicated						
EX16035	7.3	60.2	32.5	100	10.2	36.8
Joaquin	7.7	43.5	48.7	100	18.7	10.8
Monarchos	6.3	55.1	38.6	100	10.9	24.1
Sabroso	2.0	15.4	82.7	100	0.0	5.4
Ranchero	12.2	59.1	28.7	100	0.7	25.2
Granero	4.1	60.1	35.8	100	1.8	26.5
Vaquero	9.8	59.1	31.0	100	0.9	25.8
Crocket	0.0	0.0	100	100	0.0	0.0
Grand Coulee	2.1	7.3	90.6	100	1.0	0.0
LSD	**7.4**	**19.1**	**18.1**		**7.6**	**20.2**
Non-replicated						
GC6603	0.0	83.9	16.1	100	19.4	25.8
RTC1462	0.0	0.0	100	100	0.0	0.0
Sedona	17.1	62.9	20	100	2.9	17.1
Evolution	0.0	33.3	66.7	100	0.0	16.7

Summary

The onion cultivars and non-commercial varieties evaluated in this study showed a wide range of storability. In particular, Crocket, Grand Coulee, Sabroso and RTC1462 had exceptional bulb quality out of long term storage. While some of these differences may have been due to handling practices, it appears likely that cultivars with good storage potential are available. Cultivars with good disease resistance could significantly extend the current market season for processing onions in this region.

MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION, 2007 TRIAL

Clinton C. Shock, Erik B. G. Feibert, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR

Summary

Hybrid poplar (cultivar OP-367) was planted for sawlog production in April 1997 at the Malheur Experiment Station. Five irrigation treatments were established in 2000 and were continued through 2007. Irrigation treatments consisted of three treatments using microsprinklers and two using drip tape. The three microsprinkler treatments consisted of one adequately irrigated check (irrigations at 25 cb soil water tension and 2 inches of water per irrigation) and two deficit irrigation treatments (irrigations initiated when the check treatment is irrigated, but with of 1.54 and 0.77 inches applied per irrigation). The two drip-irrigated treatments were irrigated separately at 25 cb soil water tension and 1 and 0.5 inches applied per irrigation. Soil water tension was measured at 8-inch depth. Stem volume in the fall of 2007 and stem volume growth from 2000 through 2007 were highest with drip irrigation applying 1 inch of water per irrigation at a soil water tension of 25 cb.

Introduction

With timber supplies from Pacific Northwest public lands becoming less available, sawmills and timber product companies are searching for alternatives. Hybrid poplar wood has proven to have desirable characteristics for many nonstructural timber products. Growers in Malheur County, Oregon have made experimental plantings of hybrid poplars for saw logs and peeler logs. Clone trials in Malheur County during 1996 demonstrated that the clone OP-367 (hybrid of *Populus deltoides* x *P. nigra*) grew well on alkaline soils. Over the last 10 years OP-367 has continued to grow well on alkaline soils. Some other clones have higher productivity on soils with nearly neutral pH.

Hybrid poplars are known to have high growth rates (Larcher 1969) and water transpiration rates (Zelawski 1973), suggesting that irrigation management is a critical cultural practice. Research at the Malheur Experiment Station during 1997-1999 determined optimum microsprinkler irrigation criteria and water application rates for the first 3 years (Shock et al. 2002). These results showed that tree growth was maximized by irrigating at a soil water tension of 25 cb, but 38 irrigations were required for 3-year-old trees, and more were anticipated for larger trees. To reduce the number of irrigations and simplify operations, we decided to use an irrigation criterion of 50 cb for the fourth year (starting in 2000) with an irrigation rate of 2 inches per irrigation for the microsprinkler and 1.54 inches per irrigation for drip. In 2002 we noticed that the rate of increase in annual tree growth started to decline for all treatments. One of the causes probably was the use of an irrigation criterion of 50 cb. Starting in 2003 the irrigation criterion was changed to 25 cb with irrigation rates of 1 inch per irrigation for microsprinkler and drip irrigation. The objectives of this study were to evaluate poplar water requirements and to compare microsprinkler irrigation to drip irrigation.

Materials and Methods

Establishment

The trial was conducted on a Nyssa-Malheur silt loam (bench soil) with 6 percent slope at the Malheur Experiment Station. The soil had a pH of 8.1 with 0.8 percent organic matter. The field had been planted to wheat for the 2 years prior to poplar and to alfalfa before wheat. In the spring of 1997 the field was marked using a tractor, and a solid-set sprinkler system was installed prior to planting. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14-ft by 14-ft spacing. The sprinkler system applied 1.4 inches on the first irrigation immediately after planting. Thereafter the field was irrigated twice weekly at 0.6 inches per irrigation until May 26. A total of 6.3 inches of water was applied in 9 irrigations from April 25 to May 26, 1997.

In late May 1997, a microsprinkler system (R-5, Nelson Irrigation, Walla Walla, WA) was installed with the risers placed between trees along the tree row at 14-ft spacing. The sprinklers delivered water at 0.14 inches/hour at 25 psi with a radius of 14 ft. The poplar field was used for irrigation management research (Shock et al. 2002) and groundcover research (Feibert et al. 2000) from 1997 through 1999.

Procedures Common to all Treatments

In March 2000 the field was divided into 20 plots, each of which was 6 tree rows wide and 7 trees long. The plots were allocated to five treatments arranged in a randomized complete block design and replicated four times (Table 1). The microsprinkler-irrigation treatments used the existing irrigation system. For the drip-irrigation treatments, either one or two drip tapes were laid along the tree row in early May 2000 (Nelson Pathfinder, Nelson Irrigation, Walla Walla, WA). The plots with 2 drip tapes per tree row had the drip tapes spread 2 ft apart, centered on the tree row. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft at 8 psi. Each plot had a pressure regulator (set to 25 psi for the microsprinkler plots and 8 psi for the drip plots) and ball valve allowing independent irrigation. Water application amounts were recorded daily from the water meters in each plot.

Soil water tension (SWT) was measured in each plot by 6 granular matrix sensors (GMS; Watermark Soil Moisture Sensors model 200SS; Irrometer Co. Inc., Riverside, CA); 2 at 8-inch depth, 2 at 20-inch depth, and 2 at 32-inch depth. The GMS were installed along the middle row in each plot and between the riser and the third tree. The GMS were previously calibrated (Shock et al. 1998) and were read at 8:00 a.m. daily starting on May 2 with a 30 KTCD-NL meter (Irrometer Co. Inc., Riverside, CA). The daily GMS readings were averaged separately at each depth within each plot and over all plots in a treatment. Irrigation treatments were started on May 2.

In 2007, the irrigation treatments consisted of three microsprinkler and two drip-irrigated treatments (Table 2). The three microsprinkler treatments consisted of one adequately irrigated check (2 inches of water per irrigation) and two deficit irrigation treatments (irrigations initiated when the check treatment is irrigated, but with 1.54 and 0.77 inches applied per irrigation). The two drip-irrigated treatments were irrigated separately, with 1 and 0.5 inches applied per irrigation. From 2000 through 2002, all plots in the 3 microsprinkler-irrigated treatments were irrigated whenever the SWT at 8-inch depth, averaged over all plots in the check treatment, reached 50 cb. The plots in each drip-irrigated treatment were irrigated whenever the SWT at 8-inch depth, averaged over all plots in the respective treatment, reached 50 cb. In 2003, the irrigation criterion was increased from 50 cb to 25 cb. In 2006, due to salt accumulation in the soil, the irrigation rates for the microsprinkler treatments were doubled. Irrigation treatments were terminated on September 30 each year.

The heights and diameter at breast height (DBH, 4.5 ft from ground) of the central three trees in the two middle rows in each plot were measured monthly from May through September. Tree heights were measured with a clinometer (model PM-5, Suunto, Espoo, Finland) and DBH was measured with a diameter tape. Stem volumes (excluding bark and including stump and top) were calculated for each of the central six trees in each plot using an equation developed for poplars that uses tree height and DBH (Browne 1962). Growth increments for height, DBH, and stem volume were calculated as the difference in the respective parameter between October of the current year and October of the previous year. Curves of current annual increment (CAI) and mean annual increment (MAI) of stem volume over the 8 years for the microsprinkler and drip-irrigated treatments at the highest rates were used to assess the growth stage of the plantation. The MAI is the CAI divided by the tree age.

2000 Procedures

The side branches on the bottom 6 ft of the tree trunk were pruned from all trees in February, 1999. In March of 2000, another 3 ft of trunk were pruned, resulting in 9 ft of pruned trunk. The pruned branches were flailed on the ground and the ground between the tree rows was lightly disked on April 12. On April 24, Prowl® at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.7 inch of water to incorporate the Prowl. To control the alfalfa and weeds remaining from the previous years' groundcover trial in the top half of the field, Stinger® at 0.19 lb ai/acre was broadcast between the tree rows on May 19, and Poast® at 0.23 lb ai/acre was broadcast between the tree rows on June 1. On June 14, Stinger at 0.19 lb ai/acre and Roundup® at 3 lb ai/acre were broadcast between the tree rows on the whole field.

On May 19 the trees received 50 lb nitrogen (N)/acre as urea-ammonium nitrate solution injected through the microsprinkler system. Due to deficient levels of leaf nutrients in early July, the field had the following nutrients in pounds per acre injected in the irrigation systems: 0.4 lb boron (B), 0.6 lb copper (Cu), 0.4 lb iron (Fe), 5 lb magnesium (Mg), 0.25 lb zinc (Zn), and 3 lb phosphorus (P). The field was sprayed aerially for leafhopper control with Diazinon AG500® at 1 lb ai/acre on May 27 and with Warrior® at 0.03 lb ai/acre on July 10.

2001 Procedures
In March of 2001, another 3 ft of trunk were pruned, resulting in 12 ft of pruned trunk. The pruned branches were flailed on the ground on April 2. On April 4, Roundup at 1 lb ai/acre was broadcast for weed control. On April 10, 200 lb N/acre, 140 lb P/acre, 490 lb sulfur (S)/acre, and 14 lb Zn/acre (urea, monoammonium phosphate, zinc sulfate, and elemental sulfur) were broadcast. The ground between the tree rows was lightly disked on April 12. On April 13, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.8 inch of water to incorporate the Prowl.

A leafhopper, willow sharpshooter (*Graphocephala confluens,* Uhler), was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. From mid-April to early June only adults were observed in the traps. A willow sharpshooter hatch was observed on June 6, as large numbers of nymphs were noted in the traps and on the lower trunk sprouts. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 11 for leafhopper control.

2002 Procedures
In March of 2002, another 3 ft of trunk were pruned, resulting in 15 ft of pruned trunk. The pruned branches were flailed on the ground on April 12. On April 23, 80 lb N/acre, 40 lb potassium (K)/acre, 150 lb S/acre, 20 lb Mg/acre, 6 lb Zn/acre, 1 lb Cu/acre, and 1 lb B/acre (urea, potassium/magnesium sulfate, elemental sulfur, zinc sulfate, copper sulfate, and boric acid) were broadcast and the field was disked. On April 24, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.7 inch of water to incorporate the Prowl.

The willow sharpshooter was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 10 for leafhopper control.

2003 Procedures
In March of 2003, another 3 ft of trunk were pruned, resulting in 18 ft of pruned trunk. The pruned branches were flailed on the ground on March 31. On April 23, 80 lb N/acre as urea and 167 lb S/acre as elemental sulfur were broadcast and the field was disked. On April 16, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.4 inch of water to incorporate the Prowl.

Starting in 2003 the irrigation criterion was changed to 25 cb and the water applied at each irrigation was reduced accordingly. All plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWT at 8-inch depth, averaged over all plots in treatment 1, reached 25 cb. The plots in each drip-irrigated treatment were irrigated whenever the SWT at 8-inch depth, averaged over all plots in the respective treatment, reached 25 cb. Irrigation treatments were terminated on September 30.

The drip tape needed to be replaced because iron sulfide plugged the emitters. The drip tape was replaced with another brand (T-tape, T-systems International, San Diego, CA) in mid-April because Nelson Irrigation discontinued production of drip tape. The drip tape specifications were the same.

The willow sharpshooter was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 5 for leafhopper control.

2004 Procedures

On March 31, 2004, N at 80 lb/acre, S at 250 lb/acre, P at 50 lb/acre, K at 50 lb/acre, Cu at 1 lb/acre, Zn at 4 lb/acre, and B at 1 lb/acre were broadcast. The field was lightly disked on April 1. On April 13, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.4 inch of water to incorporate the Prowl. On June 12 the field was sprayed with Warrior at 0.03 lb ai/acre for leafhopper control. A leaf tissue sample taken on July 7 showed a P deficiency. On July 9, P at 10 lb/acre as phosphoric acid was injected through the sprinkler and drip systems.

2005 Procedures

A soil sample taken on April 4, 2005, showed the need for N at 50 lb/acre, and S at 400 lb/acre, which were broadcast on April 7. On April 8, Prowl at 3.3 lb ai/acre was broadcast for weed control. On June 22, the field was fertilized with N at 50 lb/acre as urea ammonium nitrate solution injected through the drip and sprinkler systems. On June 24 the field was sprayed with Warrior at 0.03 lb ai/acre for leafhopper control.

2006 Procedures

A soil sample taken on October 21, 2005, showed the need for P at 50 lb/acre, S at 400 lb/acre, and Cu at 1 lb/acre, which were broadcast on October 25, 2005. On April 14, 2006, Prowl at 3.3 lb ai/acre was broadcast for weed control. Due to bird damage the drip tape was replaced with drip tubing in May. The drip tubing (Triton X, Netafim, Fresno, CA) had emitters spaced 2 ft apart with 0.2 gal/hour flow rate. On June 12 the field was sprayed with Warrior at 0.03 lb ai/acre for leafhopper control. On June 16, the field had Fe at 1 lb/acre broadcast aerially. Leaf analyses on July 26 showed the need for N and P in the drip trees. A total of 50 lb N/acre, 20 lb P/acre, and 8.7 lb of Fe were applied to the drip plots in 2006 (Table 1). A total of 50 lb N/acre, 10 lb P/acre, and 5.2 lb Fe/acre were applied to the microsprinkler plots in 2006.

2007 Procedures

A soil sample taken on March 12, 2007 showed the need for N at 50 lb/acre, S at 400 lb/acre, Mn at 1 lb/acre, and B at 1 lb/acre, which were broadcast on April 3, 2007. On April 10, Goal® at 2 lb a.i./acre was broadcast for weed control.

Results and Discussion

The increase in the irrigation intensity starting in 2006 for the microsprinkler-irrigated plots resulted in an increase in the total amount of water applied compared to previous years. The total amount of water applied for the season was higher than estimated ET_c (47.3 inches) for all treatments except the driest microsprinkler-irrigated treatment (Table 1). In 2007 and from 2000 through 2007, drip irrigation at 1 inch per irrigation had the highest stem volume growth increment (Table 2). In the fall of 2007 (tenth year), the highest wood volume per acre was achieved with drip irrigation at 1 inch per irrigation. In the fall of 2007, the drip-irrigated treatments and the 2-inch microsprinkler treatment had among the highest DBH.

Although tree growth increased with increasing applied water up to the highest amount tested, tree growth may not have been maximized in this study (Fig. 1). The slope of the regression line between total water applied and stem volume growth from 2000 to 2007 was steeper for the drip-irrigated trees than for the microsprinkler-irrigated trees (Fig. 1). The greater stem volume growth for the drip system reflected the higher water use efficiency of the drip system.

The SWT at 8-inch depth was maintained below the criterion of 25 cb, except for brief periods during the season when microsprinkler irrigation applied 2 inches of water and for drip irrigation (Fig. 2). The average SWT at 8-inch depth reflected the treatments (Table 3).

The rate of increase in annual stem volume growth increased (growth approximately doubled every year) up to 2001, when the stem volume growth for the microsprinkler-irrigated trees started to decline (Table 4, Fig. 3). In 2002 the stem volume growth for the drip-irrigated trees started to decline. The decline in annual growth was not expected until later, when the trees approach harvest size. The reduction of the SWT for irrigation scheduling from 25 to 50 cb in 2000 might have been associated with the decline in annual stem volume growth. Tree growth was substantially greater in 2003 and was approximately double the growth in 2002; this could have been due to changing the irrigation threshold from 50 to 25 cb.

In 2004-2006, the trees in the microsprinkler-irrigated plots started exhibiting leaf chlorosis around mid-July, whereas the trees in the drip-irrigated plots did not exhibit leaf chlorosis. Foliar analysis has not revealed a clear cause-effect relationship. A small trial was conducted to evaluate two iron fertilizers as a remedy for the leaf chlorosis. Iron sulfate (75 percent) was applied at 2, 1, 0.5, 0.25, and 0.125 lb/tree (7.1, 3.5, 1.7, 0.9, and 0.4 oz Fe/tree, respectively). Iron Hi-Yield® (11 percent N, 13 percent S, and 16 percent Fe) was applied at 10, 5, 2.5, and 1.25 lb/tree. Each rate of each fertilizer was applied to one chlorotic tree in a microsprinkler-irrigated plot on July 2. The fertilizer was applied in two narrow bands adjacent to the tree trunk. By July 30 the trees receiving the iron sulfate at the 1 lb and 2 lb/tree rates showed reduced leaf chlorosis. On August 3, all trees had SulFeGro G® (8 percent Fe, Simplot Soilbuilders, Boise, ID) applied at 2 lb/tree (2.6 oz Fe/tree) in two narrow bands adjacent to the tree trunk.

The soil sodium (Na) concentration increased over the years through the fall of 2005, but decreased in 2006 and again in 2007 (Table 5). The increase in Na concentration over the years could be due to the high Na levels in the well water used for irrigation (200 ppm). The recommended maximum Na level in irrigation water is 69 ppm. The higher irrigation rates adopted in 2006 could have reduced the soil Na concentration.

The current annual increment (CAI) and the mean annual increment (MAI) for the drip-irrigated trees increased in 2007 (Fig. 3). The CAI and MAI for the microsprinkler-irrigated trees were similar in 2005, 2006, and 2007, suggesting a decline in tree growth vigor. Typically, both the CAI and MAI initially increase, reach a maximum, and then decline. The CAI peaks before the MAI. The intersection of the two curves is termed the economic rotation and is used in some poplar plantations to determine the harvest timing. The two curves were close in 2005, 2006, and 2007 for the microsprinkler trees, but not for the drip trees. The lower CAI for the microsprinkler trees could be related to the iron deficiency discussed above. The iron fertilization probably occurred too late during the 2007 season to have much of an effect on tree growth in 2007.

References

Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. British Columbia Forest Service, Forest Surveys and Inventory Division, Victoria, B.C.

Feibert, E.B.G., C.C. Shock, and L.D. Saunders. 2000. Groundcovers for hybrid poplar establishment, 1997-1999. Oregon State University Agricultural Experiment Station Special Report 1015:94-103.

Larcher, W. 1969. The effect of environmental and physiological variables on the carbon dioxide exchange of trees. Photosynthetica 3:167-198.

Shock, C.C., J.M. Barnum, and M. Seddigh. 1998. Calibration of Watermark Soil Moisture Sensors for irrigation management. Pages 139-146 *in* Proceedings of the International Irrigation Show, Irrigation Association, San Diego, CA.

Shock, C.C., E.B.G. Feibert, M. Seddigh, and L.D. Saunders. 2002. Water requirements and growth of irrigated hybrid poplar in a semi-arid environment in eastern Oregon. Western Journal of Applied Forestry 17:46-53.

Zelawski, W. 1973. Gas exchange and water relations. Pages 149-165 *in* S. Bialobok (ed.) The poplars-*Populus* L. Vol. 12. U.S. Dept. of Commerce National Technical Information Service, Springfield, VA.

Table 1. Irrigation rates, amounts, and water use efficiency for hybrid poplar submitted to five irrigation regimes in 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Irrigation threshold	Water application	Irrigation system	Total water applied[b]	Water use efficiency
	kPa[a]	inch		acre-inch/acre	ft^3 of wood/acre-inch of water
1	25	2	Microsprinkler	83.1	3.7
2	coincide with trt #1	1.54	Microsprinkler	54.3	6.5
3	coincide with trt #1	0.77	Microsprinkler	36.4	11.2
4	25	1	Drip, 2 tapes	83.7	12.0
5	25	0.5	Drip, 1 tape	58.1	9.2
LSD (0.05)				12.6	NS

[a]Soil water tension at 8-inch depth.

[b]Includes 2.59 inches of precipitation from mid-April through September.

Table 2. Height, diameter at breast height (DBH), and stem volume in early November 2007, and 2007 growth in height, DBH, and stem volume for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

	November 2007 measurements			2007 growth increment			2000-2007 growth increment
Treatment	Height	DBH	Stem volume	Height	DBH	Stem volume	Stem volume
	ft	inch	ft^3/acre	ft	inch	ft^3/acre	ft^3/acre
1	68.0	10.2	3126.7	3.6	0.21	308.0	2895.6
2	58.5	9.3	2240.5	3.8	0.39	362.3	2040.4
3	55.0	7.2	1257.6	9.7	0.59	408.6	1180.8
4	84.8	11.8	5313.1	5.9	0.60	983.4	5140.3
5	64.5	10.3	3004.2	3.1	0.74	514.9	2818.4
LSD (0.05)	NS	1.7	1417.8	NS	NS	299.9	1442.2

Table 3. Average soil water tension for hybrid poplar submitted to five irrigation treatments in 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Average soil water tension		
Treatment	1st foot	2nd foot	3rd foot
	------------------- cb -------------------		
1	27.7	27.5	26.5
2	57.2	30.6	30.9
3	61	49.6	48.3
4	27.1	24.9	27.7
5	31.9	33	24.6
LSD (0.10)	20.3	NS	9.8

Table 4. Irrigation criterion, irrigation rate, annual stem volume growth, seasonal average soil water tension at 8-inch depth, and evapotranspiration (ET_c) for the drip and microsprinkler treatments receiving the most water (Treatments 1 and 4), hybrid poplar study, Malheur Experiment Station, Oregon State University, Ontario, OR.

Year	Irrigation criterion[a]	Irrigation rate (inches per irrigation)		Annual stem volume growth		Seasonal average soil water tension at 8-inch depth		Water applied plus precipitation		ET_c
		Drip	Microspr.	Drip	Microspr.	Drip	Microspr.	Drip	Microspr.	
	cb			---- ft^3/acre ----		---- kPa ----		----- inches ------		
1997	25		0.8		1.3		21.4		27.2	
1998	25		1.2		78.5		20.0		45.0	37.1
1999	25		1.54		177.7		22.2		51.0	45.5
2000	50	1.54	2	387.9	401.5	24.2	37.9	35.2	42.1	47.1
2001	50	1.54	2	479.9	354.7	26.4	33.9	35.8	34.3	44.7
2002	50	1.54	2	440.1	256.8	31.3	35.8	30.6	38.1	44.4
2003	25	1	1	737.9	450.7	21.8	26.9	54.8	47.1	45.9
2004	25	1	1	679.4	512.3	20.2	22.2	56.3	51.7	44.1
2005	25	1	1	719.3	306.4	24.0	25.9	56.1	51.5	45.3
2006	25	1	2	629.8	303.2	26.5	26.8	74.3	89.1	49.3
2007	25	1	2	983.4	308.0	27.1	27.7	83.7	83.1	47.3

[a]soil water tension at 8-inch depth at which irrigations are initiated.

Table 5. Soil pH, soluble salts, sodium, and boron over time in field used for poplar research, Malheur Experiment Station, Oregon State University, Ontario, OR.

Year	pH	Soluble salts	Na (ppm)	B (ppm)
April 1999	8.2	0.8	159	0.5
March 2001	8.3	0.8	132	0.9
March 2003	8.4	0.7	132	0.8
April 2005	8.0	0.6	265	2.7
October 2005	8.4	0.3	200	4
April 2006	8.2	0.2	139	1.7
March 2007	8.8	0.2	53	0.6
Critical levels		<1.5	<225	0.7-1.5

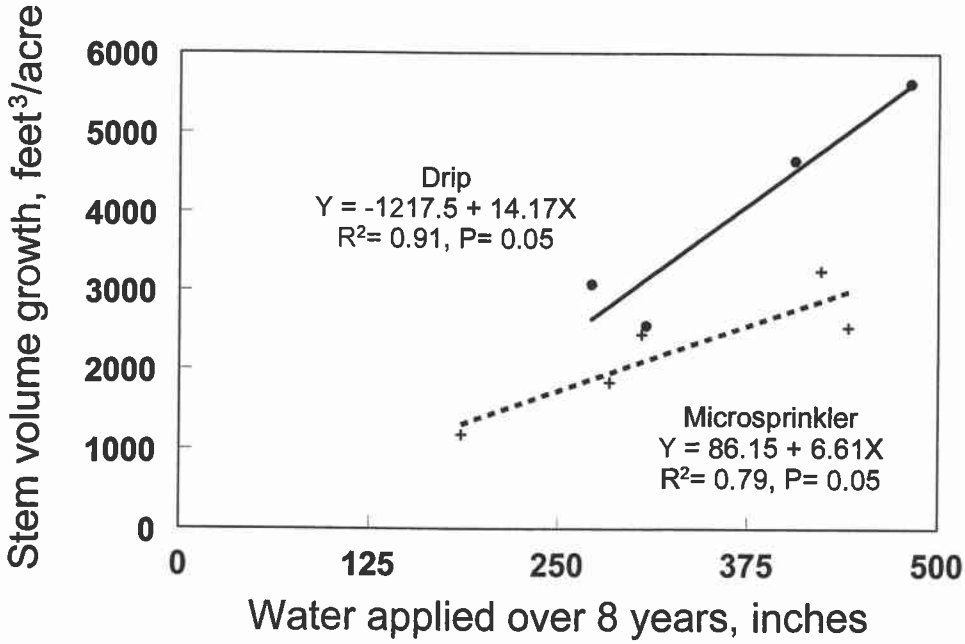


Figure 1. Response of stem volume growth to water applied from March 2000 through November 2007 for the drip and microsprinkler systems, Malheur Experiment Station, Oregon State University, Ontario, OR.

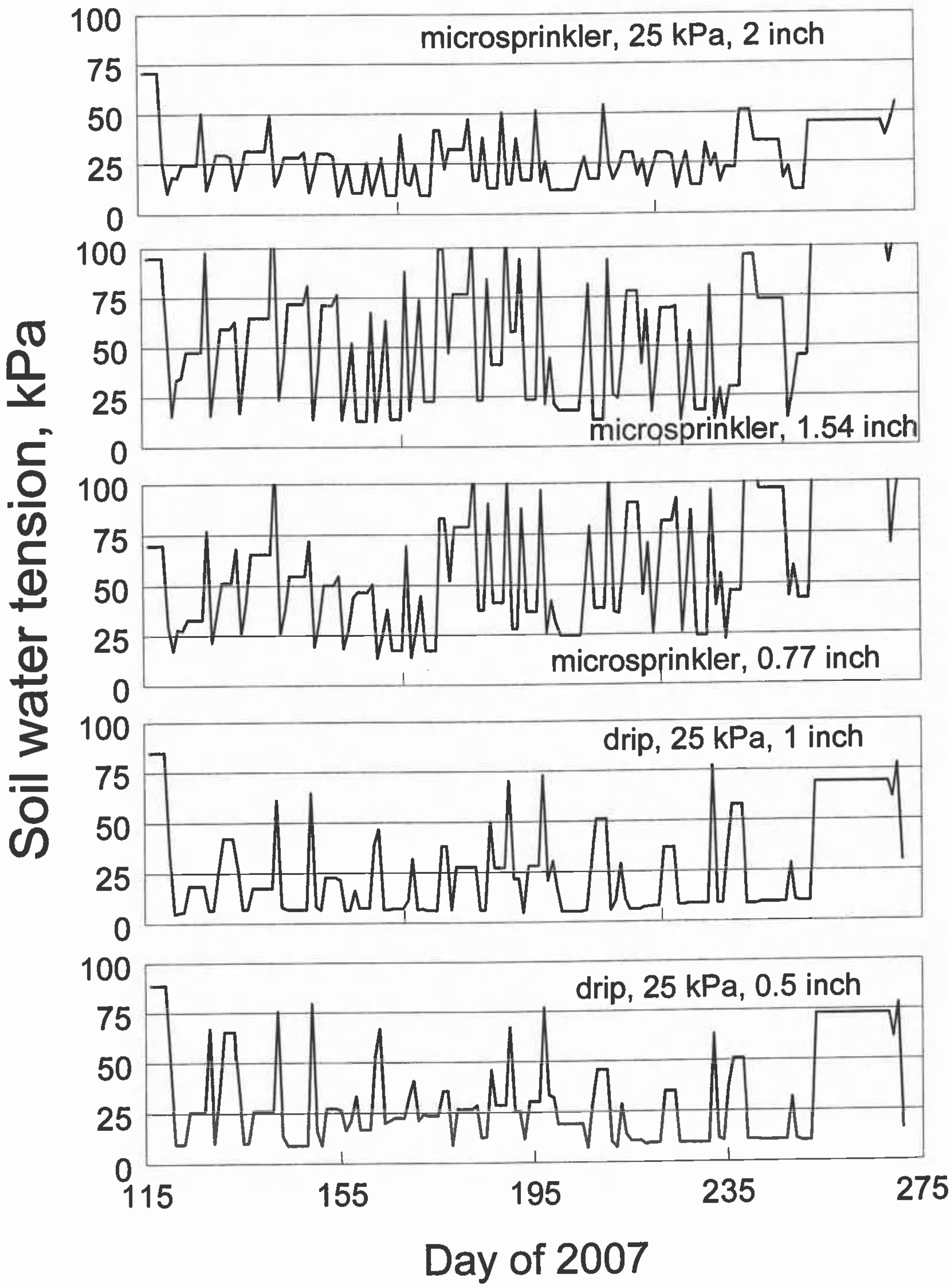
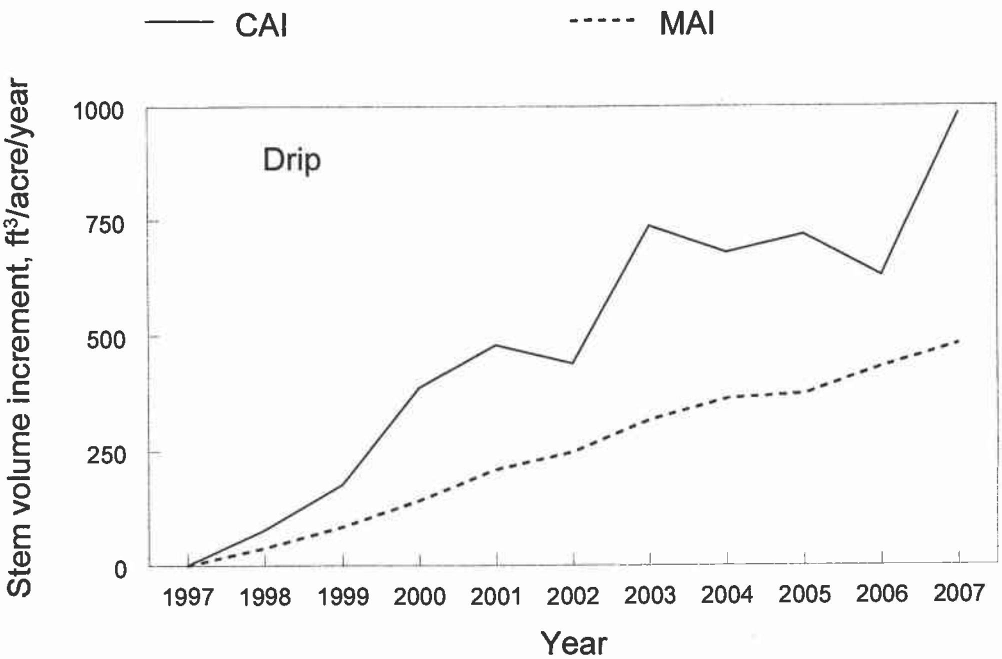


Figure 2. Soil water tension at 8-inch depth in a poplar stand submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR.



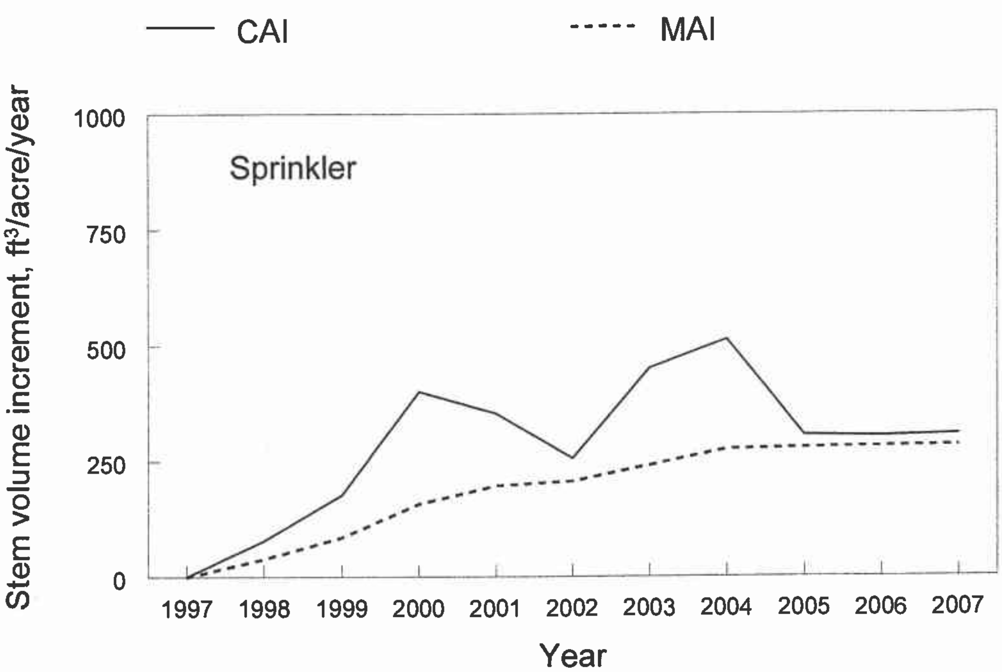


Figure 3. Current annual increment (CAI, annual stem volume growth) and mean annual increment (MAI, mean annual stem volume growth) starting at planting in 1997 through the eleventh year for drip- and microsprinkler-irrigated hybrid poplar. Data are from the check microsprinkler treatment and the treatment drip irrigated with 1 inch per irrigation. Data for 1997, 1998, and 1999 for the drip irrigation graph are the same as for the microsprinkler graph. Malheur Experiment Station, Oregon State University, Ontario, OR.

EFFECT OF PRUNING SEVERITY ON THE ANNUAL GROWTH OF HYBRID POPLAR THROUGH 2007

Clinton Shock, Erik Feibert, and Jake Eaton
Malheur Experiment Station
Oregon State University
Ontario, OR

Summary

Pruning the side branches of trees allows the early formation of clear, knot-free wood in the trunk and increases the trees' value as saw logs and peeler logs. The amount of live crown removed, if excessive, can reduce tree growth. Severe pruning might improve the efficiency of the pruning operation (fewer pruning operations to reach the final pruning height), but could reduce growth excessively. The objective of this study was to evaluate the effect of pruning severity on tree growth.

Hybrid poplar (clone OP-367) planted at 14-ft by 14-ft spacing in 1997 was submitted to three pruning treatments. Pruning treatments consisted of the rate at which the side branches were removed from the tree to achieve an 18-ft branch-free stem. Starting with a 6-ft (from ground) pruned trunk, 3-year-old trees were either left unpruned (check) or pruned to 18 ft in either 3, 4, or 5 years. Starting in March 2000, the side branches on the trunk were pruned to a height of 6, 9, or 12 ft. In subsequent years, the trees in all treatments had 3 ft of stem pruned yearly. At the start of the trial in 2000, the trees averaged 3.9 inches diameter at breast height and 29.7 ft tall. The average pruning intensities in 2000 ranged from 22 percent of the total stem that was pruned (for both the check and the least intensive pruning treatment) to 47 percent (most intensive treatment). Pruning to 18 ft was completed in 2004 for all treatments except the check. Stem volume growth in 2007 and over the previous seven seasons was not affected by the pruning treatments.

Introduction

With reductions in timber supplies from Pacific Northwest public lands, sawmills and timber products companies are searching for alternative sources of lumber. Hybrid poplar wood has proven to have desirable characteristics for many timber products. Growers in Malheur County, Oregon have made experimental plantings of hybrid poplar and demonstrated that the clone OP-367 (hybrid of *Populus deltoides x P. nigra*) performs well on alkaline soils for at least 12 years of growth. Research at the Malheur Experiment Station during 1997-1999 determined optimum irrigation criteria and water application rates for the first 3 years (Shock et al. 2002).

Materials and Methods

The trial is being conducted on a Nyssa-Malheur silt loam (bench soil) with 6 percent slope at the Malheur Experiment Station. The soil has a pH of 8.1 with 0.8 percent organic matter. The field had been planted to wheat for 2 years prior to 1997 and before that to alfalfa. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14-ft by 14-ft spacing. The field was used for irrigation management research (Shock et al. 2002) and groundcover research (Feibert et al. 2000) from 1997 through 1999. All side branches on the lower 6 ft of all trees had been pruned in February 1999.

In March 2000, the field was divided into 20 plots that were 6 rows wide and 7 trees long. The plots were allocated to five irrigation treatments that consisted of microsprinkler irrigation with three irrigation intensities and drip irrigation. The microsprinkler-irrigated plots used the existing irrigation system. For the drip-irrigated plots, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row in early May 2000. The management of the irrigation trial is discussed in an accompanying article (see "Micro-irrigation Alternatives for Hybrid Poplar Production, 2007 Trial" in this report).

For the pruning study, only plots in the two wetter microsprinkler-irrigated treatments and the drip-irrigated treatments were used. The middle 2 rows in each irrigation plot were assigned to pruning treatment 2 (Table 1). The remaining 2 pairs of border rows in each plot were randomly assigned to pruning treatments 1 and 3. The pruning treatments consisted of the height from the ground to which the stem was pruned. In the first year (2000), the trees in each treatment were pruned to different heights (intensities). Thereafter the trees in each treatment had 3 ft of stem pruned each year until the final pruned height of 18 ft was reached. An additional 4 plots, in which the trees would remain pruned only to 6 ft, were selected for the check treatment. The pruning treatments were replicated eight times. There was no significant difference between treatments in average diameter at breast height (DBH 4.5 ft from ground), height, or wood volume in the spring of 2000 (Table 3). The trees with pruning intensities 1, 2, and 3 were pruned on March 27, 2000; March 14, 2001; March 12, 2002; March 12, 2003; and March 19, 2004. All pruning treatments were completed in March of 2004. Trees were pruned by cutting all the side branches up to the specified height on the trunk, measured from ground level. The side branches were cut using loppers and pole saws.

The five central trees in the middle two rows and the five central trees in each inside row of each border pair in each plot were measured monthly for DBH and height. Trunk volumes were calculated for each of the measured trees in each plot using an equation developed for poplars that uses tree height and DBH (Browne 1962). Growth increments for height, DBH, and stem volume for 2007 were calculated as the difference in the respective parameter between October 2006 and October 2007. Growth increments for the eight seasons (2000-2007) were calculated as the difference in the respective parameter between October 1999 and October 2007.

Results and Discussion

The differences between treatments in the percentage of the tree stem that was pruned decreased over the years (Table 1). Starting in 2004, when the pruning treatments were completed, there was no difference in the percentage of the tree stem that was pruned between the three pruning treatments. The highest pruning intensity resulted in 47.3 percent of pruned stem in 2000, that declined to 21.4 percent of pruned stem by the fall of 2007. There was no significant difference between pruning treatments in wood volume growth in the years from 2000 to 2007 (Table 2). Wood volume growth from 2000 to 2007 was significantly lower for the unpruned check treatment. In the fall of 2007, the unpruned check treatment had lower height and wood volume than the pruned treatments (Table 3).

The lack of response of tree growth to pruning intensity in this study is consistent with the Oregon State University Extension recommendation to limit pruning to 50 percent of total height (Hibbs 1996). The greatest pruning intensity achieved in this study was 47 percent in 2000. The results of this study also agree with DeBell et al. (2002), who found that pruning three poplar clones to 50 percent of tree height once at age 1.5 years did not affect growth after 9 years. However, poplar grown on very wide spacing and kept pruned to one-third and one-half of tree height from years 2 through 8 showed reduced DBH from years 2 through 10 (Krinard 1985). Krinard maintained the same pruning intensity for 6 years, more intense than our study or that of DeBell et al. (2002).

The practical significance of this research is that the most severe pruning intensity used in this trial was easiest to establish and maintain. Pruning early in tree development avoids the need to cut larger diameter lateral branches in later years, which is a costly use of labor. Furthermore, the maintenance of 18 ft of tree trunk free of limbs for more years should enhance the quality of harvested lumber.

References

Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. British Columbia Forest Service, Forest Surveys and Inventory Division, Victoria, B.C.

DeBell, D.S., R. Singleton, C.A. Harrington, and B.L. Gartner. 2002. Wood density and fiber length in young *Populus* stems: relation to clone, age, growth rate, and pruning. Wood and Fiber Science 34:529-539.

Feibert, E.B.G., C.C. Shock, and L.D. Saunders. 2000. Groundcovers for hybrid poplar establishment, 1997-1999. Oregon State University Agricultural Experiment Station Special Report 1015:94-103.

Hibbs, D.E. 1996. Managing hardwood stands for timber production. The Woodland Workbook, Oregon State University Extension Service, Oregon State University, Corvallis.

Krinard, R.M. 1985. Ten year's growth of pruned and unpruned cottonwood planted at 40 by 40-foot spacing. USDA Forest Service Southern Forest Experiment Stations Research Note Sept. 1985:1-5.

Shock, C.C., E.B.G. Feibert, M. Seddigh, and L.D. Saunders. 2002. Water requirements and growth of irrigated hybrid poplar in a semi-arid environment in eastern Oregon. Western Journal of Applied Forestry 17:46-53.

Table 1. Poplar pruning treatments and actual percentage of total height that is branch-free stem after pruning in successive years. Trees were planted in April 1997, Malheur Experiment Station, Oregon State University, Ontario, OR.

Pruning intensity	Pruning height[a] (ft from ground)						Percentage of tree height that was pruned trunk in March							
	1999	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004	2005	2006	2007
Check	6	6	6	6	6	6	24.3	15.7	13.7	12.9	11.7	10.9	9.9	9.7
1	6	6	9	12	15	18	22.2	22.9	26.1	28.1	30.5	27.7	25.6	23.2
2	6	9	12	15	18	18	33.7	29.3	32.0	35.3	29.9	29.9	25.2	23.2
3	6	12	15	18	18	18	47.3	39.4	35.2	33.5	30.0	27.5	25.5	21.4
LSD (0.05)							2.8	1.7	2.6	2.2	2.6	2.5	2.3	2.7

[a]Trunk height to which all side branches were removed in March of the respective year.

Table 2. Poplar wood volume annual growth increment for three pruning intensity treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Pruning intensity	Growth increment								
	2000	2001	2002	2003	2004	2005	2006	2007	1999-2007
	ft³/acre								
Check	321.3	365.4	266.3	301.6	460.7	395.8	271.4	437.4	2,842
1	369.3	379.0	397.4	552.4	571.3	413.7	523.6	778.8	3,985
2	360.1	414.5	356.4	542.4	570.3	541.1	478.8	741.7	4,005
3	318.9	423.5	328.1	547.8	529.7	473.8	479.6	958.7	4,060
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1,028[a]

[a]Significant at 0.10 probability level.

Table 3. Poplar tree measurements before and 3 years after the end of pruning treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Pruning intensity	November 1999			November 2007		
	DBH	Height	Volume	DBH	Height	Volume
	inch	feet	ft³/acre	inch	feet	ft³/acre
Check	3.6	27.7	167.3	10.1	63.1	3,009
1	4.3	30.5	242.6	11.0	78.0	4,228
2	3.8	30.0	196.6	10.5	78.6	4,202
3	3.7	29.1	172.3	10.2	79.3	4,232
LSD (0.05)	NS	NS	NS	NS	9.3	1026[a]

[a]Significant at 0.10 probability level.

PERFORMANCE OF HYBRID POPLAR CLONES ON AN ALKALINE SOIL THROUGH 2007

Clinton C. Shock and Erik B. Feibert
Malheur Experiment Station
Oregon State University
Ontario, OR

Introduction

With timber supplies from Pacific Northwest public lands becoming less available, sawmills and timber products companies are searching for alternatives. Hybrid poplar wood has proven to have desirable characteristics for many nonstructural timber products. Plantings of hybrid poplar for sawlogs have increased in the Treasure Valley.

Many hybrid poplar clones are susceptible to nutrient deficiencies and excesses in alkaline soils, leading to chlorosis, poor growth, and eventual death of trees. Poor growth on alkaline soil can be partly a result of iron deficiency caused by the low solubility of iron compounds in alkaline soil. A symptom of iron deficiency is yellow leaves or "chlorosis". Chlorosis can also be caused by other nutrient problems. Foliar analyses often reveal high levels of many nutrients in poplar grown on alkaline soils.

Previous clone trials planted in 1995 in Malheur County demonstrated that clone OP-367 (hybrid of *Populus deltoides* x *Populus nigra*) was the only clone performing well on alkaline soils at that time. Growers in Malheur County have made experimental plantings of hybrid poplars and found that other clones have higher productivity on soils with nearly neutral pH. New poplar clones are continually being developed. The current trial seeks to provide poplar growers with updated information on the relative vigor and adaptability of a larger number of clones on alkaline soils.

Materials and Methods

2003 Procedures

The trial was conducted on Nyssa silt loam with 1.3 percent organic matter and a pH ranging from 7.7 at the top of the field to 8.4 at the bottom. The field had been planted to wheat the fall of 2002. On March 28, 2003, the wheat was sprayed with Roundup® at 1.5 lb ai/acre. Based on a soil analysis, on April 9, 2003, 20 lb magnesium (Mg), 40 lb potassium (K), 1 lb boron (B), and 1 lb copper (Cu) per acre were broadcast. The field was again sprayed with Roundup at 1.5 lb ai/acre on April 9. On April 10, 9-inch poplar sticks of 24 clones (Table 1) were planted in a randomized complete block design with 5 replicates. Tree rows were spaced 5 ft apart and trees were spaced 5 ft apart within the rows. Each plot consisted of four trees, two rows wide and two trees long. Goal® herbicide at 2 lb ai/acre was applied on April 11. The field was irrigated with 0.6 inch of water on April 11.

Three of the clones were designated as Malheur 1, 2, and 3 corresponding to 3 selections of eastern cottonwood (*Populus deltoides*) found growing vigorously in Malheur County.

Drip tubing (Netafim Irrigation, Inc., Fresno, CA) was laid along the tree rows prior to planting. The drip tubing has two emitters (Netafim On-line button dripper) spaced 12 inches apart for each tree. Each emitter has a flow rate of 0.5 gal/hour. The field was irrigated when the soil water tension at 8-inch depth reached 25 kPa. Each irrigation applied 0.6 inch of water based on an 8-ft^2 area for each tree. This irrigation strategy was able to maintain the soil water tension below 25 kPa until around mid-July, when the irrigation rate was increased to 1 inch per irrigation. The increased irrigation rate was not effective in maintaining the soil water tension below 25 kPa due to inadequate irrigation frequency, so starting in mid-August the field was irrigated 5 to 7 times per week until the last irrigation on September 30. Soil water tension was measured with six Watermark soil moisture sensors model 200SS (Irrometer Co., Riverside, CA) installed at 8-inch depth. The soil moisture sensors are read every 8 hours by a Hansen Unit datalogger (Mike Hansen Co., Wenatchee, WA).

Analysis of leaf samples (first fully expanded leaf from clone OP-367) taken on July 11 showed the unexpected needs for B and sulfur (S) fertilization (Table 1). On July 28, S at 10 lb/acre as ammonium sulfate and B at 0.2 lb/acre as boric acid were injected through the drip system.

2004 Procedures

On March 25, 2004, Casoron® 4G at 4 lb ai/acre was broadcast for weed control. Based on a soil analysis, nitrogen (N) at 80 lb/acre, Cu at 1 lb/acre, and B at 1 lb/acre were injected through the drip tape on May 10. Analysis of leaf samples (first fully expanded leaf from clone OP-367) on July 8 showed the need for B (Table 1). On July 19, B at 0.2 lb/acre was injected through the drip system. On August 20, a soil sample consisting of 20 cores was taken from each replicate and analyzed for pH.

On August 10, leaf chlorophyll content was measured on two leaves per tree using a Minolta SPAD 502 DL meter (Konica Minolta Photo Imaging U.S.A., Inc., Mahwah, NJ). On August 20, trees in all plots were evaluated subjectively for visual symptoms of leaf chlorosis. On September 10 the trees in all plots were evaluated subjectively for stem defects. The heights and diameter at breast height (DBH, 4.5 ft from ground) of all trees in each plot were measured in October of 2003 and 2004. Stem volumes (cubic feet, excluding bark and including stump and top) were calculated for each tree using an equation (Stem volume = $10^{(-2.945047+1.803973*LOG10(DBH)+1.238853*LOG10(Height))}$) developed for poplars that uses tree height and DBH (Browne 1962). To evaluate the sensitivity of the clones to soil pH, a regression analysis of leaf chlorophyll content against soil pH was separately run for each clone. If the regression analysis had a probability level of 5 percent or less, the clone was considered to be sensitive to soil pH.

2005 Procedures
In February the stand was thinned to a 10 ft by 10 ft spacing by removing every other row of trees and every other tree in the remaining rows. The stumps were painted with a 30 percent by volume 2,4D solution. On March 24, Casoron 4G at 4 lb ai/acre was broadcast for weed control. The field was irrigated and the trees were measured as previously described in 2003 and 2004.

On May 17, three log sections of OP-367 and three of Malheur 3 were sent to the Wood Materials and Engineering Laboratory at Washington State University in Pullman for wood quality testing. Each log section measured approximately 4 ft in length by 10 inches in diameter. Log sections for OP-367 were taken from 8-year-old trees at the Malheur Experiment Station. Log sections for Malheur 3 were taken from the two trees of unknown age from which the original cuttings were taken. The logs were air dried to 12 percent moisture and cut into 2-inch by 2-inch by 30-inch specimens for the flexure tests and into 2-inch by 2-inch by 6-inch pieces for the hardness tests. Flexure testing was done by incrementally applying a known load at the center of the 30-inch span and periodically recording the specimen flexure until rupture occurred. Modulus of elasticity is a measurement of the capacity of the wood to flex and to recover in response to a strain. The higher the modulus of elasticity, the more rigid the wood. Modulus of rupture is a measurement of the maximum load the wood can take before rupturing. Hardness was determined by measuring the load necessary to embed a steel sphere halfway into the specimen on the radial, tangential, and end surfaces.

2006 Procedures
On March 24, Casoron 4G at 4 lb ai/acre was broadcast for weed control. The field was irrigated and the trees were measured as previously described in 2003 and 2004.

2007 Procedures
The field was irrigated and the trees were measured as previously described.

All Years
Clonal differences in height, DBH, and wood volume were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). The LSD (0.05) values at the bottom of Table 2 should be considered when comparisons are made between clones for significant differences in performance characteristics. Differences between clones equal to or greater than the LSD (0.05) value for a characteristic should exist before any clone is considered different from any other clone in that characteristic.

Results and Discussion

2004 Leaf Chlorophyll Measurements
Chlorotic leaves were observed on trees in replicates 2, 3, and 4 of the trial. The soil pH was 7.7, 8.2, 8.4, and 8.4 for replicates 1 to 4, respectively. Relative leaf chlorophyll content rankings ranged among clones from 25.8 to 49.3 percent (Table 2). For the clones sensitive to soil pH, leaf chlorophyll content decreased with increasing soil pH.

The leaf chlorophyll content of the clones insensitive to soil pH (12 clones) averaged 42.4 percent. The leaf chlorophyll content of the clones sensitive to soil pH (12 clones) averaged 31.8 percent. There was a linear relationship ($R^2 = 0.62$, $P = 0.001$) between leaf chlorophyll content and the visual rating of leaf chlorosis. The trees insensitive to soil pH averaged a subjective visual rating of leaf chlorosis of 0.52 (0 = no visual symptoms of chlorosis, 5 = very chlorotic). The trees sensitive to soil pH averaged a visual rating of leaf chlorosis of 2.15. The three *P. deltoides* selections from Malheur County had among the darkest green leaves, and leaf sizes were smaller. For the clones sensitive to soil pH, tree growth decreased with increasing severity of leaf chlorosis and with decreasing leaf chlorophyll content. For the clones insensitive to soil pH, tree growth was not related to leaf chlorosis or leaf chlorophyll content.

Subjective rating of stem defects (0 = no defects, 2 = more than half of trees have either split tops or crooked stems) ranged from 0 defects for clone 57-276 to 1.75 for clone 49-177 (Table 2).

2005 Wood Quality Analysis

Results of the wood quality tests showed that OP-367 was slightly more rigid (higher modulus of elasticity) and stronger (higher modulus of rupture) than Malheur 3 (Table 1). Malheur 3 was slightly harder than OP-367.

2007 Measurements

By November of 2007, Malheur 3, 184-401, and 59-289 had among the highest wood volume and height (Table 2). By November of 2007, clones Malheur 3, 184-401, and OP-367 had among the highest DBH. Clones Malheur 3, 184-401, PC2, and OP-367 were among the clones with the highest wood volume increment in 2007.

Clones 15-29, 50-184, 55-260, 311-93, and DTAC-7 were eliminated from the data analysis due to tree death, resulting in an inadequate number of replicates.

References

Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. British Columbia Forest Service, Forest Surveys and Inventory Division, Victoria, B.C.

Table 1. Wood quality characteristics for clones Malheur 3 and OP-367, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Clone	
Parameter	Malheur 3	OP-367
Modulus of elasticity, psi	851,300	1,123,000
Modulus of rupture, psi	6,087	7,185
Radial and tangential hardness, lb	483.9	448.3
End surface hardness, lb	795.6	585.8

Table 2. Performance of hybrid poplar clones planted on April 10, 2003 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

			November 2007 measurements			2007 growth increment			2004 measurements		
No.	Clone	Cross	Height	DBH	Wood volume	Height	DBH	Wood volume	Leaf chlorophyll content	Leaf chlorosis symptoms	Trunk defects
			ft	inch	ft^3/tree	ft	inch	ft^3/tree	0 - 100	0 - 5[a]	0 - 2[b]
3	50-197	P. trichocarpa X P. deltoides	23.3	4.2	0.77	0.2	0.6	0.19	30.3	3	0.3
4	52-225	P. trichocarpa X P. deltoides	28.3	4.3	0.99	1.9	0.4	0.24	26.6	3	0.5
6	56-273	P. trichocarpa X P. deltoides	22.4	3.5	0.52	0.3	0.3	0.09	40.8	1	1
7	57-276	P. trichocarpa X P. deltoides	20.2	3.7	0.54	0.6	0.4	0.13	36.3	1.8	0
8	58-280	P. trichocarpa X P. deltoides	25.9	4.9	1.16	1.8	0.8	0.37	44.4	0.8	0.8
9	59-289	P. trichocarpa X P. deltoides	30.2	4.8	1.33	1.1	0.3	0.22	42	0.5	0.8
10	184-401	P. trichocarpa X P. deltoides	32.5	5.1	1.62	4.8	0.7	0.62	34	0.5	1
11	184-411	P. trichocarpa X P. deltoides	25.2	3.8	0.70	1.3	0.7	0.23	32.4	1.5	0.5
12	195-529	P. trichocarpa X P. deltoides	20.9	4.3	0.71	-0.1	0.6	0.18	32.2	1.5	0.8
13	309-74	P. trichocarpa X P. nigra	27.9	4.6	1.16	1.4	0.6	0.28	26.3	2.8	0.8
15	NM-6	P. trichocarpa X P. maximowiczii	28.1	4.0	0.86	3.3	0.5	0.26	43.5	1.5	1.3
17	OP-367	P. deltoides X P. nigra	24.3	5.0	1.14	2.3	1.1	0.53	40.6	0	0.3
18	PC1	P. deltoides X P. nigra	28.8	4.9	1.28	1.0	0.7	0.36	45.8	0	0.3
19	PC2	P. trichocarpa X P. deltoides	26.8	4.4	0.97	5.0	1.2	0.54	45.3	0.3	0.5
20	49-177	P. trichocarpa X P. deltoides	24.9	3.7	0.81	2.3	0.6	0.34	33.5	1.5	1.8
21	Malheur 1	P. deltoides, Malheur County, OR	24.8	4.1	0.84	0.8	0.9	0.30	49.3	0	0.5
22	Malheur 2	P. deltoides, Malheur County, OR	29.2	4.2	1.00	2.2	0.4	0.25	46.7	0	0.5
23	Malheur 3	P. deltoides, Malheur County, OR	32.6	5.7	2.02	3.3	0.9	0.70	42.2	0	0.3
24	DN-34	P. deltoides X P. nigra	29.6	4.0	0.99	2.4	0.4	0.25	43.8	0.5	0.3
LSD (0.05)			5.1	0.95[c]	0.62	1.9[c]	NS	0.24[c]	8.8	1.6	0.9

[a]Subjective evaluation of leaf chlorosis on a scale of 0-5: 0 = no symptoms, 5 = very chlorotic.
[b]Subjective evaluation of trunk defects on a scale of 0-2: 0 = all trees have single tops and straight stems, 1 = less than half of trees have either split tops or crooked stems, 2 = more than half of the trees have either split tops or crooked stems.
[c]significant at 0.10 probability level.

POTATO VARIETY TRIALS 2007

Clinton C. Shock, Eric P. Eldredge, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR

Introduction

New potato varieties were evaluated for their productivity and suitability for processing. Potatoes in Malheur County are grown under contract for processors to make frozen potato products for the food service industry and grocery chain stores. There is very little production for fresh pack or open market, and very few growers store potatoes on their farms. There is also no production of varieties for making potato chips.

The varieties grown for processing in Malheur County, Oregon, are mainly 'Ranger Russet', 'Shepody', and 'Russet Burbank'. Harvest begins in July, providing potatoes to processing plants directly from the field. Yield of harvests later than mid-August may be limited by the "early die" syndrome, which causes early senescence of the vines of susceptible varieties, especially Shepody and Russet Burbank. Early die is caused by a complex of soil pathogens, including bacteria, nematodes, and fungi, particularly Verticillium wilt. Early die is worse when the rotation between potato crops is shorter.

Small acreages of new varieties or advanced selections are sometimes grown under contract to study the feasibility of expanding their use. To displace an existing processing variety, a new potato variety must have several outstanding characteristics. The yield should be at least as high as the yield of the currently contracted varieties. The tubers need to have low reducing sugars for light fry color, and high specific gravity. A new variety should be resistant to tuber defects or deformities caused by disease, water stress, or heat. It should begin tuber bulking early and grow rapidly for early harvest. Late harvest varieties should be resistant to early die to continue bulking tubers until harvest.

Potato variety development trials at the Malheur Experiment Station in 2007 included the Western Regional Late Harvest Trial with 19 entries, the Oregon Statewide Trial with 19 entries, the Western Regional Specialty Trial of 24 colored skin and/or flesh potato varieties, and the Oregon Specialty Trial of 11 colored skin and/or flesh potato varieties. Through these trials and active cooperation with other scientists in Idaho, Oregon, and Washington, promising new lines are bred and evaluated. Eventually, the best of them may be released as new varieties.

Materials and Methods

The potato variety trials were grown using sprinkler irrigation on Greenleaf silt loam, where winter wheat was the previous crop and potato had not been grown for the past

11 years. A soil test taken on September 18, 2006 showed 160 lb nitrogen (N)/acre in the top 2 ft of soil, and 11 ppm phosphate (P_2O_5), 388 ppm potash (K_2O), 8 ppm sulfate (SO_4), 2763 ppm calcium (Ca), 407 ppm magnesium (Mg), 1.7 ppm zinc (Zn), 7 ppm iron (Fe), 3 ppm manganese (Mn), 0.7 ppm copper (Cu), 0.4 ppm boron (B), organic matter 1.7 percent, and pH 7.7. Fertilizer was applied in the fall to supply 172 lb P_2O_5 /acre, 200 lb sulfur (S)/acre, 4 lb Mg/acre, and 2 lb B/acre. The soil was fumigated in the fall with Telone® II at 25 gal/acre and was bedded on 36-inch row spacing.

On April 19, 2007, the field was sprayed with Roundup® at 4 pt/acre. Seed of all varieties was hand cut into 2-oz seed pieces and treated with Tops-MZ® plus Gaucho® dust and placed in storage to suberize. Potato seed pieces were planted in single row plots using a two-row assist-feed planter with 9-inch seed spacing in 36-inch rows. Red potatoes were planted at the end of each plot as markers to separate the potato plots at harvest, except in the specialty trials where russet was used as the marker.

The Western Regional Late Harvest, Oregon Statewide Trial, the Oregon Specialty Trial, and the Western Regional Specialty Trial were planted on April 26, 2007. Each trial had plots that were 30 seed pieces long with 4 replicates.

After planting, hills were re-formed over the rows with a Lilliston rolling cultivator. Prowl® at 1 lb ai/acre plus Dual® at 2 lb ai/acre were applied as a tank mix for weed control on May 8 and were incorporated with the Lilliston. Matrix® at 1.5 oz/acre plus Eptam® at 6 pt/acre were applied on May 29 through the sprinkler system and incorporated with 0.84-inch sprinkler irrigation.

Irrigation was applied 22 times (Fig. 1), from May 29 to September 10, with scheduling based on seven Watermark soil moisture sensors Model 200SS connected to an Irrometer Monitor (Irrometer Co. Inc., Riverside, CA) and six Watermark granular matrix sensors (Irrometer Co., Riverside, CA) connected to an AM400 data logger (M.K. Hansen Co., Wenatchee, WA) that recorded soil water tension at seed piece depth (Fig. 1). Irrigations were managed to prevent the soil at the seed piece depth from drying beyond 60 cb soil water tension. Crop evapotranspiration (ET_c) was estimated by the U.S. Bureau of Reclamation using data from an AgriMet weather station on the Malheur Experiment Station (Fig. 2). Irrigation water applied was measured using an inline flow meter (McCrometer, Hemet, CA).

Fungicide applications for control of early blight and prevention of late blight infection started with an aerial application of Ridomil Gold® and Bravo® at 2 lb/acre on June 18. On July 1, Topsin® fungicide at 20 oz product/acre plus Dithane® at 2 lb product/acre was applied. Tanos® at 8 oz product/acre was applied on July 28, and on August 7 ammonium polyphosphate 10-34-0 at 0.18 gal/acre plus Folo Spray 20-20-20 at 4 lb/acre plus liquid sulfur at 6 lb S/acre was applied to remedy a nutrient deficiency and to prevent a two-spotted spider mite infestation.

Petiole tests were taken every 2 weeks from June 17 and fertilizer was injected into the sprinkler system during irrigation to supply the crop nutrient needs. A total of 185 lb

N/acre, 1.5 lb P_2O_5/acre, 1 lb K_2O/acre, 6 lb S/acre, 0.45 lb Zn/acre, 4.2 lb Mn/acre, 2.2 lb Cu/acre, 0.4 lb Fe/acre, and 1.08 lb B/acre were applied through the sprinkler lines and aerial applications.

The vines were flailed on September 18. The vines of most entries were still green. Potatoes in the Specialty Trial were dug on October 2, the Oregon Preliminary Yield Trial on October 3-4, the Statewide Trial on October 4, and the Western Regional Late Harvest Trial was dug on October 5. At each harvest, the potatoes in each plot were lifted with a two-row digger that laid the tubers back onto the soil in each row. Visual evaluations included observations of desirable traits, such as a high yield of large, smooth, uniformly shaped and sized, oblong to long, attractively russetted tubers, with shallow eyes evenly distributed over the tuber length. Notes were also taken of tuber defects such as growth cracks, knobs, curved or irregularly shaped tubers, pointed ends, stem-end decay, attached stolons, heat sprouts and chain tubers, folded bud ends, rough skin due to excessive russetting, pigmented eyes, or any other defect. A note was made for each plot to keep or discard the clone based on the overall appearance of the tubers.

Tubers were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading. Tubers were graded by market class (U.S. No. 1 and U.S. No. 2) and weight (<4 oz, 4-6 oz, 6-12 oz, and >12 oz). Tubers were graded as U.S. No. 2 if any of the following conditions occurred: growth cracks, bottleneck shape, abnormally curved shape, or two or more knobs. A 20-tuber sample from each plot was placed into storage. The storage temperature was gradually reduced to 45°F. After 6 weeks, a 20-tuber sample from each plot (except the Specialty Trial) was evaluated for tuber quality traits for processing. Specific gravity was measured using the weight-in-air, weight-in-water method. Ten tubers per plot were cut lengthwise and the 10 center slices were fried for 3.5 min in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each slice using a Photovolt Reflectance Meter model 577 (Seradyn, Inc., Indianapolis, IN), with a green tristimulus filter, calibrated to read 0 percent light reflectance on the black standard cup and 73.6 percent light reflectance on the white porcelain standard plate.

Data from all trials were analyzed with the General Linear Models analysis of variance procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT) using Fisher's protected LSD (least significant difference) for means separation at the 95 percent confidence level.

Results and Discussion

Soil water potential at the seedpiece depth was allowed to become drier at the end of the growing season, after the vines died on the early maturing entries, by applying frequent sprinkler irrigations of short duration, as shown in Figure 1. This was necessary to avoid swollen lenticels and the associated possibility of rotting tubers of entries maturing early or susceptible to the early die disease syndrome, while continuing to supply a portion of the ET_c requirement for entries maturing late or resistant to early die.

Precipitation for May 25 through September 17 was 0.80 inch, the potato crop evapotranspiration (ET_c) for the late-harvest trials totaled 29.26 inch, and the trials received 28.45 inch of irrigation plus precipitation (Fig. 2). The incremental increases in the irrigation plus rainfall curve show the 21 sprinkler irrigations applied during the growing season.

Western Regional Late Harvest Trial

The clones with the highest total yields in the Western Regional Late Harvest Trial were 'AO96164-1', with 827 cwt/acre, 'AO96141-3', with 822.8 cwt/acre, and Russet Burbank with 763.8 cwt/acre (Table 1). The clones AO96164-1, 'A97287-6', and 'CO95172-3RU' had among the highest U.S. No. 1 yields. Clone AO96164-1 produced 777.3 cwt/acre marketable yield, 51.7 fry color light reflectance, zero percent sugar ends, and 1.0883 specific gravity. Russet Burbank and AO96141-3 produced significantly more U.S. No. 2 tubers than other clones in this trial.

Oregon Statewide Trial

At this location in 2007, AO96164-1, AO96141-3, Russet Burbank, and CO95172-3RU were among the clones with the highest total yields. The clones AO96164-1, A97287-6, and CO95172-3RU were among the clones with the highest yields of U.S. No. 1 tubers. The clones AO96141-3, Ranger Russet, 'A95409-1', and AO96164-1 had specific gravity, a measure of tuber solids, among the highest in this trial. The clones 'AO96052-1RU', AO96164-1, 'AO95154-1', and 'AOTX95265-2ARu', had among the lightest fry color for processing (Table 2).

Colored Flesh Potato Trials

This was the second year of testing colored flesh potato varieties at the Malheur Experiment Station. Potato tubers with red to yellow carotinoid or red, blue, and purple anthocyanin pigments are of interest because of the anti-oxidant properties of those pigments in human nutrition. Two trials tested specialty potato varieties in 2007: Western Region Specialty and Oregon Specialty.

Western Region Specialty Trial

In the Western Region Specialty Trial, 'POR02PG5-1', 'AC97521-1R/Y', 'A96510-4Y', and 'ATTX98500-2P/Y' were among the clones with the highest total yield (Table 3). Clones AC97521-1R/Y, ATTX98500-2P/Y, POR02PG5-1, and 'POR01PG20-12' had among the highest yield of 4- to 10-oz tubers. 'Dark Red Norland', 'Red LaSoda', 'ATTX961014-1R/Y', ATTX98500-2P/Y, POR02PG5-1, 'Yukon Gold', A96510-4Y, and 'POR02PG26-5' had more than 100 cwt/acre of oversized tubers over 10 oz, which are considered cull tubers in the usual markets for specialty potatoes. Clones varied greatly in appearance and taste (Tables 5 and 6).

Oregon Advanced Specialty Potato Trial

The clone 'OR00068-11' with 848.3 cwt/acre, had the highest total yield, followed by 'POR04PG03-9' with 726.8 cwt/acre, and 'POR04PG01-2' with 714.9 cwt/acre, far higher than the check varieties Yukon Gold with 465.3 cwt/acre and 'All Blue' with 566.2

cwt/acre (Table 4). Yukon Gold, 'POR03PG80-2', and 'POR04PG39-2' had more than 100 cwt/acre of oversized tubers over 10 oz. Promising clones with favorable yield, appearance, and taste (Tables 7 and 8) are being advanced to the Western Regional Specialty Trial.

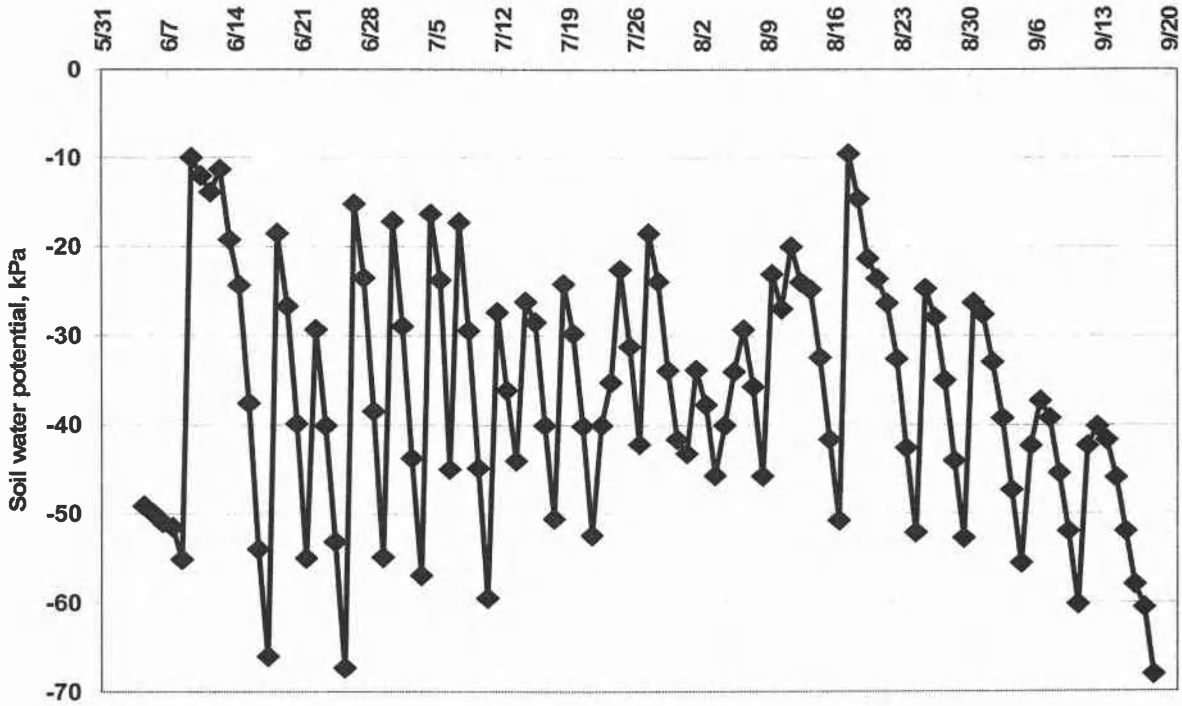


Figure 1. Soil water potential in the sprinkler-irrigated potato variety trials at Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

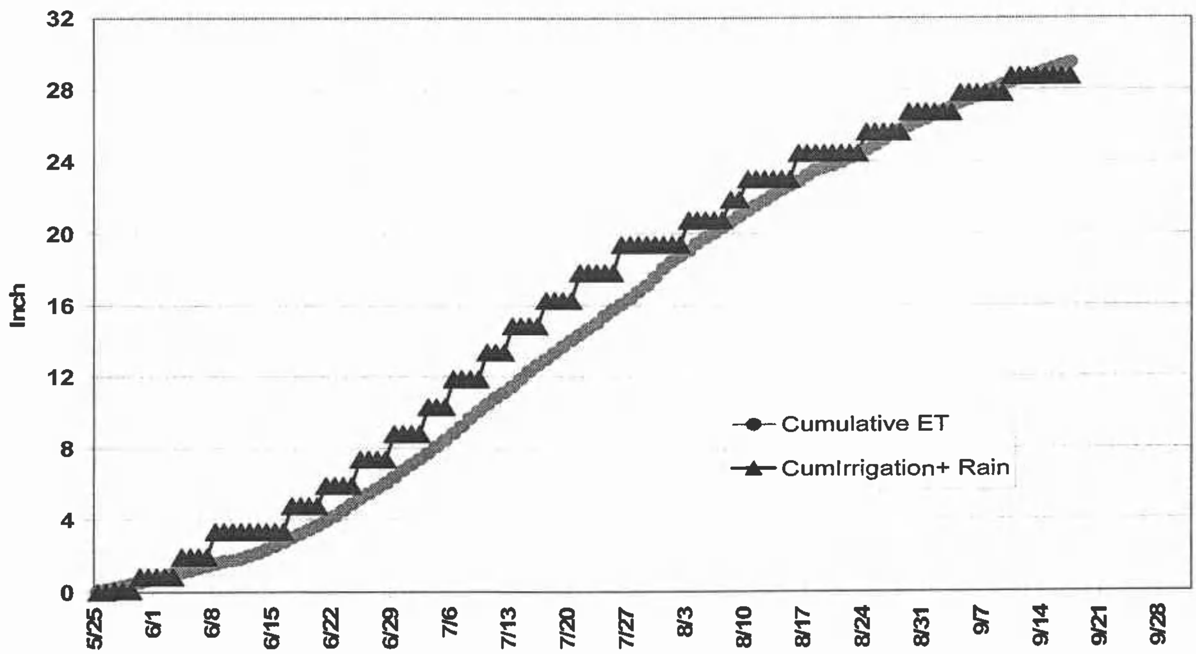


Figure 2. Crop evapotranspiration (ET_c) and sprinkler-irrigation applied (plus rain) to potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Table 1. Western Regional Late Harvest Trial potato yield, grade, and processing quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total No. 1	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length /width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								ratio	g cm-3	%	%
Ranger Russet	693.2	71.4	494.0	254.2	194.4	45.5	132.0	626.0	44.1	20.4	1.91	1.0907	44.8	0
Russet Burbank	763.8	62.7	479.1	164.3	250.1	64.7	198.4	677.5	56.8	27.7	1.97	1.0779	44.5	0
Russet Norkotah	527.7	79.2	416.3	117.4	217.3	81.6	46.2	462.5	51.7	13.3	1.88	1.0645	39.3	2.5
A95409-1	618.8	89.9	558.9	302.8	216.7	39.4	32.4	591.3	22.7	0.0	1.76	1.0894	32.8	0
A96104-2	669.9	83.6	563.3	206.7	267.0	89.6	41.1	604.5	58.0	7.5	1.74	1.0830	45.1	0
A97287-6	714.2	88.0	628.7	271.8	288.9	68.0	37.6	666.3	44.6	3.3	1.77	1.0874	47.4	0
AC96052-1RU	570.4	87.4	498.7	145.9	283.7	69.1	22.7	521.4	45.6	2.0	1.65	1.0825	52.2	0
AO96141-3	822.8	72.1	592.4	196.1	321.2	75.1	182.2	774.6	44.5	1.7	1.94	1.0916	43.8	0
AO96164-1	827.0	86.7	716.7	322.5	313.8	80.4	60.6	777.3	32.8	15.1	1.77	1.0883	51.7	0
AOA95154-1	646.3	85.5	555.6	151.1	319.0	85.5	28.8	584.4	58.9	2.4	1.62	1.0878	51.1	0
AOA95155-7	610.9	84.6	518.8	249.5	238.0	31.2	49.0	567.7	33.6	6.1	1.76	1.0790	47.4	0
AOTX95265-2ARu	559.5	88.2	493.2	246.6	193.3	53.4	22.6	515.8	33.1	9.8	1.74	1.0683	50.5	0
AOTX95265-3Ru	658.4	89.2	586.9	270.0	254.0	63.0	30.3	617.3	35.4	2.8	1.92	1.0690	34.4	0
AOTX95265-4Ru	506.8	83.3	421.9	228.2	148.7	45.1	47.8	469.7	28.9	4.4	1.80	1.0669	37.0	0
CO95172-3RU	738.7	82.2	609.4	177.6	357.7	74.1	66.4	675.9	54.2	3.6	1.69	1.0876	36.0	0
CO97087-2RU	666.6	66.6	442.5	168.5	208.5	65.4	141.2	583.6	51.3	20.6	1.75	1.0835	38.1	0
CO97138-3RU	531.0	85.3	453.1	188.7	212.2	52.2	30.1	483.2	36.8	9.2	1.74	1.0741	47.7	2.5
CO97138-7RU	665.3	81.0	539.0	293.9	198.0	47.1	75.2	614.2	49.5	1.6	1.65	1.0682	33.6	0
TXA549-1Ru	663.1	84.6	562.9	311.4	212.6	38.9	47.0	609.9	37.9	9.5	1.46	1.0784	33.4	0
Mean	655.5	81.7	533.2	224.6	247.1	61.5	68.0	601.2	43.2	8.5	1.76	1.0799	42.7	0.3
LSD (0.05)	103.2	6.6	104.1	79.6	67.5	22.7	39.5	106.2	17.3	NS	0.13	0.0191	2.9	NS

Table 2. Oregon Statewide Trial potato yield, grade, and processing quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	-----------------------------------cwt/acre							-----------------------------------	ratio	g cm-3	%	%
Russet Burbank	659.2	40.1	265.3	92.6	124.0	48.8	260.5	525.9	41.4	82.7	1.94	1.0751	39.1	2.5
Ranger	606.7	73.2	443.6	230.2	168.0	45.4	99.4	543.0	27.4	34.8	1.95	1.0885	45.3	2.5
Shepody	645.0	65.8	424.5	239.8	155.4	29.3	135.5	559.9	17.0	63.6	1.44	1.0869	42.6	0
Norkotah	552.3	75.8	417.8	166.3	205.1	46.3	90.8	508.6	31.3	10.0	1.85	1.0686	32.8	2.5
AO96164-1	698.1	74.9	523.3	214.1	235.4	73.8	134.4	657.7	36.2	2.0	1.77	1.0863	52.6	0
AO96141-3	729.0	63.9	466.5	128.6	273.2	64.8	184.3	650.8	55.1	23.0	1.79	1.0933	51.9	0
AO96305-3	547.2	81.4	450.3	161.9	235.3	53.1	59.2	509.5	34.2	1.9	2.03	1.0853	51.1	0
AO96365-2	664.5	79.7	531.3	170.5	284.6	76.3	80.3	611.6	44.7	8.2	1.52	1.0852	43.8	0
AO98282-5	807.1	80.6	648.2	277.2	295.9	75.1	106.3	754.5	36.1	16.0	1.85	1.0985	50.8	0
AO00057-2	524.0	87.0	455.1	249.7	178.3	27.1	49.1	504.2	16.5	3.4	1.74	1.0894	50.3	0
AO98259-6	473.9	74.0	349.7	82.7	205.3	61.7	98.0	447.7	18.2	6.7	1.53	1.0845	49.5	0
AO98286-4	656.1	82.0	536.6	242.0	227.5	67.1	69.8	606.4	33.1	15.4	1.66	1.0733	35.9	0
AO01057-5	549.1	83.5	459.7	195.9	209.6	54.2	57.5	517.2	30.6	1.3	1.65	1.0794	42.3	0
AO02027-6	584.6	78.5	457.2	195.8	219.8	41.6	99.5	556.7	22.1	4.9	1.82	1.082	48.5	0
AO02103-1	429.6	75.4	323.3	120.5	154.6	48.1	72.3	395.6	24.0	7.9	1.76	1.0752	48.4	0
AO02182-1	569.9	78.4	448.1	229.8	164.1	54.2	89.3	537.3	31.0	1.5	1.97	1.074	42.0	0
AO02183-2	694.3	79.3	554.0	263.1	223.7	67.3	86.5	640.5	39.3	13.3	1.95	1.0855	52.1	0
AO02196-5	480.6	80.9	387.5	214.1	146.7	26.7	75.8	463.3	14.4	1.6	1.88	1.0943	51.9	0
OR03029-2	480.2	52.1	253.2	10.2	83.0	160.1	4.3	257.4	222.2	0.0	1.54	1.0995	51.7	0
Mean	597.4	74.0	441.8	183.4	199.4	59.0	97.5	539.4	40.8	15.7	1.80	1.1	46.5	0.4
LSD (0.05)	108.6	9.5	108.8	86.9	56.9	23.6	53.1	109.1	13.4	13.0	0.15	0.0046	3.3	NS

Table 3. Western Regional Specialty Potato Trial yield and grade of colored flesh clones. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Skin/flesh color	Total yield	U.S. No. 1 <4 oz	U.S. No. 1 4-6 oz	U.S. No. 1 6-10 oz	U.S. No. 1 4-10 oz	>10 oz	U.S. No. 2	Cull	U.S. No. 2 + culls	Rotten tubers	Ave. tuber weight	No. of tubers /plant
		cwt/acre										oz	
Dk Red Norland	red/white	686.9	48.6	76.4	281.7	358.1	266.2	14.0	0.0	14.0	0.0	7.1	8.0
Red LaSoda	red/white	625.9	45.4	46.3	192.5	238.8	323.2	16.5	0.0	16.5	1.9	7.0	7.4
CO98012-5R	red/white	596.2	304.7	169.2	107.2	276.4	5.8	8.9	0.0	8.9	0.4	3.1	15.9
AC97521-1R/Y	red/yellow	837.4	223.5	261.2	251.0	512.3	31.4	68.8	0.0	68.8	1.4	4.2	16.4
ATTX961014-1R/Y	red/yellow	657.1	105.0	114.4	252.0	366.3	142.8	43.0	0.0	43.0	0.0	5.5	9.9
ATTX98500-2P/Y	red/yellow	784.0	115.6	149.2	343.4	492.6	119.3	55.2	0.0	55.2	1.4	5.4	12.1
CO97232-1R/Y	red/yellow	482.6	123.0	131.5	173.6	305.0	36.6	18.0	0.0	18.0	0.0	4.7	8.6
CO97232-2R/Y	red/yellow	479.7	116.0	108.8	180.4	289.2	54.2	20.3	0.0	20.3	0.0	4.7	8.6
CO97233-3R/Y	red/yellow	552.2	128.4	94.9	146.4	241.3	80.8	101.3	0.0	101.3	0.4	4.8	9.5
POR00PG4-1	red/yellow	342.0	86.2	69.2	111.9	181.1	64.9	9.9	0.0	9.9	0.0	4.8	6.1
CO97222-1R/R	red/red	447.0	209.7	112.6	101.4	214.0	20.7	2.5	0.0	2.5	0.0	3.2	11.6
CO97226-2R/R	red/red	562.3	228.8	139.4	143.6	283.0	25.7	24.0	0.8	24.8	0.0	3.3	14.1
POR01PG20-12	red/red	695.6	206.6	160.8	222.6	383.4	66.2	36.5	0.0	36.5	2.9	4.1	14.1
POR01PG22-1	red/red	593.4	362.9	113.6	50.2	163.8	4.5	60.6	0.0	60.6	1.5	2.5	20.1
POR02PG5-1	red/red	881.6	70.9	93.4	332.8	426.2	357.8	26.2	0.0	26.2	0.5	6.9	10.5
All Blue	purple/purple	559.1	333.0	120.0	37.3	157.3	7.6	60.5	0.0	60.5	0.8	2.6	18.1
CO97215-2P/P	purple/purple	555.2	252.8	135.2	129.4	264.6	14.6	22.4	0.0	22.4	0.8	3.2	14.3
CO97227-2P/PW	purple/purple	669.9	425.4	115.3	73.5	188.7	4.4	50.7	0.0	50.7	0.7	2.6	22.0
POR01PG16-1	purple/purple	333.1	223.5	60.1	12.1	72.1	0.0	36.4	0.0	36.4	1.0	2.4	11.3
Yukon Gold	white/yellow	448.3	33.9	56.2	169.3	225.5	173.3	14.9	0.0	14.9	0.7	6.9	5.4
A96510-4Y	russet/yellow	821.9	51.7	48.8	198.4	247.2	460.0	62.9	0.0	62.9	0.1	7.2	9.5
POR02PG26-5	yellow/yellow	610.2	90.6	124.0	258.3	382.3	104.9	31.1	0.0	31.1	1.2	5.5	9.3
POR02PG37-2	yellow/yellow	581.7	187.4	168.8	188.1	356.9	33.1	4.4	0.0	4.4	0.0	4.1	11.8
Mean		600.1	172.8	116.0	172.0	288.1	104.3	34.3	0.0	34.3	0.7	4.6	11.9
LSD (0.05)		109.5	41.7	39.7	58.2	77.2	63.9	38.1	NS	38.2	NS	0.8	2.1

Table 4. Oregon Specialty Potato Trial yield and grade of colored flesh clones. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Total yield	U.S. No. 1 >4 oz	U.S. No. 1 4-6 oz	U.S. No. 1 6-10 oz	U.S. No. 1 4-10 oz	U.S. No. 1 >10 oz	U.S. No. 1 <10 oz	U.S. No. 2	Cull	U.S. No. 2 + culls	Rotten tubers
	cwt/acre										
Yukon Gold	465.3	30.8	63.3	161.2	224.5	255.3	187.5	18.5	0.0	18.5	4.1
All Blue	566.2	300.5	167.5	76.3	243.9	544.3	4.8	17.1	0.0	17.1	0.0
PA96RR1-193	654.6	173.5	191.5	240.1	431.6	605.1	31.9	15.4	0.0	15.4	2.2
POR01PG45-5	683.1	163.0	177.4	275.3	452.7	615.6	44.5	20.5	1.7	22.2	0.7
OR00068-11	848.3	209.1	287.2	286.9	574.1	783.2	45.3	14.2	0.0	14.2	5.6
POR03PG12-2	409.7	159.9	134.1	93.1	227.2	387.1	15.0	7.0	0.0	7.0	0.6
POR03PG23-1	545.3	358.6	128.6	48.6	177.2	535.8	0.0	7.8	1.3	9.1	0.3
POR03PG80-2	635.1	26.4	60.8	237.2	298.0	324.4	258.9	48.5	0.0	48.5	3.4
POR04PG01-2	714.9	147.1	174.7	284.8	459.5	606.5	83.2	24.6	0.0	24.6	0.6
POR04PG03-9	726.8	308.3	209.9	155.0	364.9	673.2	46.8	5.9	0.0	5.9	0.8
POR04PG39-2	705.5	81.8	100.3	238.8	339.0	420.8	174.4	105.2	0.0	105.2	5.1
Mean	632.3	178.1	154.1	190.7	344.8	522.8	81.1	25.9	0.3	26.2	2.1
LSD (0.05)	100.3	36.1	40.4	58.0	85.4	83.9	60.2	19.2	NS	19.0	NS

Table 5. Observations of potato varieties in the Western Regional Specialty Trial, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

No.	Variety	Field observations	Observations after storage
1	Dark Red Norland	Unattractive medium red, large, irregular, flattened tubers	Ugly
2	Red LaSoda	Unattractive pale red, large tubers, folded bud ends	Ugly
3	CO98012-5R	Nice bright red, uniform size	Nice red appearance
4	AC97521-1R/Y	Pear shaped, pointed ends	Some shatter bruise
5	ATTX961014-1R/Y	Some pear shaped, pointed	Some sprouting
6	ATTX98500-2P/Y	Dark attractive purple, some irregular	Some sprouting
7	CO97232-1R/Y	Pale red skin, some irregular, heart, pear, knobs	Skins easily
8	CO97232-2R/Y	Russeted red, some pears and folded bud end	Some sprouting
9	CO97233-3R/Y	Pear shaped	Cracked skin
10	POR00PG4-1	Bright splashed ugly-pink skin, rhizoctonia, died early	
11	CO97222-1R/R	Dark red scaly skin tends to brown, good size distribution	Skin cracks are ugly
12	CO97226-2R/R	Drab dark red, tubers can be large, irregular, folded bud ends, growth cracks	Peeping, cracked skin
14	POR01PG20-12	Violet-rose color, irregular, pointed, pear shaped, curved	
15	POR01PG22-1	Rhizoctonia on fingerlings, greening on apical ends	
16	POR02PG5-1	Unattractive skin, productive	Ugly cracked skin
17	All Blue	Attractive skin, some curved, pointed irregular, dumbbell, bottle-necked tubers	Ugly cracked skin
18	CO97215-2P/P	Round purple, some irregular tubers	Black, nice
19	CO97227-2P/PW	Dark purple, some irregular	Black
20	POR01PG16-1	Very dark purple, some irregular, pointed, curved, shatter bruise	Some skin cracking
21	Yukon Gold	Light yellow, some irregular, folded bud end, oversized, shatter bruise	Greening
22	A96510-4Y	Russet, Big, irregular, growth cracks, secondary growth	Huge tubers
23	POR02PG26-5	Splashed red skin, irregular, some too big	Rhizoctonia ruins appearance
24	POR02PG37-2	Splashed red skin, uniform size, some irregular	Heavily sprouted

Table 6. Potato color and subjective taste rating of varieties in the Western Regional Specialty Trial, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

No.	Variety	Skin color/flesh color	Cooked color and subjective evaluation (4 tasters), microwaved 10 minutes
1	Dark Red Norland	Red/white	Gray white color, bitter
2	Red LaSoda	Pale red/white	White, off flavor
3	CO98012-5R	Red/bright white	Bright white, good flavor
4	AC97521-1R/Y	Red/light yellow	Yellow, good flavor, creamy, pasty
5	ATTX961014-1R/Y	Red/light yellow	Pale yellow with pink flecks, grainy
6	ATTX98500-2P/Y	Purple/light yellow	Bright yellow to variable, good flavor
7	CO97232-1R/Y	Red/light yellow	Yellow, somewhat bitter
8	CO97232-2R/Y	Red/light yellow	Yellow, agreeable, different
9	CO97233-3R/Y	Red/light yellow	Light yellow, repugnant taste
10	POR00PG4-1	Purple to russet/light yellow	Light yellow, good taste, somewhat bitter aftertaste
11	CO97222-1R/R	Reddish/bright red	Dark red, good, sweetness, grainy, latent aftertaste
12	CO97226-2R/R	Reddish/red	Dark red, mostly okay, slightly off flavor
14	POR01PG20-12	Reddish/red	Mottled to patterned red and white to purplish, variable by tuber, from okay to bitter to terrible
15	POR01PG22-1	Reddish/red	Uniform pink, okay
16	POR02PG5-1	Reddish/mottled red	Mottled purple inside unattractive gray-white ring, okay taste, grainy appearance
17	All Blue	Purple/purple	Mottled purple inside unattractive gray-white ring, okay, slightly pasty, slight aftertaste
18	CO97215-2P/P	Purple/purple	Dark purple, bland, grainy, varies from sweet to bitter
19	CO97227-2P/PW	Purple/purple	Very attractive, uniform royal purple, okay, dense, slight off flavor
20	POR01PG16-1	Purple/purple	Dark purple, very firm - needed slightly more cooking, okay, slight off flavor
21	Yukon Gold	Light yellow/light yellow	Very light yellow, okay, distinctive flavor
22	A96510-4Y	Russet/light yellow	Almost white, like an ordinary potato
23	POR02PG26-5	White w. pink eyes/light yellow	Very slightly yellow, okay, pasty, slightly bitter
24	POR02PG37-2	White w. pink eyes/light yellow	Very slightly yellow, slightly sweet, slightly pasty, slightly off flavor

Table 7. Observations of potato varieties in the Oregon Advanced Specialty Trial, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

No.	Variety	Field observations	Observations after storage
1	Yukon Gold	Irregular, some oversized	
2	All Blue	Small tubers, plants died early	
3	PA96RR1-193	Plants died early	A few sprouts
4	POR01PG45-5	Irregular, pear shaped, folded bud ends	
5	OR00068-11	Tends to be round, irregular	
6	POR03PG12-2	Died early	
7	POR03PG23-1	Round to pointed ends	Red skin is cracked
8	POR03PG80-2	Some bottleneck and pointed ends, "lavender glow" skin	Really big tubers
9	POR04PG01-2	Prominent eyebrows, uniform size	Badly sprouted, ugly
10	POR04PG03-9	Irregular, attractive	Sprouted
11	POR04PG39-2	Some big tubers	Nice appearance

Table 8. Potato color and subjective taste rating of varieties in the Oregon Advanced Specialty Trial, Oregon State University Malheur Experiment Station, Ontario, OR, 2007.

No.	Variety	Skin color/flesh color	Subjective evaluation (4 tasters), microwaved 10 minutes
1	Yukon Gold	Light yellow/light yellow	Moist, creamy, smooth, light yellow when cooked
2	All Blue	Med. purple/mottled purple	Slightly bitter, unattractive dark when cooked
3	PA96RR1-193	Red/red with white center	Sweet, agreeable, pretty, medium pink cooked
4	POR01PG45-5	Pale purple/yellow	Dry, chalky texture, lighter than Yukon Gold when cooked
5	OR00068-11	Dark purple/mottled purple	Bitter aftertaste, medium blue
6	POR03PG12-2	Dark purple/mottled purple	Pasty, horrible taste, ruins other food, pale blue cooked
7	POR03PG23-1	Red with white/red w. white	Attractive, agreeable, a different potato, dark pink
8	POR03PG80-2	Light purple/yellow	Similar flavor to Yukon Gold, slightly darker and stronger
9	POR04PG01-2	Purple with white/yellow with purple pattern	Nice texture, some aftertaste
10	POR04PG03-9	Red with white/mottled red and white	Okay but slightly acid
11	POR04PG39-2	Red/pink	Bizarre mottled cooked appearance, thick without being dry, yummy

EVALUATION OF V-10142 (IMAZOSULFURON) FOR YELLOW NUTSEDGE CONTROL IN POTATOES

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Weeds are a major production problem for potato growers in eastern Oregon and other parts of the world. If not controlled in a timely manner, weeds can reduce tuber yields through direct competition with the crop for light, moisture, and nutrients, and may harbor insects and diseases that affect potatoes. Growers are always looking for newer and better herbicides to control weeds, especially in the earlier part of the growing season when newly emerged potato plants are vulnerable to competition. Products that control yellow nutsedge are especially sought by growers in eastern Oregon where the weed is widely distributed. Control of yellow nutsedge is extremely critical and a major emphasis is to use soil residual herbicides before the weeds emerge and establish to compete with the crop. If left uncontrolled, yellow nutsedge will reduce potato tuber yield and most importantly, it will produce more tubers that help to sustain its distribution in the field. There are reports that yellow nutsedge rhizomes can penetrate potato tubers and lower both yield and quality (Boldt 1976).

The varieties grown for processing in Malheur County, Oregon are mainly 'Ranger Russet', 'Shepody', and 'Russet Burbank'. Potatoes are generally planted in late March in beds formed during the previous fall. All soil-applied herbicides are sprayed and incorporated before potato emergence. The herbicide tested in this study, V-10142, is soil applied but does not require incorporation, and as such will reduce field activities.

Materials and Methods

A field study was established in a grower field planted to Russet Burbank near Adrian, Oregon. The objective was to determine the most efficient rates, timings, and phytotoxicity of V-10142 herbicide when applied to potatoes alone and in combinations with other herbicides. The study was laid out in a randomized complete block design with four replications; individual plots measured 9 ft wide by 30 ft long. The potatoes were planted in 30-inch beds on April 6 and emerged on May 7, 2007. Pre-emergence (PRE) treatments were applied on April 30 using a CO_2 sprayer with a boom fitted with four EVS 8002 flat-fan nozzles. There was no incorporation of the herbicides after applications were done. All postemergence (POST) treatments included methylated seed oil (MSO) at 1 percent V/V and were applied on May 24, 2007 when potato seedling height was about 6 inches and yellow nutsedge was about 4 inches high. Evaluations for phytotoxicity and yellow nutsedge control were done at 7, 14, and 46 days after treatment (DAT). Evaluations were based on visual estimates on a 0-100 percent (0 = no crop phytotoxicity or weed control and 100 = total crop injury or excellent weed control). The data were subjected to analysis of variance and means separated using the least significant difference (LSD) at P = 0.05 percent. Potatoes received overhead irrigation to keep the soil moist and were fertilized and sprayed for insect and disease prevention using recommended production practices for the area. Potatoes were harvested at maturity from the center row, graded following USDA standards, and specific gravity was determined.

Results and Discussion

There was no evident potato injury with any of the V-10142 treatments at any of the evaluation dates (Table 1). The best yellow nutsedge control was observed when a sequential application of PRE was followed by a POST application of V-10142. Yellow nutsedge control was low when V-10142 was applied PRE at 6.4 oz/acre. Yellow nutsedge control at the time of potato canopy closure tended to be greater with sequential applications of V-10142 applied PRE and POST than with single applications of V-10142 applied PRE. Control of yellow nutsedge by sequential applications at 21 DAT ranged from 88 to 94 percent and was similar to that provided by the standard herbicide application of Eptam® plus Prowl® H2O plus Dual Magnum® at 4.5 plus 1.58 plus 1.0 pt/acre, respectively. A similar trend was observed for the evaluations at potato row closure (July 9, 2007). With the exception of the lowest rate of V-10142 applied PRE, all herbicide treatments increased the marketable potato tuber yield compared to the untreated control (Table 2). Tuber yields tended to be greater with sequential application of V-10142 PRE followed by POST than PRE alone. The herbicide V-10142 has potential to become a valuable product for yellow nutsedge control in potato.

References

Boldt, P.F. 1976. Factors influencing the selectivity of U-compounds on yellow nutsedge. M. S. Thesis, Cornell University, Ithaca, NY.

Table 1. Potato response to V-10142 herbicide and yellow nutsedge control on June 1 and 7, 2007 at the Malheur Experiment Station, Oregon State University, Ontario, OR.

			Potato			Yellow nutsedge	Potato			Yellow nutsedge
			6/1/2007				6/7/2007			
			Chlorosis	Necrosis	Growth reduction	Control	Chlorosis	Necrosis	Growth reduction	Control
Treatment[a]	Rate	Timing[b]	%				%			
1 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0
2 V10142	8.5 oz/acre	PRE	0.0	0.0	0.0	77.5	0.0	0.0	0.0	78.8
3 V10142	10.7 oz/acre	PRE	0.0	0.0	0.0	70.0	0.0	0.0	0.0	72.5
4 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	86.3	0.0	0.0	0.0	78.8
V10142	6.4 oz/acre	POST								
MSO	1.6 pt/acre	POST								
5 V10142	8.5 oz/acre	PRE	0.0	0.0	0.0	90.0	0.0	0.0	0.0	87.5
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
6 V10142	10.7 oz/acre	PRE	0.0	0.0	0.0	95.0	0.0	0.0	0.0	90.0
V10142	10.7 oz/acre	POST								
MSO	1.6 pt/acre	POST								
7 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	92.5	0.0	0.0	0.0	90.0
D. Magnum	1.0 pt/acre	PRE								
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
8 Matrix	1.0 oz/acre	PRE	0.0	0.0	0.0	86.3	0.0	0.0	0.0	81.3
D. Magnum	1.0 pt/acre	PRE								
Matrix	1.0 oz/acre	POST								
MSO	1.6 pt/acre	POST								
9 D. Magnum	1.0 pt/acre	PRE	0.0	0.0	0.0	90.0	0.0	0.0	0.0	81.3
Sencor 4	0.38 pt/acre	PRE								
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
10 D. Magnum	1.0 pt/acre	PRE	0.0	0.0	0.0	93.8	0.0	0.0	0.0	88.8
Sencor 4	0.38 pt/acre	PRE								
Matrix	1.0 oz/acre	POST								
MSO	1.6 pt/acre	POST								
11 Eptam 7E	4.5 pt/acre	PRE	0.0	0.0	0.0	78.8	0.0	0.0	0.0	63.8
Prowl H2O	1.58 pt/acre	PRE								
D. Magnum	1.0 pt/acre	PRE								
12 untreated			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD (P = 0.05)			--	--	--	12.35	--	--	--	18.82
Standard Deviation			--	--	--	8.55	--	--	--	13.02
CV			--	--	--	11.28	--	--	--	18.13

[a]MSO = Methylated seed oil; D. Magnum = Dual Magnum.

[b]Timing PRE = Pre-emergence, POST = Post-emergence.

Table 1 continued. Potato response to V-10142 herbicide and yellow nutsedge control on June 14 and July 9, 2007 at the Malheur Experiment Station, Oregon State University, Ontario, OR.

			Potato			Yellow nutsedge	
			6/14/2007			6/14/2007	7/9/2007
			Chlorosis	Necrosis	Growth reduction	Control	Control
Treatment[a]	Rate	Timing[b]	%			%	
1 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	55.0	65.0
2 V10142	8.5 oz/acre	PRE	0.0	0.0	0.0	75.0	78.8
3 V10142	10.7 oz/acre	PRE	0.0	0.0	0.0	82.5	86.3
4 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	88.8	92.5
V10142	6.4 oz/acre	POST					
MSO	1.6 pt/acre	POST					
5 V10142	8.5 oz/acre	PRE	0.0	0.0	0.0	88.8	90.0
V10142	8.5 oz/acre	POST					
MSO	1.6 pt/acre	POST					
6 V10142	10.7 oz/acre	PRE	0.0	0.0	0.0	95.0	95.0
V10142	10.7 oz/acre	POST					
MSO	1.6 pt/acre	POST					
7 V10142	6.4 oz/acre	PRE	0.0	0.0	0.0	95.0	95.0
D. Magnum	1.0 pt/acre	PRE					
V10142	8.5 oz/acre	POST					
MSO	1.6 pt/acre	POST					
8 Matrix	1.0 oz/acre	PRE	0.0	0.0	0.0	87.5	88.8
D. Magnum	1.0 pt/acre	PRE					
Matrix	1.0 oz/acre	POST					
MSO	1.6 pt/acre	POST					
9 D. Magnum	1.0 pt/acre	PRE	0.0	0.0	0.0	93.8	95.0
Sencor 4	0.38 pt/acre	PRE					
V10142	8.5 oz/acre	POST					
MSO	1.6 pt/acre	POST					
10 D. Magnum	1.0 pt/acre	PRE	0.0	0.0	0.0	95.0	95.0
Sencor 4	0.38 pt/acre	PRE					
Matrix	1.0 oz/acre	POST					
MSO	1.6 pt/acre	POST					
11 Eptam 7E	4.5 pt/acre	PRE	0.0	0.0	0.0	95.0	95.0
Prowl H2O	1.58 pt/acre	PRE					
D. Magnum	1.0 pt/acre	PRE					
12 untreated			0.0	0.0	0.0	0.0	0.0
LSD (P =.05)			--	--	--	10.57	8.81
CV			--	--	--	9.23	7.5

[a]MSO = Methylated seed oil; D. Magnum = Dual Magnum.
[b]Timing PRE = Pre-emergence, POST = Post-emergence.

Table 2. Potato tuber yield in response to V-10142 herbicide application to control yellow nutsedge at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment[a]	Rate	Timing[b]	<4oz CWT/acre	4-6oz CWT/acre	6-12oz CWT/acre	>12oz CWT/acre	Marketable CWT/acre	twos CWT/acre	cull CWT/acre	Specific gravity g/cm^{-3}
			---- Potato Tuber Yield						----	
1 V10142	6.4 oz/acre	PRE	56	54	204	152	411	50	3	1.0738
2 V10142	8.5 oz/acre	PRE	41	57	202	146	406	55	10	1.0698
3 V10142	10.7 oz/acre	PRE	76	65	198	133	396	83	28	1.0715
4 V10142	6.4 oz/acre	PRE	56	62	270	117	409	56	2	1.0785
V10142	6.4 oz/acre	POST								
MSO[a]	1.6 pt/acre	POST								
5 V10142	8.5 oz/acre	PRE	68	72	217	147	436	79	13	1.0748
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
6 V10142	10.7 oz/acre	PRE	52	75	256	153	483	80	20	1.0828
V10142	10.7 oz/acre	POST								
MSO	1.6 pt/acre	POST								
7 V10142	6.4 oz/acre	PRE	65	82	261	127	470	48	4	1.0780
Dual Magnum	1.0 pt/acre	PRE								
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
8 Matrix	1.0 oz/acre	PRE	69	69	255	191	515	82	29	1.0780
Dual Magnum	1.0 pt/acre	PRE								
Matrix	1.0 oz/acre	POST								
MSO	1.6 pt/acre	POST								
9 Dual Magnum	1.0 pt/acre	PRE	56	67	231	180	478	47	9	1.0770
Sencor 4	0.38 pt/acre	PRE								
V10142	8.5 oz/acre	POST								
MSO	1.6 pt/acre	POST								
10 Dual Magnum	1.0 pt/acre	PRE	66	71	270	180	522	45	18	1.0775
Sencor 4	0.38 pt/acre	PRE								
Matrix	1.0 oz/acre	POST								
MSO	1.6 pt/acre	POST								
11 Eptam 7E	4.5 pt/acre	PRE	54	96	247	116	459	76	9	1.0813
Prowl H2O	1.58 pt/acre	PRE								
Dual Magnum	1.0 pt/acre	PRE								
12 untreated			55	87	206	106	400	28	2	1.0848
LSD (P = 0.05)			NS	24.4	57.2	45.4	79.7	41.3	21.5	NS
CV			34.43	23.61	16.87	21.57	12.3	46.96	120.79	0.77

[a]MSO = Methylated seed oil. [b]Timing PRE = Pre-emergence, POST = Post-emergence.

SOYBEAN PERFORMANCE IN ONTARIO IN 2007

Clinton C. Shock, Erik B.G. Feibert, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR

Introduction

Soybean is a potentially valuable new crop for the Pacific Northwest. Soybean can provide raw materials for biodiesel, high quality protein for animal nutrition, and oil for human consumption, all of which are in short supply in the Pacific Northwest. In addition, edible or vegetable soybean production can provide a raw material for specialized food products. Soybean is valuable as a rotation crop because of the soil-improving qualities of its residues and its nitrogen (N_2)-fixing capability. Because high-value irrigated crops are typically grown in the Snake River Valley, soybeans may be economically feasible only at high yields. The most common rotation crop in the Treasure Valley is irrigated winter wheat, so soybeans need to be competitive with winter wheat. Through breeding, selection, and the development of appropriate cultural practices, we have succeeded in achieving high yields.

Soybean varieties developed for the midwestern and southern states are not necessarily well adapted to Oregon's lower night temperatures, lower relative humidity, and other climatic differences. Previous research at Ontario, Oregon has shown that, compared to the commercial cultivars bred for the Midwest, plants for eastern Oregon need to have high tolerance to seed shatter, reduced plant height and lodging, increased seed set, and higher harvest index (ratio of seed to the whole plant).

M. Seddigh and G.D. Jolliff at Oregon State University, Corvallis, identified a soybean line that would fill pods when subjected to cool night temperatures. This line was crossed at Corvallis with productive lines to produce 'OR 6' and 'OR 8', among others. At this point, the development moved to Ontario, Oregon. The latter two lines were crossed at our request for several years with early maturing high-yielding semi-dwarf lines by R.L. Cooper (USDA, Agriculture Research Service, Wooster, OH) to produce semi-dwarf lines with potential adaptation to the Pacific Northwest. Selection criteria for F_2 and subsequent lines at the Malheur Experiment Station (MES) included high yield, zero lodging, zero shatter, low plant height, and maturity in the available growing season. We specifically chose seed lines with clear hilum so that off colors would not contaminate possible food products with off colors. Also, we selected for light seed coat and seed color to allow the widest possible food product manufacture.

In 1992, 241 single plants were selected from 5 F_5 lines that were originally bred and selected for adaptation to eastern Oregon. Seed from these selections was planted and evaluated in 1993; 18 F_6 selections were found promising and selected for further testing in larger plots from 1994 through 1999. Through these years of breeding and selection we successfully reduced plant height, reduced plant lodging, and increased yields. Of the 18 lines, 8 were selected for further testing.

In 1999, selections from one of the advanced MES lines were made by P. Sexton at the Central Oregon Agricultural Research and Extension Center (COAREC) in Madras, Oregon to help maintain germplasm true to type. Sixteen of these selections made in Madras were chosen for further testing. In 2000, we made further selections from six of our 1992 MES lines and from OR-6 to help maintain germplasm true to type.

Starting in 2005, a new planting configuration was used. The old planting configuration had one plant row on a 22-inch bed. The new planting configuration has 3 rows on a 30-inch bed. Our objective is to provide a more uniform distribution of the plants over the soil surface. The more uniform plant distribution resulted in higher yields, perhaps due to improved access to light, nutrients, and water for individual plants. The new planting configuration retains the same seeding rate of 200,000 seeds/acre as the old configuration.

This report summarizes work done in 2007 as part of our continuing breeding and selection program to adapt soybeans to eastern Oregon and includes the added yield enhancements achieved by changing the planting configuration. Our soybean reports from the last decade are available at our station web site <**http://www.cropinfo.net**>. There is a search function on the home page that will conveniently find all of our recent reports dealing with soybeans by using the key word "soybean".

Materials and Methods

The 2007 trial was conducted on an Owyhee silt loam (pH of 8.0 and 1.2 percent organic matter) previously planted to wheat. One hundred and seventy-two pounds of phosphate (P_2O_5), 100 lb sulfur (S), 5 lb iron (Fe), 5 lb manganese (Mn), 2 lb copper (Cu), and 1 lb of boron (B) were broadcast in the fall of 2006. After fertilization, the field was disked twice, moldboard plowed, groundhogged twice, and bedded to 30-inch rows. On May 15, 2007, Micro-Tech® herbicide was applied at 3 lb ai/acre and the field was harrowed to incorporate it.

Five commercial cultivars, 5 older lines selected at MES in 1992, and 29 lines selected in 1999 and 2000 were evaluated; these 39 selections were arranged in 10-ft by 25-ft plots in a randomized complete block design with four replicates. The seed was planted on May 16 at 200,000 seeds/acre in 3 rows on each 30-inch bed using a plot drill with disk openers. The rows were spaced 7 inches apart (Fig. 1). *Bradyrhizobium japonicum* inoculant (Cell-Tech®, EMD Crop BioScience, Brookfield, WI) was applied to the seed before planting. Emergence started on May 21.

The field was furrow irrigated when the soil water tension at 8-inch depth reached 50-60 centibars (cb). To understand how to irrigate using soil water tension as an irrigation criteria, see our extension brochure (Shock et al. 2005) listed below. Soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed in the bed center at 8-inch depth. Sensors were automatically read three times a day with an AM-400 meter (Mike Hansen Co., East Wenatchee, WA).

For lygus bug, stinkbug, and spider mite control, the field was sprayed with Lannate® at 0.9 lb ai/acre on July 15, dimethoate at 0.5 lb ai/acre on August 3, and Comite® at 2 lb ai/acre on August 10.

Plant height and reproductive stage were measured weekly for each cultivar. Prior to harvest, each plot was evaluated for lodging and seed shatter. Lodging was rated as the degree to which the plants were leaning over (0 = vertical, 10 = prostrate). The middle two beds in each four-bed plot were harvested on October 16 using a Wintersteiger Nurserymaster small plot combine. Beans were cleaned, weighed, and a subsample was oven dried to determine moisture content. Moisture at the time of analysis was determined by oven drying at 100°C for 24 hours. Dry bean yields were corrected to 13 percent moisture. Variety lodging, plant population, yield, and seed count were compared by analysis of variance. Means separation was determined by the protected least significant difference test.

Results and Discussion

The soybeans in 2007 were planted earlier than in the past and emergence started on May 21, the earliest since 2002. Plant height and lodging in 2007 were on average the highest since 2005 (Tables 1-3). In 2007, only two varieties had lodging of 5 or less on a scale of 1 to 10. The increased plant height and lodging in 2007 could have been due to the earlier emergence, longer vegetative growth stage before floral induction in early to mid-July, and more degree day units. Lodging has also tended to be higher on average with the new planting arrangement.

Yields in 2007 ranged from 49.1 bu/acre for '909' to 69.8 bu/acre for 'M12' (Table 1). Several of the lines had seed counts sufficient for the manufacturing of tofu (<2,270 seeds/lb). Several lines combined high yields, little lodging, and early maturity. Under the new planting arrangement, started in 2005, lines 'M1', M12, 'M13', 'M16', and '608' have had yields higher than 65 bu/acre, lodging less than 8, and seed counts less than 2,270 seeds/lb.

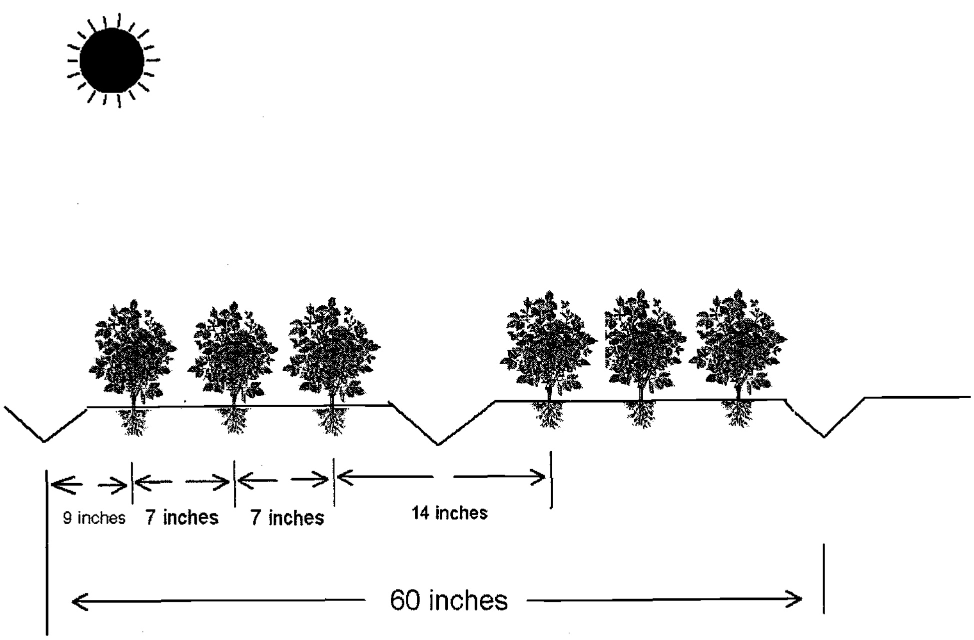


Figure 1. Soybean planting configuration used in 2005-2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Summary

We have found over the years that high soybean yields can be achieved in the Treasure Valley by employing varieties selected for the environment, high planting rates, modest fertilization, use of *Bradyrhizobium japonicum* inoculation, proper May planting dates, appropriate irrigation, and timely control of lygus and spider mites.

References

Shock, C.C., R.J. Flock, E.B.G. Feibert, C.A. Shock, A.B. Pereira, and L.B. Jensen. 2005. Irrigation monitoring using soil water tension. Oregon State University Extension Service. EM8900 6pp. **http://extension.oregonstate.edu/catalog/pdf/em/em8900.pdf**

Table 1. Performance of soybean cultivars in 2007. Cultivars are ranked by yield, Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Origin	Days to maturity	Days to harvest maturity	Lodging	Height	seeds/lb	Yield
		days from emergence		0-10	cm	seeds/lb	bu/acre
909	OR-6	116	128	9.3	125.7	2,338	49.1
601	M92-314	106	118	5.3	82.5	2,321	50.7
311	M92-220	106	118	6.8	91.4	2,370	54.1
905	OR-6	106	118	9.3	134.6	2,401	55.0
309	M92-220	106	118	4.0	104.1	2,304	56.6
M92-220		106	118	4.8	91.4	2,359	57.4
514	M92-237	116	128	8.5	116.8	2,465	59.6
Korada		106	118	6.5	101.6	2,191	61.1
305	M92-220	106	118	7.5	95.3	2,427	61.2
M3	M92-330	106	118	8.3	120.7	2,123	61.5
308	M92-220	106	118	5.5	94.0	2,252	61.6
303	M92-220	106	118	7.8	105.4	2,437	61.8
107	M92-085	106	118	7.8	102.9	2,146	62.5
101	M92-085	106	118	7.5	108.0	2,062	62.7
OR-6		106	118	9.3	157.5	2,322	62.9
313	M92-220	106	118	7.3	99.1	2,267	63.2
Sibley		116	128	8.8	114.3	1,959	63.3
M9	M92-330	106	118	8.3	149.9	2,187	63.8
511	M92-237	116	128	7.8	127.0	2,378	64.0
103	M92-085	106	118	8.3	104.1	2,061	64.1
312	M92-220	106	118	7.5	90.2	2,262	64.3
106	M92-085	106	118	8.0	83.8	2,038	64.7
M4	M92-330	106	118	7.0	118.1	2,109	64.8
M15	M92-330	106	118	8.5	88.9	2,243	64.8
M13	M92-330	106	118	8.5	111.8	2,137	65.6
M2	M92-330	106	118	8.8	96.5	2,062	65.7
M92-225		106	118	7.5	86.4	2,059	65.8
OR-8		116	128	9.5	144.8	2,178	65.8
608	M92-314	106	118	8.3	116.8	2,037	66.3
M92-085		106	118	8.8	119.4	2,057	66.5
Evans		106	118	9.3	110.5	2,268	66.7
Lambert		116	128	9.8	167.6	2,409	66.9
108	M92-085	106	118	7.8	115.6	2,173	66.9
104	M92-085	106	118	8.0	102.9	2,105	67.2
307	M92-220	106	118	7.8	99.1	2,278	67.4
M1	M92-330	106	118	7.8	118.1	2,094	68.0
M16	M92-330	106	118	8.0	120.7	2,128	69.0
Gnome 85		106	118	8.8	113.0	2,188	69.2
M12	M92-330	106	118	8.8	134.6	2,178	69.8
average		108	120	7.8	111.9	2,215	63.1
LSD (0.05)				1.3		141	10.3

Table 2. Performance of soybean varieties from 2005 to 2007. Cultivars are ranked by average yield. Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Yield 2005	Yield 2006	Yield 2007	Average 2005 - 2007 Yield	Average 2005 - 2007 Days to maturity	Average 2005 - 2007 Height
	------------ bu/acre	------------	------------	bu/acre		cm
601	65.6	66.4	50.7	60.9	102	87.8
909	70.8	66.2	49.1	62.0	102	97.6
Sibley	56.2	66.8	63.3	62.1	112	91.4
311	68.1	67.4	54.1	63.2	102	91.8
M92-220	63.4	68.8	57.4	63.2	102	92.5
309	67.5	66.2	56.6	63.4	102	93.4
308	64.6	65.2	61.6	63.8	106	91.0
305	64.2	66.6	61.2	64.0	102	94.4
905	71.1	66.2	55.0	64.1	99	98.9
OR-8	57.8	69.6	65.8	64.4	112	99.9
313	62.5	68.4	63.2	64.7	102	94.0
514	68.6	66.6	59.6	64.9	105	104.9
303	67.7	67.0	61.8	65.5	99	100.1
M2	62.0	70.0	65.7	65.9	102	90.2
511	65.0	70.2	64.0	66.4	109	106.0
Korada	67.8	70.6	61.1	66.5	102	100.5
M92-225	68.0	66.0	65.8	66.6	99	95.8
M13	67.9	66.6	65.6	66.7	99	103.6
OR-6	65.1	72.2	62.9	66.7	99	105.5
307	64.3	70.0	67.4	67.2	102	93.0
M92-085	71.9	64.4	66.5	67.6	99	98.5
108	70.5	65.8	66.9	67.7	99	98.9
M3	69.6	72.2	61.5	67.7	99	106.9
312	68.4	71.8	64.3	68.1	102	90.7
608	70.2	68.0	66.3	68.2	99	99.6
104	70.9	66.6	67.2	68.2	99	98.6
M9	73.9	68.2	63.8	68.6	99	105.0
Evans	69.3	71.0	66.7	69.0	102	95.5
M15	73.9	68.4	64.8	69.0	99	94.6
106	72.0	70.4	64.7	69.0	99	83.6
101	74.4	70.2	62.7	69.1	99	102.7
M16	69.1	69.6	69.0	69.2	99	102.9
Gnome 85	65.4	75.3	69.2	70.0	102	94.3
M12	70.4	70.0	69.8	70.0	99	102.9
103	73.7	72.4	64.1	70.1	99	98.4
M4	73.0	72.6	64.8	70.1	99	99.7
M1	73.0	70.6	68.0	70.5	99	99.4
107	76.6	74.2	62.5	71.1	99	95.0
Lambert	73.3	81.9	66.9	74.0	107	112.2
Average	68.4	69.2	63.1	66.9	101	97.7
LSD (0.05)	8.0	6.1	10.3			

Table 3. Performance of soybean varieties from 2005 to 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Lodging				Seed count			
	2005	2006	2007	average	2005	2006	2007	average
	0-10				seeds/lb			
M92-085	5.8	5.3	8.8	6.6	2,255	2,324	2,057	2,212
M92-220	8.3	6	4.8	6.4	2,393	2,463	2,359	2,405
M92-225	5.8	6.8	7.5	6.7	2,338	2,418	2,059	2,272
OR-6	9.5	8.5	9.3	9.1	2,344	2,300	2,322	2,322
OR-8	9.8	8.7	9.5	9.3	2,041	2,142	2,178	2,120
Evans	9.3	8.5	9.3	9.0	2,286	2,431	2,268	2,328
Gnome 85	9.5	8.8	8.8	9.0	2,300	2,278	2,188	2,255
Korada	5.3	5.5	6.5	5.8	2,306	2,315	2,191	2,271
Lambert	9.3	7.8	9.8	9.0	2,304	2,344	2,409	2,352
Sibley	9.8	8.5	8.8	9.0	1,976	2,273	1,959	2,069
M1	6	5.5	7.8	6.4	2,284	2,216	2,094	2,198
M2	6.5	5.3	8.8	6.9	2,296	2,295	2,062	2,218
M3	3.8	7.3	8.3	6.5	2,352	2,285	2,123	2,253
M4	4.3	6.3	7	5.9	2,349	2,345	2,109	2,268
M9	7.5	2.5	8.3	6.1	2,292	2,455	2,187	2,311
M12	6.8	6.5	8.8	7.4	2,290	2,208	2,178	2,225
M13	4	6.5	8.5	6.3	2,253	2,328	2,137	2,239
M15	4.5	6.3	8.5	6.4	2,220	2,201	2,243	2,221
M16	4.3	5.3	8	5.9	2,268	2,310	2,128	2,235
101	6	5.3	7.5	6.3	2,295	2,172	2,062	2,176
103	5.8	5.5	8.3	6.5	2,318	2,287	2,061	2,222
104	5.3	6.3	8	6.5	2,395	2,154	2,105	2,218
106	5.8	4.5	8	6.1	2,299	2,259	2,038	2,199
107	5	4.3	7.8	5.7	2,269	2,274	2,146	2,230
108	4.8	3.5	7.8	5.4	2,379	2,355	2,173	2,302
303	7	4.8	7.8	6.5	2,480	2,421	2,437	2,446
305	6	5.3	7.5	6.3	2,427	2,490	2,427	2,448
307	6.5	3	7.8	5.8	2,404	2,495	2,278	2,392
308	5.3	3.3	5.5	4.7	2,396	2,622	2,252	2,423
309	6	3.3	4	4.4	2,447	2,499	2,304	2,417
311	7	3.3	6.8	5.7	2,409	2,510	2,370	2,430
312	5.8	4	7.5	5.8	2,403	2,480	2,262	2,382
313	7.5	4.3	7.3	6.4	2,506	2,523	2,267	2,432
511	7	3.8	7.8	6.2	2,563	2,573	2,378	2,505
514	7.3	7	8.5	7.6	2,345	2,316	2,465	2,375
601	6.5	3.8	5.3	5.2	2,336	2,475	2,321	2,377
608	6.8	5.5	8.3	6.9	2,294	2,399	2,037	2,243
905	9	8.8	9.3	9.0	2,430	2,318	2,401	2,383
909	9.3	8.5	9.3	9.0	2,391	2,196	2,338	2,308
Average	6.6	5.7	7.8	6.7	2,332	2,353	2,215	2,300
LSD (0.05)	2	1.7	1.3		131	181	141	

SUGAR BEET VARIETY TRIALS 2007

Clinton C. Shock, Lamont D. Saunders, and Eric P. Eldredge
Malheur Experiment Station
Oregon State University
Ontario, OR

Introduction

The sugar beet industry in southern Idaho and eastern Oregon, in cooperation with Oregon State University, tests conventional and transgenic sugar beet varieties at multiple locations each year to identify varieties with high sugar yield and root quality. A seed advisory committee evaluates the data each year to select the best varieties for sugar production. This report provides the agronomic practices and results for the Malheur Experiment Station location of the 2007 trials.

Methods

Sugar beet varieties were entered by ACH Seeds, Betaseed, Hilleshog/Syngenta, Holly Hybrids, and Seedex in 2007. Thirty varieties were tested in the conventional trial, and 33 varieties were tested in the transgenic trial. In this report, conventional varieties are varieties that are not transgenic, while the transgenic varieties have not yet been released as commercial varieties for sale to the area growers. Seed was organized by Amalgamated Sugar Company, Paul, Idaho.

The 2007 sugar beet trials were grown on Greenleaf silt loam soil where winter wheat was the previous crop. A soil test taken on September 18, 2006, showed pH 7.7, 1.39 percent organic matter, 200 lb available nitrogen (N)/acre in the top 2 ft of soil, 24 ppm extractable phosphorus (P), 436 ppm exchangeable potassium (K), 8 ppm sulfate (SO_4), 472 ppm magnesium (Mg), 83 ppm sodium (Na), 2.4 ppm zinc (Zn), 1.4 ppm copper (Cu), 10 ppm manganese (Mn), 15 ppm iron (Fe), and 0.8 ppm boron (B). The grain stubble was chopped and the field was irrigated and disked, and 200 lb sulfur (S)/acre and 2 lb B/acre fertilizer were applied on October 21. The field was deep ripped, plowed, and ground hogged before Telone® C17 at 15 gal/acre was injected on November 17 and the field was bedded in 22-inch rows.

On March 29, 2007, the bed tops were dragged off with a bed harrow. On March 30, Nortron® was applied at 6 pt/acre and incorporated using the bed harrow on the half of the field where the conventional trial would be planted. This was the first trial of transgenic glyphosate-resistant sugar beet varieties at Malheur Experiment Station. Both the conventional trial and the transgenic trial were planted on April 2. Seed for the 30 varieties tested in the conventional trial, and 33 varieties in the transgenic trial was organized by Amalgamated Sugar Company. Seeds were planted using John Deere model 71 flexi-planter units with double-disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed the seed. Plots of each variety were 4 rows wide (22-inch row spacing) by 23 ft long, with a 3-ft alley separating each tier of plots. The seeding rate was 8 viable seed/ft of row. Each entry was replicated eight times in a randomized complete block design.

On April 4, Counter® 15G was applied in a band over the row at 7.4 lb/acre. The first irrigation was applied on April 11 for 24 hours. The field was furrow irrigated with surge irrigation from gated pipe, using a Waterman LVC-5 surge valve (Waterman Ind. Inc., Exeter, CA). Soil moisture was monitored using seven Watermark soil moisture sensors Model 200SS connected to an Irrometer Monitor (Irrometer Co. Inc., Riverside, CA) and another set of six Watermark soil moisture sensors Model 200SS connected to an AM400 Hansen datalogger (M.K. Hansen Co., Wenatchee, WA) soil moisture was maintained at a soil water tension wetter than 70 centibars (cb) at 10-inch depth in the beet row.

Beets had emerged by April 14, and were still mostly in the cotyledon stage by April 26. The conventional trial was sprayed with Progress® at 1.5 pt/acre plus Upbeet® at 0.5 oz/acre on April 27. The transgenic trial was sprayed with Roundup® WeatherMAX at 22 oz/acre on April 27. On May 3 the beets in the conventional trial were mostly in the 4- to 6-leaf stage, and in the transgenic trial were mostly in the 2- to 4-leaf stage. Alleys were hoed on May 4. Seedlings were thinned by hand to 1 plant per 7 inches on May 10 and 11. On May 11, urea was sidedressed to supply 173 lb N/acre.

The field was sidedressed with Temik® 15G at 10 lb/acre on May 14 to control sugar beet root maggot, and recorrugated. The field was irrigated for 24 hours on May 14 to move the insecticide with the wetting front into the sugar beet seedlings' root zone. On May 20, the conventional trial was sprayed with Progress at 4 pt/acre, Upbeet at 1 oz/acre, Stinger® at 0.5 pt/acre, and Treflan® at 1.5 pint/acre, and the transgenic trial was sprayed with Roundup WeatherMAX at 22 oz/acre. The field was cultivated on May 23 and irrigated on May 29. The first irrigation in the wheel and center furrows was applied on June 4.

The first petiole test, taken on June 8, showed N low at 6,336 ppm, when the sufficiency level was 11,220 ppm; phosphate (P_2O_5) was at the low end of the sufficiency range with 0.27 ppm when the range was 0.25 to 0.7 ppm; SO_4 was low at 0.10 ppm when the sufficiency range was from 0.17 to 0.5 ppm; Mg was marginally sufficient at 0.29 ppm in the sufficiency range of 0.20 to 0.70 ppm; Zn was 19 ppm when the sufficiency range was 17 to 35 ppm; Cu was 9 ppm when the sufficiency range was 5 to 25 ppm; B was slightly low at 22 ppm when the sufficiency range was 23 to 80 ppm, and all other nutrients were sufficient.

Headline® fungicide at 12 oz/acre plus 9-28-3 to supply 1 lb P_2O_5/acre, 0.2 lb Zn/acre, and 0.2 lb Cu/acre were applied by aerial applicator on June 16 to amend nutrients and prevent powdery mildew. With the June 18 irrigation, Epsom salt to supply 5 lb Mg/acre and 6.6 lb SO_4/acre, ammonium thiosulfate (thio-sul) to supply 3.4 lb SO_4 and 2.6 lb

N/acre, solution 32 (UAN) to supply 17.4 lb N/acre, and boron solution to supply 0.2 lb B/acre were applied in the irrigation water.

The second petiole test, taken June 25, showed that N was low at 6,400 ppm when sufficiency was 10,050 ppm and B was low at 22 ppm when sufficiency was 23 ppm. The conventional trial was hand weeded on June 25 in a total of 15 hours, and the transgenic trial was not hand weeded. UAN to supply 20 lb N/acre was applied in the irrigation on June 26. Enable® fungicide at 8 oz/acre with 4 lb S/acre and 0.1 lb B/acre was applied by aerial applicator on June 30. The transgenic trial was sprayed with Roundup WeatherMAX at 22 oz/acre in a spray volume of 28 gal/acre on July 2.

The third petiole test, taken July 9, showed deficiencies in N, SO_4, Mg, and Zn. Thio-sul, UAN, Epsom salt and che-Zinc were applied in the irrigation water on July 12 to supply 20 lb N/acre, 27 lb SO_4/acre, 1.5 lb Mg/acre, and 0.25 lb Zn/acre. An aerial application of Headline fungicide at 12 oz/acre was done on July 15 and included 4 lb S/acre, 0.25 lb Mg/acre, and 0.2 lb Zn/acre.

TopsinM® fungicide at 1 lb/acre plus 4 lb S/acre, 0.25 lb Mg/acre, 0.2 lb Zn/acre, and 0.1 lb Cu/acre were applied by aerial applicator on August 1 to amend nutrients and prevent powdery mildew. The trials were hand weeded on August 2, taking a total of 8 hours on the conventional trial and 7 hours on the transgenic trial.

A fourth petiole test taken on August 14 showed nitrate high at 14,620 ppm when sufficiency was 6,150 ppm, and deficiencies in P_2O_5, S, and Zn. Several species of lepidoptera larvae began feeding on the foliage in mid-August and were controlled with an aerial application on August 23 of Asana® at 9.6 oz/acre. The application included Enable at 8 oz/acre and S at 4 lb/acre because powdery mildew was seen on some young leaves and P_2O_5 at 10 lb/acre and Zn at 0.25 lb/acre to correct nutrient deficiencies.

Bolted beets were counted and removed from plots in the transgenic trial beginning on June 25, and again on July 2, July 9, July 23, and August 15. 'HM9047RR' had a total of 39 bolters, 'HM9076RR' had 28, 'HM9058RR' had 25, and 'HM9040RR' had 2 bolters.

The transgenic sugar beets were harvested October 15 and the conventional trial was harvested October 16. The foliage was flailed and the crowns were removed with rotating disks. All sugar beets in the center two rows of each plot were dug with a two-row wheel-lifter harvester and weighed, and two eight-beet samples were taken from each plot. Samples were hauled each day to the Snake River Sugar factory for laboratory analysis of percent sucrose, nitrate concentration, and conductivity.

The root weight data were examined for outliers as is customary for calculations of sugar beet variety data in these trials. Observations more than two standard deviations from the mean for each variety were deleted. Sugar sample data were checked for errors in sugar percentages and conductivity. Any erroneous sample readings were deleted from the data set.

The weight of sugar beets from each plot was multiplied by 0.90 to estimate tare. Sugar concentrations were "factored" by multiplying measured sucrose by 0.98 to estimate the sugar that would have been lost to respiration if the beets had been stored in a pile. The data for each plot with two samples were averaged for analysis. The percent extraction was calculated using the formula:

$$Ext = 250 + [(1{,}255.2 * Cond) - (15{,}000 * Sug) - 6{,}185] / Sug * (98.66 - 7.845 * Cond)$$

where Ext is percent extraction, Cond is the electrical conductivity in mmho, and Sug is the sucrose concentration in percent.

Variety differences in yield, sucrose content, conductivity, percent extraction, and estimated recoverable sugar were calculated using least-squares means analysis. The varieties are listed in the tables in descending order of estimated recoverable sugar.

Reports of previous years' Oregon State University variety trials are available online at www.cropinfo.net.

Results

The 1.5-acre conventional beet trials required a total of 23 hours of weeding to remain weed free at harvest while the 1.5-acre transgenic trial required only 7 hours.

Variety results were grouped by estimated recoverable sugar for the conventional trial (Table 1) and the transgenic trial (Table 2). The root weights were tared 10 percent, as explained above.

Root yield in the conventional trial averaged 45.18 tared ton/acre and 17.9 percent sugar content (Table 1). Varieties with the highest root yield in the conventional trial included 'Beta 4720R' (49.54 ton/acre), 'Crystal 333R', 'Crystal 316R', 'HH Meridian R', 'HH 06HX623 R', 'Crystal 597R', 'HM 2996Rz', 'Crystal 505R', 'HH Pomerelle R', 'HM 2993Rz', 'HH 06HX620R', and 'Beta 5181N'. Varieties among those with the highest recoverable sugar per acre included Beta 4720R (14,189 lb/acre), Crystal 597R, Crystal 333R, Beta 5181N, Crystal 316R, HH Meridian R, Crystal 505R, 'HM 2996Rz', HH 06HX623 R, HH 06HX620 R, HM 2993Rz, and HH Pomerelle R.

Root yield in the transgenic trial averaged 47.19 tared ton/acre and 17.67 percent sugar content (Table 2). Varieties with the highest root yield in the transgenic trial included 'BTS27RR10' (53.17 ton/acre), 'BTS 26RR18', 'HM9036RR', 'HM 9077RR', 'BTS26RR14', 'Crystal RR929', 'BTS 27RR20', 'BTS 25RR07', and 'BTS 25RR05'.

Varieties with the highest recoverable sugar per acre included BTS 27RR10 (15,880 lb/acre), BTS 26RR18, Crystal RR929, BTS 25RR05, HM 9036RR, HM 9077RR, BTS 27RR20, BTS 26RR14, and BTS 25RR07.

Table 1. Performance of conventional sugar beet varieties, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

Variety	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar		
	ton/acre	%	lb/acre	mmhos	%	lb/ton	lb/acre	ranking[a]
Beta 4720R	49.54	16.81	16651	0.729	85.23	286.6	14189	a
Crystal 597R	47.45	17.59	16696	0.765	84.91	298.7	14177	a
Crystal 333R	49.01	16.79	16448	0.756	84.87	284.9	13960	ab
Beta 5181N	45.03	17.93	16147	0.658	86.37	309.7	13943	abc
Crystal 316R	48.99	16.81	16461	0.778	84.59	284.4	13922	abc
HH Meridian R	48.11	17.10	16453	0.796	84.40	288.7	13890	abc
Crystal 505R	46.49	17.46	16216	0.763	84.90	296.4	13760	abc
HM 2996Rz	47.45	17.08	16200	0.771	84.73	289.5	13729	abc
HH 06HX623 R	47.82	16.95	16205	0.791	84.45	286.2	13686	a-d
HH 06HX620 R	45.15	17.57	15859	0.700	85.76	301.4	13599	a-e
HM 2993Rz	45.92	17.15	15750	0.737	85.19	292.2	13419	a-f
HH Pomerelle R	46.08	17.11	15769	0.744	85.09	291.2	13417	a-f
HM 2999Rz	45.50	17.14	15595	0.773	84.72	290.5	13213	b-g
Crystal 217R	46.25	16.86	15601	0.779	84.58	285.2	13199	b-g
HH Acclaim R	47.01	16.51	15520	0.756	84.82	280.1	13165	b-g
HM 2984Rz	47.42	16.24	15400	0.703	85.45	277.6	13157	b-g
SX Raptor Rz	45.03	17.22	15508	0.769	84.78	292.0	13148	c-g
SX 1524 Rz	44.66	17.10	15264	0.779	84.63	289.3	12917	d-h
Beta 4773R	44.89	17.00	15269	0.806	84.26	286.6	12866	e-i
HH 06HX626 R	40.71	18.12	14751	0.600	87.15	315.8	12851	e-i
HH Phoenix R	46.28	16.32	15087	0.777	84.50	275.9	12743	f-j
HH Eagle R	44.98	16.58	14924	0.731	85.15	282.4	12711	f-j
HM 2988Rz	41.80	17.76	14846	0.739	85.25	302.7	12659	f-j
HM 1339Rz	43.29	17.23	14900	0.759	84.91	292.6	12655	f-j
SX Cascade	47.91	15.17	14535	0.595	86.60	262.7	12586	g-j
Beta 4199R	41.17	17.52	14436	0.826	84.09	294.8	12141	h-k
HH Condor R	40.33	17.38	14030	0.678	86.01	299.0	12065	ijk
Beta 4910R	40.38	17.53	14152	0.794	84.52	296.3	11961	jk
Beta 4490R	39.37	17.68	13911	0.796	84.51	298.8	11755	k
Beta 4023R	41.02	16.97	13923	0.861	83.51	283.5	11629	k
LSD (0.05)	2.71	0.33	940	0.065	0.88	7.1	811	
Grand Mean:	45.18	17.09	15422	0.751	84.99	290.5	13108	

[a]Estimated recoverable sugar amounts followed by different letters are significantly different. If the same letter is shared, the amounts are not statistically different.

Table 2. Performance of transgenic sugar beet varieties, Oregon State University, Malheur Experiment Station, Ontario, OR, 2007.

Variety	Root yield	Sugar content	Gross sugar	Conduc-tivity	Extrac-tion	Estimated recoverable sugar		
	ton/acre	%	lb/acre	mmhos	%	lb/ton	lb/acre	ranking[a]
BTS 27RR10	53.17	17.05	18131	0.551	87.58	298.7	15880	a
BTS 26RR18	52.27	17.34	18125	0.591	87.12	302.2	15790	ab
Crystal RR929	48.61	18.24	17732	0.599	87.19	318.1	15461	abc
BTS 25RR05	46.98	18.42	17312	0.614	87.03	320.7	15066	a-d
HM 9036RR	50.93	16.97	17271	0.596	86.99	295.3	15025	a-d
HM 9077RR	49.83	17.42	17356	0.639	86.52	301.4	15017	a-d
BTS 27RR20	48.58	17.68	17177	0.598	87.10	308.1	14956	a-e
BTS 26RR14	49.80	17.21	17134	0.577	87.28	300.5	14955	a-e
BTS 25RR07	48.23	17.83	17197	0.628	86.74	309.4	14920	a-f
Crystal RR919	48.58	17.45	16946	0.551	87.66	306.0	14854	b-g
BTS 26RR13	48.49	17.53	16979	0.584	87.25	305.8	14817	b-h
Crystal RR968	48.08	17.54	16867	0.610	86.92	304.9	14664	c-i
BTS 26RR11	48.43	17.56	16997	0.666	86.20	302.7	14650	c-i
HM 9058RR	47.13	17.72	16696	0.573	87.43	310.0	14598	c-i
BTS 26RR15	45.46	18.03	16393	0.482	88.64	319.6	14532	c-j
HM 9040RR	48.58	17.24	16734	0.647	86.39	297.9	14456	d-k
HH SV702RR	46.81	17.60	16485	0.578	87.34	307.4	14401	d-k
BTS 26RR17	48.32	17.26	16665	0.664	86.16	297.5	14364	d-k
HH SV701RR	46.75	17.66	16497	0.600	87.07	307.5	14360	d-k
HM 9047RR	45.38	17.83	16191	0.559	87.62	312.5	14191	d-k
HM 90706RR	46.95	17.60	16503	0.688	85.90	302.3	14178	d-k
Crystal RR989	45.88	18.01	16513	0.706	85.75	309.0	14162	d-k
HM 90701RR	45.38	17.84	16185	0.573	87.45	311.9	14151	d-k
HM 9006RR	45.79	17.73	16230	0.618	86.86	308.1	14096	d-k
HH B05G26001RR	44.89	17.86	16041	0.589	87.25	311.6	13995	e-k
HM 9008RR	45.30	17.77	16100	0.617	86.87	308.7	13985	e-k
HM 9076RR	45.09	17.80	16016	0.604	87.04	309.8	13947	f-k
HM 9052RR	45.06	17.89	16100	0.646	86.52	309.5	13919	g-k
Crystal RR985	45.21	17.63	15939	0.619	86.81	306.0	13840	h-k
Crystal RR966	44.34	18.20	16132	0.721	85.59	311.4	13810	ijk
HM 9009RR	45.41	17.41	15793	0.621	86.75	302.2	13700	ijk
HM 9041RR	44.28	17.74	15690	0.644	86.51	307.0	13580	jk
BTS 25RR06	42.86	17.97	15386	0.557	87.68	315.1	13493	k
LSD (0.05)	3.10	0.37	1107	0.058	0.76	7.5	989	
Grand Mean:	47.19	17.67	16655	0.610	86.94	307.2	14481	

[a]Estimated recoverable sugar amounts followed by different letters are significantly different. If the same letter is shared, the amounts are not statistically different.

CRITICAL PERIOD OF WEED CONTROL IN ROUNDUP READY® SUGAR BEETS

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Knowledge of the critical weed-free period is important in order to ensure timely weed management and to maximize profit. Timely application also contributes to judicious use of herbicides and builds positively to environmental stewardship. The critical period of weed control consists of two complementary events that lead to a necessary weed-free period during the crop growth cycle.

The first component of this study examines the effect of weeds that emerge with the crop and then are removed after a set time. The second component examines the effect of weeds that emerge sometime after crop emergence and remain until crop harvest. Once these events are combined, a specific critical weed-free period can be identified for the crop growth cycle.

Materials and Methods

A field experiment was conducted at the Malheur Experiment Station near Ontario, Oregon to determine the critical period of weed control using Roundup OriginalMax® on Roundup Ready® (RR) sugar beet. Growing degree days after emergence (GDDAE) were calculated using the formula

$$GDD = \frac{Temp(High) + Temp(Low)}{2}$$

Where Temp (High) = daily high temperature in °F, Temp (Low) = daily low temperature in °F. For sugar beets, if daily low temp was less than 34°F, 34°F was used as the low temperature. Similarly, if the daily high was over 86°F, 86°F was used as the high temperature.

The first Roundup OriginalMax ("Roundup" hereafter) application was made when sugar beets were at the cotyledon stage for the weed-free treatment, and subsequent applications were made every 150 growing degree days. Roundup was applied at different times depending on the treatment, from 150 until 900 GDDAE.

The first set of treatments established 6 levels of increasing duration of weed interference by delaying weed control from the time of crop emergence up to a pre-determined crop growth stage (150, 300, 450, 600, 750, and 900 GDDAE), at which weed control was initiated and maintained for the remainder of the growing season.

The second set of treatments established 6 levels of increasing length of the weed-free period by maintaining weed control from the time of crop planting to 150, 300, 450, 600, 750, and 900 GDDAE and subsequent emerging weeds were left uncontrolled for the remainder of the season. In addition, season-long weedy and weed-free controls were included.

The study was laid out in a randomized complete block design with four replications, and individual plots were four rows wide by 30 ft long. The soil type was Owyhee silt loam with a pH of 7.6, 2.08 percent organic matter, and the CEC (cation exchange capacity) of 18.5 meq/100 g soil. The sugar beet variety 'BTSCT01RR07' was planted on April 19, 2007 in 22-inch rows using tractor-mounted flexi-planter units with double-disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed the seeds within the row. Sugar beet seeds were dropped at the rate of 8 seeds/ft of row and were thinned on May 16, 2007 to 8-inch spacing between plants within a row. Thick planting and thinning to 8 inches between plants within the row provided a uniform plant population and a fair way to evaluate different weed control treatments.

The predominant weeds in the field were kochia, common lambsquarters, pigweed species, hairy nightshade, lady's thumb, and barnyardgrass. Herbicides were broadcast applied using a pressurized CO_2 sprayer calibrated to deliver 20 gal/acre using EVS 8002 nozzles. Evaluations to assess crop injury and weed control were done using a visual scale of 0-100 percent (0 = no injury or no weed control and 100 percent = total crop kill or complete weed control).

The two center rows of each plot were harvested at maturity for root yield and beet samples were transported to the Snake River Sugar factory to determine sugar content and other variables. The data were subjected to analysis of variance to determine treatment variations and means compared using Least Significant Difference (LSD) at the 5 percent level of significance.

Results

The level of weed control at sugar beet maturity varied among Roundup application timings (Table 1). Control of kochia, redroot pigweed, common lambsquarters, lady's thumb, hairy nightshade, and barnyardgrass was 99 percent for the applications starting at 50, 150, 300, 450, 600, 750, and 900 GDDAE. Weed control was generally reduced when Roundup was sprayed only up to 150, 300, 450, and 600 GDDAE. Kochia control was lowest when Roundup was applied once at 150 GDDAE or with two applications up to 300 and three times up to 450 GDDAE, and ranged from 88 to 90 percent. Kochia control improved to 99 percent when Roundup application was extended to 750 and 900 GDDAE.

Redroot pigweed control was lowest (22.5 percent) when Roundup was applied once at 150 GDDAE. Applying Roundup twice up to 300 GDDAE or three times up to 600 GDDAE did not improve redroot pigweed control. However, extending Roundup applications up to 750 and 900 GDDAE provided 99 percent control for redroot pigweed, common lambsquarters, lady's thumb, hairy nightshade, and barnyardgrass. Common lambsquarters and hairy nightshade control was reduced to 59, 60, and 70 percent when Roundup was applied once at 150 GDDAE, twice up to 300 GDDAE, and three times up to 450 GDDAE, respectively. The level of control for lady's thumb followed the same trend as kochia. Barnyardgrass control was reduced for Roundup applications between 150 GDDAE and 600 GDDAE and ranged between 36 and 66 percent, respectively.

Sugar beet root yield was 56.7 and 9.9 tons/acre for the weed-free treatment and the untreated control, respectively (Table 2). The root yield for different Roundup application timings ranged from 51.7 to 58.9 tons/acre. The estimated recoverable sugar ranged from 14,523 to 17,230 lb/acre and the untreated control had the lowest at 2,850 lb/acre. Root yield and estimated recoverable sugar yield followed the same trend as the level of weed control for different Roundup application timings. The results suggest that two to three Roundup applications will be required to control weeds in Roundup Ready sugar beets. The initial application should be done soon after sugar beet emergence and the last one just before sugar beet row closure.

Table 1. Average weed control on October 11, 2007 in Roundup Ready sugar beets (var BTSCT01RR07) in response to different Roundup OriginalMax application timings at Malheur Experiment Station, Oregon State University, Ontario, OR, 2007

Treatment[a]	Rate/acre	Application dates	Kochia	Redroot pigweed	Common lambsquarters	Lady's thumb	Hairy nightshade	Barnyard grass
			Control (0-100%)					
1 Weed free start at 50 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	22.0 fl oz	5/4; 5/15; 5/31; 6/18						
2 Start at 150 GDD			99.0	99.0	99.0	99.0	99.0	98.0
Roundup OriginalMax	22.0 fl oz	5/6; 5/25; 6/18						
3 Start at 300 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	22.0 fl oz	5/11; 5/25; 6/18						
4 Start at 450 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/15; 5/25; 6/18						
5 Start at 600 GDD			99.0	96.8	99.0	96.8	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/23; 5/31; 6/18						
6 Start at 750 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/26; 6/18						
7 Start at 900 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/31; 6/18						
8 Untreated control	----	--	0.0	0.0	0.0	0.0	0.0	0.0
9 Spray only at 150 GDD			87.5	22.5	58.8	88.8	58.8	36.3
Roundup OriginalMax	22.0 fl oz	5/6						
10 Spray only up to 300 GDD			90.0	38.8	60.0	90.0	60.0	62.5
Roundup OriginalMax	22.0 fl oz	5/6; 5/11;						
11 Spray only up to 450 GDD			90.0	36.3	70.0	91.3	70.0	60.0
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/15;						
12 Only up to 600 GDD			91.3	67.5	90.0	95.8	90.0	66.3
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/23;						
13 Only up to 750 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/26;						
14 Only up to 900 GDD			99.0	99.0	99.0	99.0	99.0	99.0
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/31						
LSD (P = 0.05)			1.4	17.1	17.6	2.8	17.6	17.3
CV			1.1	15.9	14.8	2.2	14.8	15.2

[a]Roundup applications included ammonium sulfate (AMS) at 2% v/v.

Table 2. Average root yield, sugar content, conductivity, gross sugar, percent extraction, and estimated recoverable sugar of Roundup Ready sugar beet (var BTSCT01RR07) following application of Roundup OriginalMax at different timings at Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment[a]	Rate/acre	Application dates	Root yield	Sugar content	Conductivity	Gross sugar	Sugar Extraction	Estimated recoverable sugar	
			ton/acre	%	mmho	lb/acre	%	lb/ton	lb/acre
1 Weed free start at 50 GDD			56.7	16.9	0.768	19,211.0	84.7	287	16,277
Roundup OriginalMax	22.0 fl oz	5/4; 5/15; 5/31; 6/18							
2 Start at 150 GDD			51.7	17.4	0.745	17,989.5	85.1	296	15,312
Roundup OriginalMax	22.0 fl oz	5/6; 5/25; 6/18							
3 Start at 300 GDD			57.8	17.2	0.805	19,824.5	84.3	289	16,712
Roundup OriginalMax	22.0 fl oz	5/11; 5/25; 6/18							
4 Start at 450 GDD			57.9	17.1	0.830	19,769.0	83.9	287	16,595
Roundup OriginalMax	32.0 fl oz	5/15; 5/25; 6/18							
5 Start at 600 GDD			57.6	17.3	0.755	19,942.0	85.0	294	16,947
Roundup OriginalMax	32.0 fl oz	5/23; 5/31; 6/18							
6 Start at 750 GDD			55.5	17.1	0.840	18,964.8	83.8	287	15,894
Roundup OriginalMax	32.0 fl oz	5/26; 6/18							
7 Start at 900 GDD			55.1	16.8	0.863	18,555.0	83.5	281	15,482
Roundup OriginalMax	32.0 fl oz	5/31; 6/18							
8 Untreated control		--	9.9	16.9	0.768	3,361.0	84.7	287	2,850
9 Spray only at 150 GDD			53.6	17.0	0.743	18,239.8	85.1	290	15,526
Roundup OriginalMax	22.0 fl oz	5/6							
10 Spray only up to 300 GDD			56.1	16.9	0.778	18,979.8	84.6	286	16,060
Roundup OriginalMax	22.0 fl oz	5/6; 5/11;							
11 Spray only up to 450 GDD			52.1	16.6	0.833	17,322.3	83.8	279	14,523
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/15;							
12 Only up to 600 GDD			53.8	17.1	0.815	18,436.5	84.2	288	15,518
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/23;							
13 Only up to 750 GDD			57.6	17.0	0.848	19,587.8	83.7	285	16,394
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/26;							
14 Only up to 900 GDD			58.9	17.2	0.760	20,288.5	84.9	292	17,230
Roundup OriginalMax	32.0 fl oz	5/6; 5/11; 5/31							
LSD ($P = 0.05$)			4.4	0.8	0.101	1,593.8	1.4	17	1,398
CV			5.9	3.1	8.9	6.2	1.2	4	7

[a]Roundup applications included ammonium sulfate (AMS) at 2% v/v.

MARKETABLE SUGAR LOSS IN SUGAR BEETS PARASITIZED BY DODDER (*Cuscuta spp.*) IN THE TREASURE VALLEY OF EASTERN OREGON

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Dodder (*Cuscuta* spp.) is an annual obligate plant known to attach itself to and parasitize plants, causing them severe damage. There are about 150 dodder species in the world, all parasitizing different crops and weeds. One species in particular, *Cuscuta campestris*, has been found parasitizing many crops and weed species including alfalfa (*Medicago sativa*), asparagus (*Asparagus officinalis)*, melons (*Cucumis* spp), safflower (*Carthamus tinctorius)*, sugar beet (*Beta vulgaris*), tomato, pigweed *(Amaranthus* spp.), lambsquarters *(Chenopodium album),* and field bindweed *(Convolvulus arvensis).* Dodder seems to lack an elaborate dispersal mechanism, and it is believed that soil movement within and between fields helps to move it from one field to another. Dodder produces a copious number of seeds that will last up to 60 years in the soil. The plant is characterized by cream-colored trailing stems that strangle plant leaves. Unlike other parasitic plants, dodder does not need a host to germinate, but must find one and attach within 10 days or it risks dying. Mature stems that have been removed from infested fields are known to reattach to green vegetations at the disposal site. The objective of this survey was to find out the level of root and sugar yield loss results from field dodder parasitization in sugar beets.

Procedures

A survey of grower fields planted to sugar beets was conducted during October 2007 to determine the effect of field dodder parasitization on harvestable root yield and sugar content of parasitized and nonparasitized plants in eastern Oregon. Sugar beet parasitization by dodder may be related to weed management programs used by growers in eastern Oregon, but may also be attributed to continuous emergence throughout summer.

Recommended production practices including fertilization and spraying for insect and disease prevention were practiced by all growers. The surveyed fields were planted in March, harvested in October, and the beet roots transported to the Snake River Sugar factory for sugar processing. All fields were furrow irrigated and did not show signs of moisture deficit at the time of sampling. Surveyed fields were chosen randomly and were representative of dodder infestation in the area.

Weed control in sampled fields was based on the micro-rate program of phenmedipham plus desmedipham plus ethofumesate plus triflusulfuron methyl plus dimethenamid at 150g plus 5.8 g plus 35 g ai/ha, respectively, plus methylated oil at 1.5 percent V/V. A total of 10 samples (8 sugar beets each) were randomly harvested at crop maturity from 2 rows covering approximately 1 $yard^2$ each in areas with and without dodder parasitization. Sample weight was recorded before transporting the sugar beet roots for commercial sugar content determination.

Results

Sugar beet root yield and percent sugar content were significantly reduced for parasitized samples compared to dodder-free (Table 1). Overall, sugar beet root yield for parasitized samples ranged between 13.1 and 39.7 ton/acre with an average of 26.4 ton/acre compared to 30.9 and 45.4 ton/acre with an average of 38.6 ton/acre for nonparasitized samples. The average sugar content for parasitized samples was 13 percent compared to 16 percent for nonparasitized roots. As a consequence, the estimated marketable sugar per acre was reduced 43 percent for parasitized areas. Root yield, sugar content, and estimated recoverable sugar varied widely between parasitized and nonparasitized sections within and among sampled fields. These results suggest that grower loss from dodder parasitization is great since both root yield and percent sugar content are used by the sugar processing company to determine payments.

Table 1. Sugar beet root yield, percent sugar, and estimated recoverable sugar in response to field dodder parasitization, Ontario, OR, Summer 2007.

Field (± Dodder)	Root wt	Sugar	Extractable sugar	Gross sugar	Conductivity	Estimated recoverable sugar	
	ton/acre	%	%	lb/acre	mmho	lb/acre	lb/ton
1 +Dodder	38.7	15.1	84.8	11,710	0.73	9,929.0	256.6
1 -Dodder	42.3	15.3	85.8	12,935	0.66	11,094.3	262.1
2 +Dodder	31.6	12.5	84.5	7,915	0.69	6,690.5	211.5
2 -Dodder	45.4	14.8	83.6	13,418	0.82	11,221.5	247.3
3 +Dodder	39.7	13.1	85.6	10,427	0.63	8,925.1	225.0
3 -Dodder	37.8	16.9	87.2	12,762	0.58	11,132.2	294.7
4 +Dodder	25.5	14.7	82.4	7,467	0.91	6,150.9	241.4
4 -Dodder	39.1	14.0	76.6	10,958	1.31	8,395.5	214.5
5 +Dodder	21.7	12.5	83.2	5,439	0.79	4,527.5	208.8
5 -Dodder	37.2	15.8	84.5	11,779	0.77	9,954.6	267.6
6 +Dodder	16.9	11.3	83.8	3,829	0.71	3,209.5	189.5
6 -Dodder	33.1	16.4	85.1	10,869	0.73	9,253.6	279.2
7 +Dodder	17.0	12.1	84.5	4,103	0.69	3,465.9	204.0
7 -Dodder	39.5	15.8	87.7	12,509	0.52	10,971.2	277.7
8 +Dodder	28.6	12.3	84.4	7,016	0.70	5,918.1	206.7
8 -Dodder	39.1	17.4	87.2	13,637	0.58	11,896.5	304.2
9 +Dodder	23.9	13.4	86.8	6,424	0.54	5,576.2	233.1
9 -Dodder	30.9	14.6	85.5	9,005	0.67	7,696.9	248.8
10 +Dodder	20.3	12.2	81.6	4,960	0.91	4,049.6	199.1
10 -Dodder	41.0	15.4	85.6	12,627	0.68	10,804.8	263.8
Mean +Dodder	26.4	12.9	84.2	6,929.2	0.73	5,844.2	217.6
Mean -Dodder	38.6	15.6	84.9	12,049.9	0.73	10,242.1	265.9

APPLICATION TIMING AND TANK MIXES WITH ROUNDUP ORIGINALMAX® OVER-THE-TOP OF ROUNDUP READY® SUGAR BEETS

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Weed control is considered a major challenge in many, if not all, crops and production systems. Sugar beets are especially vulnerable to weeds due to their poor competitiveness at the early growth stage, before their leaves cover the ground. Emerging sugar beets are small, lack vigor, and take about 60-90 days to cover the ground. This is why sugar beet growers have traditionally used preplant or preemergence (PRE) herbicides to control weeds that emerge together with the crop. The introduction of Roundup Ready® (RR) sugar beets presents an opportunity for growers to employ a total postemergence (POST) weed management program. If root yields are to be maximized, the total POST weed management program will require diligent monitoring of weed cohorts that emerge in succession. The proponents of soil-applied herbicides argue that it is a sound way to minimize weed biotype selection and a viable way to provide sustainable weed control. A field study was conducted at the Malheur Experiment Station in Ontario, Oregon to determine crop response to herbicide tank mixtures of conventional herbicides with RoundUp OriginalMax® to control weeds in RR sugar beets.

Materials and Methods

A trial was conducted during 2007 in a field that had been ripped, moldboard plowed, disked several times, and bedded during fall of the previous year. The beds were 22 inches wide and the field was bed harrowed during spring following application of Roundup OriginalMax at 18 fl oz/acre to control all emerged weeds before planting. The field had previously been planted to wheat, and had a pH of 7.65, 2.1 percent organic matter, CEC (cation exchange capacity) of 18.5, and the predominant soil was an Owyhee silt loam.

The study was laid out following a randomized complete block design with plots measuring 4 rows wide by 30 ft and four replications. Sugar beet seeds, variety 'BTSCT01RR07', were planted on April 19, 2007 using tractor-mounted flexi-planter units with double-disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed the seeds within the row. Sugar beet seeds were dropped at the rate of 8 seeds/ft of row and later thinned to 8 inches between plants within a row.

The study was sidedressed with Temik 15G® at 10 lbs/acre on May 22 to control sugar beet maggot and the rows were recorrugated to allow free movement of irrigation water. The field was furrow irrigated for 24 hours to move the insecticide into the sugar beet seedling root zone. The study was initially irrigated for 24 hours every 2 weeks starting April 20 and weekly starting May 23 until September 18, 2007. Cultivation and corrugation to open up irrigation furrows was done three times before leaf canopy closure.

All herbicide treatments were applied using a CO_2 backpack sprayer calibrated to deliver 20 gal/acre with a boom fitted with four TeeJet EVS 8002 flat fan nozzles. Treatments that included Nortron® PRE (application timing code A) were applied on April 11 and incorporated as required by the label. Other herbicide application timings were May 4, 2007 (B = sugar beet at the cotyledon stage); May 10 (C = sugar beet at the 2-leaf stage); May 25 (D = sugar beet at the 4-leaf stage); May 25 (E = sugar beet at the 6-leaf stage); and June 16 (H = sugar beet at canopy closure).

Enable® fungicide at 8 fl oz/acre with 1 percent v/v crop oil concentrate plus sulfur at 4 lb/acre and boron at 0.10 lb/acre were applied using an aerial applicator on June 30. Additional aerial application of fungicides/insecticides on July 14, August 1, and August 22, 2007 delivered Headline® at 12 oz/acre, Topsin M® at 1lb/acre, and Asana® at 9.6 oz/acre plus Enable at 8 oz/acre, respectively.

A final weed evaluation was done on October 9, 2007 before the foliage was flailed and the crowns removed with rotating knives on tractor-mounted equipment. Sugar beets were mechanically harvested on October 12, 2007 and a beet weight for each plot was recorded before transporting samples to the Snake River Sugar factory for sugar analysis.

The sugar beet weight from each plot was multiplied by a factor of 0.90 to correct for tare. Sugar concentrations were determined by multiplying measured sucrose by 0.98 to estimate the sugar that would have been lost to respiration if the beets had been stored in a pile. The percent sugar extraction was calculated using the formula:

$$Ext = 250 + [(1,255.2 * Cond) - (15,000 * Sug) - 6,185] / Sug * (98.66 - 7.845 * Cond)$$

Where Ext is percent sugar extraction, Cond is the electrical conductivity in mmho, and Sug is the sucrose concentration in percent.

The data were subjected to analysis of variance to determine treatment differences using the least significant difference at $P = 0.05$.

Results

Roundup Ready sugar beet responded differently to soil-applied herbicides followed by POST application of Roundup OriginalMax tank-mixes with other products (Tables 1-5). There was a noticeable reduction in the level of control for kochia, pigweed species, common lambsquarters, and hairy nightshade when Nortron at 3 pt/acre was applied PRE followed by a combination of Progress Ultra® plus Upbeet® plus Stinger® at 0.77 pt/acre plus 1.5 oz/acre plus 4 oz/acre, respectively, and the micro-rate program. Visual evaluations done on May 25, 2007 (14 days after application of treatment code C) indicated a reduction in sugar beet growth for POST treatments that included a combination of Progress Ultra plus Upbeet plus Stinger at 0.77 pt/acre plus 1.5 oz/acre plus 4 oz/acre, respectively (Table 2). The sugar beet leaves were lime yellow and the plants were relatively shorter compared to those treated with other herbicide combinations. The reduction in growth and yellowing of the leaves was still visible during the evaluation on July 3, 2007 (Tables 4 and 5). The observed reduction in growth for these treatments (11 and 12) culminated in a significant reduction in sugar beet root yield and gross sugar (lbs/acre) (Table 6).

Weed control was generally excellent for treatments 1-10 and the hand-weeded control (Tables 1-5). Kochia, pigweed species, and common lambsquarters control ranged from 90 to 99 percent regardless of the treatment (Tables 1-5). Reduced hairy nightshade control was observed for treatment 12 throughout the season. Barnyardgrass control was very low for treatments 11 and 12 starting July 3, 2007 (Tables 4 and 5). Sugar beet root yield ranged from 53 to 55.9 ton/acre for treatments 1-10 and the hand-weeded control, but was reduced to 29.5 and 43.9 ton/acre for treatments 11 and 12, respectively (Table 6). The trend for root yield reduction was consistent with the level of growth reduction and weed control that was observed during the growing season. As a result, there was a significant drop in the estimated recoverable sugar yield.

Table 1. Roundup Ready® sugar beet response and weed control on May 17, 2007 (7 days after C timing) with postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Timing*	Visual crop growth reduction	Kochia	Pigweed species	Common lambsquarters	Hairy nightshade
			(0-100%)				
Roundup OriginalMax	1.33 pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
+ NIS	0.4 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	E					
+ Ammonium sulfate	3.2 pt/acre						
+ Outlook	1.12 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
+ Stinger	4 oz/acre						
Roundup OriginalMax	1.33 pt/acre	E;H					
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
+ Outlook	18 oz/acre						
Roundup OriginalMax	1.33 pt/acre	E;H					
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
+ Select	8 oz/acre						
Roundup OriginalMax	1.33 pt/acre	E;H					
+ Ammonium sulfate	3.2 pt/acre						
Nortron	4 pt/acre	A	0	99	99	99	99
Roundup OriginalMax	1.33 pt/acre	C;E;H					
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	E					
+ Ammonium sulfate	3.2 pt/acre	E					
+ Nortron	2.25 pt/acre	E					
Nortron	3 pt/acre	A	0	99	99	99	99
Roundup OriginalMax	1.33 pt/acre	C;H					
+ Ammonium sulfate	3.2 pt/acre						
Roundup OriginalMax	1.33 pt/acre	E					
+ Ammonium sulfate	3.2 pt/acre						
+ Nortron	32 oz/acre						
Progress Ultra	3 oz/acre	B:C;D;E	0	99	99	99	99
+ Upbeet	0.128 oz/acre						
+ Stinger	1.28 oz/acre						
+ Methylated Oil	15 ml/l						
Nortron	3 pt/acre	A	0	95	90	90	28
Progress Ultra	0.77 pt/acre	C					
+ Upbeet	0.5 oz/acre						
+ Stinger	4 oz/acre						
Handweeded control			0	99	99	99	99
Untreated Check			0	0	0	0	0
LSD (0.05)			--	1	NS	NS	1
CV			--	0	0	0	1

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure.

Table 2. Roundup Ready® sugar beet response and weed control on May 25, 2007 (14 days after emergence) with postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate		Timing*	Visual crop growth reduction	Kochia	Pigweed species	Common lambsquarters	Hairy nightshade
				------------------------- (0-100%) -------------------------				
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
+ NIS	0.4	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre						
+ Outlook	1.12	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	3	99	99	98	99
+ Ammonium sulfate	3.2	pt/acre						
+ Stinger	4	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	1	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
+ Outlook	18	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	0	99	99	97	99
+ Ammonium sulfate	3.2	pt/acre						
+ Select	8	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Nortron	4	pt/acre	A	0	99	99	99	99
Roundup OriginalMax	1.33	pt/acre	C;E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	8	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre	E					
+ Nortron	2.25	pt/acre	E					
Nortron	3	pt/acre	A	3	99	99	99	99
Roundup OriginalMax	1.33	pt/acre	C;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre						
+ Nortron	32	oz/acre						
Progress Ultra	3	oz/acre	B:C;D;E	20	89	99	80	78
+ Upbeet	0.128	oz/acre						
+ Stinger	1.28	oz/acre						
+ Methylated Oil	15	ml/l						
Nortron	3	pt/acre	A	24	91	90	90	21
Progress Ultra	0.77	pt/acre	C					
+ Upbeet	0.5	oz/acre						
+ Stinger	4	oz/acre						
Handweeded control				0	99	99	99	99
Untreated check				29	0	0	0	0
LSD (*P* = 0.05)				5	3	NS	5	4
CV				53	3	0	4	3

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure.

Table 3. Roundup Ready® sugar beet response and weed control on June 1, 2007 (36 days after emergence) with postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate		Timing*	Visual Crop Growth Reduction	Kochia	Pigweed species	Common lambsquarters	Hairy nightshade
				(0-100%)				
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
+ NIS	0.4	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	0	97	97	97	97
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre						
+ Outlook	1.12	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	0	99	99	98	99
+ Ammonium sulfate	3.2	pt/acre						
+ Stinger	4	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
+ Outlook	18	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C	0	98	98	98	98
+ Ammonium sulfate	3.2	pt/acre						
+ Select	8	oz/acre						
Roundup OriginalMax	1.33	pt/acre	E;H					
+ Ammonium sulfate	3.2	pt/acre						
Nortron	4	pt/acre	A	0	99	99	99	99
Roundup OriginalMax	1.33	pt/acre	C;E;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	C;H	0	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre	E					
+ Nortron	2.25	pt/acre	E					
Nortron	3	pt/acre	A	0	99	99	99	99
Roundup OriginalMax	1.33	pt/acre	C;H					
+ Ammonium sulfate	3.2	pt/acre						
Roundup OriginalMax	1.33	pt/acre	E					
+ Ammonium sulfate	3.2	pt/acre						
+ Nortron	32	oz/acre						
Progress Ultra	3	oz/acre	B:C;D;E	19	85	85	85	85
+ Upbeet	0.128	oz/acre						
+ Stinger	1.28	oz/acre						
+ Methylated Oil	15	ml/l						
Nortron	3	pt/acre	A	25	89	90	90	49
Progress Ultra	0.77	pt/acre	C					
+ Upbeet	0.5	oz/acre						
+ Stinger	4	oz/acre						
Handweeded control				0	99	99	99	99
Untreated check				0	0	0	0	0
LSD (0.05)				13	4	4	4	18
CV				155	3	3	3	15

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure.

Table 4. Roundup Ready® sugar beet response and weed control on July 3, 2007 (67 days after emergence) with postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate		Timing*	Visual crop growth reduction	Kochia	Pigweed species	Common lambsquarters	Hairy nightshade	Barnyard grass
				(0-100%)					
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	98	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C;E;H	0	98	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
+ NIS	0.4	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C;H	0	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C;H	3	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	E						
+ Ammonium sulfate	3.2	pt/acre							
+ Outlook	1.12	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C	3	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
+ Stinger	4	oz/acre							
Roundup OriginalMax	1.33	pt/acre	E;H						
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C	1	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
+ Outlook	18	oz/acre							
Roundup OriginalMax	1.33	pt/acre	E;H						
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C	3	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
+ Select	8	oz/acre							
Roundup OriginalMax	1.33	pt/acre	E;H						
+ Ammonium sulfate	3.2	pt/acre							
Nortron	4	pt/acre	A	0	99	99	99	99	99
Roundup OriginalMax	1.33	pt/acre	C;E;H						
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	C;H	1	99	99	99	99	99
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	E						
+ Ammonium sulfate	3.2	pt/acre	E						
+ Nortron	2.25	pt/acre	E						
Nortron	3	pt/acre	A	1	98	98	98	98	99
Roundup OriginalMax	1.33	pt/acre	C;H						
+ Ammonium sulfate	3.2	pt/acre							
Roundup OriginalMax	1.33	pt/acre	E						
+ Ammonium sulfate	3.2	pt/acre							
+ Nortron	32	oz/acre							
Progress Ultra	3	oz/acre	B:C;D;E	15	90	59	90	90	25
+ Upbeet	0.128	oz/acre							
+ Stinger	1.28	oz/acre							
+ Methylated Oil	15	ml/l							
Nortron	3	pt/acre	A	79	26	66	66	66	25
Progress Ultra	0.77	pt/acre	C						
+ Upbeet	0.5	oz/acre							
+ Stinger	4	oz/acre							
Handweeded control				0	100	100	100	100	100
Untreated check				65	0	0	0	0	0
LSD (P = 0.05)				17	16	23	16	16	22
CV				99	13	18	12	12	19

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure.

Table 5. Roundup Ready® sugar beet response and weed control on October 9, 2007 (165 days after emergence) with postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Timing*	Lady's thumb	Kochia	Pigweed species	Common lambsquarters	Hairy nightshade	Barnyard grass
			----------	----------	----------	(0-100%)	----------	----------
Roundup OriginalMax + Ammonium sulfate	1.33 pt/acre 3.2 pt/acre	C;E;H	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate + NIS	1.33 pt/acre 3.2 pt/acre 0.4 pt/acre	C;E;H	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate	1.33 pt/acre 3.2 pt/acre	C;H	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate Roundup OriginalMax + Ammonium sulfate + Outlook	1.33 pt/acre 3.2 pt/acre 1.33 pt/acre 3.2 pt/acre 1.12 pt/acre	C;H E	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate + Stinger Roundup OriginalMax + Ammonium sulfate	1.33 pt/acre 3.2 pt/acre 4 oz/acre 1.33 pt/acre 3.2 pt/acre	C E;H	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate + Outlook Roundup OriginalMax + Ammonium sulfate	1.33 pt/acre 3.2 pt/acre 18 oz/acre 1.33 pt/acre 3.2 pt/acre	C E;H	99	99	99	99	99	95
Roundup OriginalMax + Ammonium sulfate + Select Roundup OriginalMax + Ammonium sulfate	1.33 pt/acre 3.2 pt/acre 8 oz/acre 1.33 pt/acre 3.2 pt/acre	C E;H	97	99	99	97	97	95
Nortron Roundup OriginalMax + Ammonium sulfate	4 pt/acre 1.33 pt/acre 3.2 pt/acre	A C;E;H	99	99	99	99	99	99
Roundup OriginalMax + Ammonium sulfate Roundup OriginalMax + Ammonium sulfate + Nortron	1.33 pt/acre 3.2 pt/acre 1.33 pt/acre 3.2 pt/acre 2.25 pt/acre	C;H E E E	99	99	99	99	99	99
Nortron Roundup OriginalMax + Ammonium sulfate Roundup OriginalMax + Ammonium sulfate + Nortron	3 pt/acre 1.33 pt/acre 3.2 pt/acre 1.33 pt/acre 3.2 pt/acre 32 oz/acre	A C;H E	99	99	99	99	99	99
Progress Ultra + Upbeet + Stinger + Methylated Oil	3 oz/acre 0.128 oz/acre 1.28 oz/acre 15 ml/l	B:C;D;E	52	95	88	90	87	5
Nortron Progress Ultra + Upbeet + Stinger	3 pt/acre 0.77 pt/acre 0.5 oz/acre 4 oz/acre	A C	65	92	92	92	92	31
Handweeded control			100	100	100	100	100	100
Untreated check			18	0	0	0	18	0
LSD (P = 0.05)			26	3	2	3	14	18
CV			21	2	2	2	11	16

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure

Table 6. Roundup Ready® sugar beet root yield and yield components in response to postemergence application of Roundup OriginalMax® with and without soil residual herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

			Root yield	Sugar content	Conductivity	Extraction	Estimated recoverable sugar	
Treatment	Rate	Timing*	ton/acre	%	mmho	%	lb/acre	lb/ton
Roundup OriginalMax	1.33 pt/acre	C;E;H	53.0	17.4	0.77	84.9	15,619	295
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C;E;H	54.0	17.5	0.77	84.8	15,946	296
+ Ammonium sulfate	3.2 pt/acre							
+ NIS	0.4 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C;H	55.4	17.3	0.77	84.9	16,265	294
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C;H	55.1	17.6	0.97	82.1	15,906	289
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	E						
+ Ammonium sulfate	3.2 pt/acre							
+ Outlook	1.12 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C	56.0	17.3	0.81	84.3	16,304	291
+ Ammonium sulfate	3.2 pt/acre							
+ Stinger	4 oz/acre							
Roundup OriginalMax	1.33 pt/acre	E;H						
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C	54.5	17.3	0.77	84.8	16,021	294
+ Ammonium sulfate	3.2 pt/acre							
+ Outlook	18 oz/acre							
Roundup OriginalMax	1.33 pt/acre	E;H						
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C	55.7	17.3	0.80	84.4	16,217	291
+ Ammonium sulfate	3.2 pt/acre							
+ Select	8 oz/acre							
Roundup OriginalMax	1.33 pt/acre	E;H						
+ Ammonium sulfate	3.2 pt/acre							
Nortron	4 pt/acre	A	54.7	17.4	0.77	84.8	16,160	296
Roundup OriginalMax	1.33 pt/acre	C;E;H						
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	C;H	57.2	17.6	0.71	85.7	17,262	302
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	E						
+ Ammonium sulfate	3.2 pt/acre							
+ Nortron	2.25 pt/acre							
Nortron	3 pt/acre	A	55.9	17.3	0.79	84.5	16,295	292
Roundup OriginalMax	1.33 pt/acre	C;H						
+ Ammonium sulfate	3.2 pt/acre							
Roundup OriginalMax	1.33 pt/acre	E						
+ Ammonium sulfate	3.2 pt/acre							
+ Nortron	32 oz/acre							
Progress Ultra	3 oz/acre	B:C;D;E	43.9	17.2	0.86	83.6	12,574	287
+ Upbeet	0.128 oz/acre							
+ Stinger	1.28 oz/acre							
+ Methylated Oil	15 ml/l							
Nortron	3 pt/acre	A	29.5	17.5	0.81	84.4	8,722	296
+ Progress Ultra	0.77 pt/acre	C						
+ Upbeet	0.5 oz/acre							
+ Stinger	4 oz/acre							
Handweeded control			54.7	17.4	0.82	84.2	15,993	293
Untreated check			11.1	17.4	0.76	85.0	3,287	295
LSD (P = 0.05)			4.4	0.8	0.16	2.3	1,361	NS
CV			6.2	3.1	14.41	1.9	7	4.2

*Timing A = preplant incorporated; B = cotyledon stage; C = 2-leaf sugar beet; D = 4-leaf sugar beet; E = 6-leaf sugar beet, F = 8-leaf sugar beet; G = 10- to 12-leaf sugar beet; H = canopy closure.

2007 WINTER ELITE WHEAT TRIAL

Clinton C. Shock, Eric P. Eldredge, and Lamont D. Saunders
Malheur Experiment Station
Jim Peterson and Mike Flowers
Crop and Soil Science
Oregon State University
Ontario, OR

Introduction

Malheur Experiment Station provides one location for the Oregon State University Statewide Winter Elite Wheat variety testing program. This location compares soft white winter wheat variety performance in a furrow-irrigated, high yield potential environment. Plant breeders can use information on variety performance to compare advanced lines with released cultivars. Growers can use this information to make decisions about which soft white winter wheat varieties may perform best in their fields.

Methods

The trial was grown on Owyhee silt loam where the previous crop was sweet corn. After harvest, the corn stalks were flailed, the field was disked, and the soil was sampled and analyzed. The analysis showed 264 lb available nitrogen (N) per acre in the top 2 ft of soil. The top foot of soil contained 35 ppm phosphorus (P), 368 ppm potassium (K), and 13 ppm sulfate (SO_4)/acre, 1,878 ppm calcium (Ca), 506 ppm magnesium (Mg), 96 ppm sodium (Na), 1 ppm zinc (Zn), 7 ppm iron (Fe), 6 ppm manganese (Mn), 0.7 ppm copper (Cu), 0.3 ppm boron (B), pH 7.2, and 1.75 percent organic matter. Pre-plant fertilizer consisted of 2 lb B/acre that was broadcast on October 5, 2006. The crop received no further fertilization during the production cycle. The soil was deep ripped, plowed, and groundhogged to prepare the seedbed. The field was corrugated into 30-inch rows.

The Winter Elite Wheat Trial was comprised of 40 soft white winter (SWW) wheat cultivars or lines, five of which were club types, and eight with resistance to imazamox herbicide for use in the BASF "Clearfield®" system (designated SWW-Cl). Seed was treated with Dividend® XL RTA® fungicide seed treatment. The experimental design was a randomized complete block with three replications. Grain was planted on October 19, 2006, with a small-plot grain drill in plots 5 by 20 ft, and the field was recorrugated. Seed was planted at 30 live seed/ft^2, corresponding to approximately 110 lb/acre. The soil was dry so the wheat was irrigated on October 24, 2006. There was slow emergence and little growth through the dry winter.

Broadleaf weeds were controlled with Bronate Advance™ herbicide at 18 oz/acre applied on April 24. Alleys were cut with a sickle bar mower on June 15. Plant height at maturity was measured in the trial on July 6. The alleys were recut with a Hege plot combine on July 16 and the resulting length of each plot was measured and recorded. The plots were harvested on July 17 with a Hege plot combine. Yield and test weight differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). Differences in yield or test weight between varieties should be equal to or greater than the corresponding LSD (0.05) value before any variety is considered different from another in this trial.

Results

The date of 50 percent heading in the Winter Elite Wheat Trial varieties, when half of the culms had extended the peduncle above the collar of the flag leaf, ranged from May 20 (day of year 140) for 'ORH010837' and 'Gene' to May 30 (day of year 150) for 'ARS00235' (Table 1). Height at maturity ranged from 35.3 inches for Gene to 43.7 inches for 'ARSC96059-1' and 'ID99-435'. No lodging was observed in any of the varieties. Test weights in this year ranged from 58.7 lb/bu for 'OR2050910' to 62.5 lb/bu for 'ORH010085'. Protein content of the grain ranged from 7.0 percent for 'ID9364901A' to 8.9 percent for Gene.

Yields ranged from 132.7 bu/acre for '99x1009-23' to 86.2 bu/acre for 'Cara' club wheat (Table 2). Among the highest yielding wheat varieties in 2007 were the top 17 lines in the trial from 99x1009-23 to 'Salute'. 'Stephens', a check variety in this trial, and the soft white winter wheat variety most commonly grown in this production area, continues to show excellent yield performance, placing among the top yielding varieties in the trial at 130.4 bu/acre.

Information on previous wheat trials at Malheur Experiment Station is available on the web at http://cropinfo.net. Information on the performance of the varieties in this trial at other Oregon locations is available on the web at http://cropandsoil.oregonstate.edu/wheat/state_performance_data.htm.

Table 1. Winter Elite Wheat Trial market class, test weight, percent moisture, protein, plant height, and 50 percent heading date, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

		2007 agronomic data				
Variety	Class	Test weight	Harvest moisture	Plant height	Heading date	Protein
		lb/bu	%	inches	DOY	%
99x1009-23	SWW	59.9	9.4	43.3	146.0	7.6
ID9364901A	SWW	60.5	9.3	41.3	142.0	7.0
STEPHENS	SWW	60.1	9.4	40.0	143.0	7.9
MASAMI	SWW	60.4	9.2	41.7	149.0	7.6
GOETZE (ORH010920)	SWW	59.9	9.2	37.7	141.0	8.2
TUBBS	SWW	60.8	8.8	42.0	143.0	8.0
ORH010085	SWW	62.5	9.3	37.7	145.0	8.4
XERPHA (WA 7973)	SWW	61.4	9.2	40.7	148.0	8.2
OSUPOP-27-3	SWW	60.8	9.3	40.7	148.0	7.8
WEATHERFORD	SWW	61.0	9.2	41.0	145.0	8.7
TUBBS-06/ROD BLEND	SWW	60.5	9.3	41.3	147.0	7.5
OR2050913	SWW	59.7	9.4	41.3	149.0	8.2
OR2050910	SWW	58.9	9.3	40.3	147.0	8.2
WESTBRED 528	SWW	61.4	9.4	39.7	141.0	8.0
ORH010837	SWW	59.1	9.3	37.7	140.0	7.9
IDAHO 587	SWW	60.4	9.4	39.7	145.0	7.9
SALUTE	SWW	60.9	9.2	41.0	145.0	7.9
BRUNDAGE 96	SWW	59.7	9.1	38.0	148.0	8.1
ARSC96059-1	Club	62.2	9.4	43.7	148.0	7.5
SIMON	SWW	60.6	9.3	40.3	148.0	8.1
BU6W00-523	SWW	60.9	9.3	39.7	146.0	7.7
OR2010239	SWW	59.2	9.3	39.3	144.0	7.8
ARS00235	Club	60.6	9.4	43.3	150.0	7.7
OR2050914	SWW	59.5	9.5	40.3	149.0	7.9
ID99-435	SWW	60.5	9.4	43.7	141.0	8.3
TUBBS-06	SWW	60.6	9.3	41.0	144.0	7.8
OR9901619	SWW	60.2	9.4	42.7	148.0	7.8
ORSS-1757	SWW	60.2	9.2	40.7	145.0	7.6
ARS970278-2	Club	60.1	9.4	41.7	145.0	8.1
ID92-22407A	SWW	60.8	9.3	43.0	145.0	7.5
GENE	SWW	60.3	9.2	35.3	140.0	8.9
ORI2042037	SWW	59.8	9.4	39.0	149.0	7.6
AP 700CL	SWW	61.9	9.3	41.7	143.0	7.9
MADSEN	SWW	60.6	9.1	38.0	147.0	7.6
ORCF-102	SWW	60.7	9.4	40.7	145.0	7.9
ORCF-101	SWW	60.5	9.3	38.3	145.0	8.2
CARA	Club	59.3	9.2	36.3	151.0	8.7
Site Average		60.5	9.3	40.4	145.5	7.9
LSD (0.05)		0.4	0.3	2.0		0.5
CV (%)		0.4	1.9	3.1		3.5

Table 2. Winter Elite Wheat Trial market class, yield ranked by 2007 productivity, and 2-year and 3-year average yields. All yields are at 12 percent moisture. Grain yields shaded in gray are not significantly different from the highest yield at this site. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

		2007 yields		2-year average yield		3-year average yield	
Variety	Class	Yield	Rank	Yield	Rank	Yield	Rank
		bu/acre		bu/acre		bu/acre	
99x1009-23	SWW	132.7	1				
ID9364901A	SWW	131.3	2				
STEPHENS	SWW	130.4	3	118.5	1	123.4	2
MASAMI	SWW	128.1	4	111.6	5	118.6	6
GOETZE (ORH010920)	SWW	122.8	5	113.0	2	124.3	1
TUBBS	SWW	122.4	6	107.8	10	120.9	3
ORH010085	SWW	122.3	7	112.2	3	119.6	5
XERPHA (WA 7973)	SWW	121.9	8				
OSUPOP-27-3	SWW	120.8	9				
WEATHERFORD	SWW	120.6	10	111.7	4	116.8	9
TUBBS-06/ROD BLEND	SWW	120.3	11				
OR2050913	SWW	120.2	12				
OR2050910	SWW	119.0	13				
WESTBRED 528	SWW	118.4	14	107.5	11	120.1	4
ORH010837	SWW	117.7	15	108.5	8		
IDAHO 587	SWW	117.7	16	108.4	9	118.3	8
SALUTE	SWW	116.7	17				
BRUNDAGE 96	SWW	116.3	18	104.3	14	112.5	13
ARSC96059-1	Club	115.6	19	105.0	13		
SIMON	SWW	115.3	20	101.7	17	115.6	10
BU6W00-523	SWW	115.1	21				
OR2010239	SWW	113.6	22	111.1	6	118.5	7
ARS00235	Club	113.0	23				
OR2050914	SWW	113.0	24				
ID99-435	SWW	112.3	25	103.4	16		
TUBBS-06	SWW	111.9	26	111.0	7		
OR9901619	SWW	111.0	27	104.3	15	113.2	12
ORSS-1757	SWW	109.3	28	98.7	21	111.9	15
ARS970278-2	Club	107.4	29				
ID92-22407A	SWW	107.1	30	100.1	20	113.5	11
GENE	SWW	106.4	31	97.6	22	107.8	17
ORI2042037	SWW	105.7	32	105.7	12		
AP 700CL	SWW	104.3	33				
MADSEN	SWW	104.1	34	101.6	18	111.0	16
ORCF-102	SWW	101.4	35	100.2	19	112.0	14
ORCF-101	SWW	99.3	36	95.3	23	106.6	18
CARA	Club	86.2	37	83.1	24		
Site Average		114.9		105.1		115.8	
LSD (0.05)		16.3		12.4		9.2	
CV (%)		8.7		10.3		8.5	

2007 PERFORMANCE OF WINTER BARLEY (*Hordeum vulgare* ssp. *vulgare*) AND SPRING WAXY BARLEY VARIETIES PLANTED IN THE FALL

O. Steven Norberg
Malheur County Extension Service
Clinton C. Shock, Lamont D. Saunders, and Eric P. Eldredge
Malheur Experiment Station
Oregon State University
Ontario, OR

Andrew Ross, Pat Hayes, and Juan Rey
Oregon State University
Corvallis, OR

Introduction

In December of 2005, the Food and Drug Administration ruled that barley could have the same health food claim as oats, in that, if enough barley beta-glucan soluble fiber was consumed, it would reduce the risk of coronary heart disease (Federal Register 2005). A high beta-glucan variety, 'Salute', is available from Western Plant Breeders (Bozeman, MT). Western Plant Breeders applied for plant variety protection on February 26, 2007 and the application is currently pending (U.S. Plant Variety Protection Office). Waxy starch is another favorable trait for food barley that is available in released varieties, and demand for waxy barley starch may increase. Waxy barley grain has starch that is characterized by lower amylase and higher amylopectin content than traditional barley. Waxy starch has properties that may benefit the snack food industry, such as longer shelf life and crispier texture.

Higher protein barley may also be beneficial as it would increase the nutritional value of the grain. Very little research has been done on growing food barley for high protein or the protein response of food barley varieties to nitrogen application. Previous barley variety evaluations at the University of Idaho at Parma have shown that 'Merlin', Salute and 'YU599-006', the spring genotypes developed by Western Plant Breeders, are among the highest yielding waxy cultivars available (Brown 2006). Salute (two-row barley) and YU599-006 (six-row barley) contain higher levels of beta-glucan than normal. Merlin is a two-rowed hull-less waxy barley but is not considered a high beta-glucan barley.

A winter barley genotype would work best in local crop rotational systems due to higher yields and would compete with wheat and corn acres for profitability. Unfortunately, right now there are no winter waxy barley cultivars available. Pat Hayes, barley breeder at Oregon State University (OSU), has started a winter waxy breeding project but no varieties are available yet. The best performing winter feed barley varieties for the irrigated Treasure Valley are 'Strider' and 'Maja' (Stab113), released by OSU, 'Eight-

Twelve' released by the USDA-ARS at Aberdeen, and 'Sunstar Pride' released by Sunderman Breeding.

The purpose of this work was to determine winter survival of the fall-planted, spring waxy barley varieties compared to winter feed barley standard varieties. This was the second year for this trial. The first year of the trial was reported in the 2007 Malheur Experiment Station Report (Norberg et al 2007). This trial also compared yield, yield components, test weight, protein, and beta-glucan levels of spring waxy genotypes to the four feed barley varieties when nitrogen (N) was foliarly applied at heading.

Methods

The barley was planted on an Owyhee silt loam at the Malheur Experiment Station in a field that was fallowed the previous year. Seedbed preparation included disking, cultivating, and furrowing during the fall of 2006. Soil samples were collected prior to fall tillage and showed 128 lb N/acre in the top 2 ft of the soil profile. The soil analysis also showed 60 ppm phosphorus (P) (Olson method), 523 ppm potassium (K), 10 ppm sulfate (SO_4), 2,861 ppm calcium (Ca), 363 ppm magnesium (Mg), 0.7 ppm zinc (Zn), 3 ppm iron (Fe), 3 ppm magnesium (Mn), 0.3 ppm copper (Cu), 0.4 ppm boron (B), and 1.5 percent organic matter in the top 12 inches. The barley varieties were planted on October 19, 2006 using a plot drill on 30-inch beds with 3 rows per bed. The experimental design was a randomized complete block design with four replications. Plot size was 5 ft wide by 20 ft long.

Urea nitrogen was applied in the spring of 2007 at 100 lb N/acre on February 23, 2007. Visual plant stand estimates were made on April 27, 2007 with ratings from 0 to 100 percent (0 = no plants, 100 = perfect stand). Eight flag leaves were taken from all plots and combined into one sample for each variety on May 25 for total N analysis at Brookside Laboratory, New Knoxville, Ohio. A heading N application of 40 lb N/acre of fluid urea was made on May 30, 2007, when most varieties had reached 50 percent heading.

The trial was sprayed for weed control with Buctril® at1 qt/acre on March 15, 2007 and again with Bronate® applied at 1 qt/acre on April 3, 2007. The trial was furrow irrigated for 24 hours on April 19, May 10, May 24, June 5, and June 19. Plant height was measured on June 13 at four locations within the plot with a yard stick. Lodging was estimated on July 12, 2007 by estimating the percent of the plot that was leaning more than a 45 degree angle. Plots were trimmed with a sickle mower to square them up and help eliminate border effects. The plots were harvested with a Hege combine on July 19.

Response variables were compared using ANOVA and protected least significant differences at the 5 percent probability, LSD (0.05). Differences between response variables should be equal to or greater than the corresponding LSD (0.05) value before any variety is considered different from another in this trial.

Results

Stands of Salute (13 percent), Merlin (29 percent) and YU599-006 (56 percent) were significantly less than the winter varieties in 2007, which ranged from 96 to 98 percent (Table 1). Reductions in stands occurred in 2006 but were not as pronounced. Averaged over both years, Salute and Merlin had about 50 percent stand reduction compared to winter varieties and showed an unacceptable level of winter damage. At heading, birds ate the grain from the two-rowed barleys (Salute and Merlin). Since the plots had just been irrigated, application of bird netting was delayed 4 days, and during this time considerable damage was done to the heads of Merlin and Salute. In very small fields, birds can present a significant problem. However, it has been our experience that in larger fields bird damage is not as significant. After experiencing poor winter stand survival and bird losses, Merlin and Salute yields in 2007 were less than one-third of Sunstar Pride (195.8 bu/acre), which was the highest yielding winter variety (Table 2). Sunstar Pride had the highest yield in 2006 as well. Averaged over years, Salute and Merlin yielded less than one-half of the winter varieties.

This is the first comprehensive examination of beta-glucan levels for winter barley varieties typically grown in the Treasure Valley. YU599-006 had a significantly higher level of beta-glucan, 7.31 percent, than any other variety in the experiment (Table 2). For the value-added beta-glucan market, YU599-006 would be the variety of choice, as it was 2.2 percent higher than Salute or Merlin. YU599-006 was not included in the 2006 trial, and beta-glucan levels were only tested in 2007. YU599-006 is short, with plant height of about 29 inches (Table 2.); birds did not bother it in this experiment. In general, birds do not bother six-row barleys as the awns make it harder for birds to eat the grain (Brown 2006). The short plant height would reduce lodging problems with added N fertilizers, especially if high protein barley is desirable and profitable.

In 2007, Salute, Merlin, and YU599-006 had higher protein than the winter types, with Merlin reaching 16.3 percent protein. Unfortunately, varieties with the highest yields had lower protein. More nitrogen than was used in this experiment would have to be applied to the higher yielding barley varieties for higher protein. In the 2007 experiment, 268 lb of N was available to the barley, including the 40 lb/acre foliarly applied.

Conclusion

The spring barley varieties planted in this experiment are not sufficiently winter hardy to be fall planted in the Treasure Valley. A significant price incentive would be required to overcome the yield decrease of planting Merlin, Salute, or YU599-006 in the spring compared to Sunstar Pride or Strider in the fall. Further breeding research is needed to develop winter waxy, high beta-glucan barley genotypes for the Treasure Valley.

References

Brown, B. 2006. Cereal Sentinel Newsletter. February 26, 2006 41:8-9. http://agweb.ag.uidaho.edu/swidaho/Newsletters/Sentinel41.pdf

Federal Register. 2005. Food labeling: health claims; soluble dietary fiber from certain foods and coronary heart disease. December 23, 2005 (Volume 70, Number 246): Pages 76150-76162.

Norberg, O., C. Shock, L. Saunders, E. Eldredge, A. Ross, P. Hayes, and J. Ray. 2007. Performance of winter barley (*Hordeum vulgare ssp. vulgare*) and spring waxy barley varieties planted in the fall. Oregon State University Agriculture Experiment Station Special Report 1075:157-159.

U.S. Plant Variety Protection Office: http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl

Table 1. Barley stand comparisons showing maturity, heading date, and plant height at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Variety	Type and traits[a]	Plant stand	Date of 50% heading	Plant height	Plant maturity	Lodging	Flag leaf N
		%	date	inch	date	%	%
2006							
Sunstar Pride	W	89	May 28	27.7	Aug. 5	0	2.5
Strider	W	89	May 18	30.9	July 27	0	2.6
Maja (Stab 113)	W	90	May 16	32.7	July 25	0	3.0
Eight-Twelve	W	89	May 18	28.8	July 24	0	2.7
Merlin	S, Wx, HL	61	May 21	20.2	July 25	0	2.5
Salute	S, HB, Wx	74	May 21	30.1	July 27	0	2.5
LSD (0.05)		7	N/A[b]	3.1	2.5	N/A[b]	N/A[b]
2007							
Sunstar Pride	W	98	May 25	31.9	-	0.5	3.5
Strider	W	98	May 12	35.5	-	7	4.0
Maja (Stab 113)	W	96	May 10	37.1	-	0	3.8
Eight-Twelve	W	97	May 13	33.8	-	19	4.2
YU599-006	S, HB, Wx	56	May 13	29.4	-	0	4.3
Merlin	S, Wx, HL	29	May 23	28.4	-	0	4.1
Salute	S, HB, Wx	13	May 22	36.7	-	0	4.2
LSD (0.05)		8.4	1	2.5	-	9.7	N/A[b]
2006 & 2007							
Sunstar Pride	W	94	May 25	29.8	-	0.25	3.0
Strider	W	93	May 12	33.2	-	3.5	3.3
Maja (Stab 113)	W	93	May 10	34.9	-	0	3.4
Eight-Twelve	W	93	May 13	31.3	-	8.5	3.5
Merlin	S,Wx,HL	45	May 23	24.3	-	0	3.3
Salute	S,Wx,HB	44	May 22	33.4	-	0	3.4
LSD (0.05)		5	1	1.6	-	N/A[b]	N/A[b]

[a]W = winter, S = spring, HB = high beta-glucan, Wx = waxy starch, HL = hull-less.
[b]N/A = Not available since not replicated.

Table 2. A comparison showing barley yield and quality results, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Variety	Type and traits[a]	Yield[b]	Seed no. per area	Seed weight	Crude protein	Beta-glucan	Test weight
		bu/acre	Seed no./ft^2	seed no./lb	%		lb/bu
2006							
Sunstar Pride	W	135.3	2,102	11,270	8.3	-	52.2
Strider	W	99.5	1,677	12,270	11.1	-	49.4
Maja (Stab113)	W	73.1	1,194	11,870	10.9	-	50.6
Eight-Twelve	W	75.9	1,189	11,400	10.3	-	51.0
Merlin	S, Wx, HL	67.5	866	9,330	12.1	-	61.6
Salute	S, HB, Wx	83.9	1,308	11,290	11.1	-	53.6
LSD (0.05)		17.5	316	936	1.2	-	0.9
2007							
Sunstar Pride	W	195.8	2,370	10,981	9.1	4.17	49.5
Strider	W	177.7	1,968	10,037	11.4	4.05	47.1
Maja (Stab113)	W	174.9	2,120	11,019	10.5	3.89	49.0
Eight-Twelve	W	145.9	1,811	11,295	10.7	4.15	47.9
YU599-066	S, HB, Wx	102.7	1,007	8,920	13.4	7.31	48.1
Merlin	S, Wx, HL	58.0	648	10,127	16.3	4.94	55.2
Salute	S, Wx, HB	37.7	355	8,556	14.9	5.07	48.9
LSD (0.05)		21.5	230	454	1.6	0.47	0.9
2006 & 2007							
Sunstar Pride	W	165.6	2,236	11,124	8.7	-	50.9
Strider	W	138.6	1,822	11,155	11.3	-	48.3
Maja (Stab113)	W	124.0	1.657	11,443	10.8	-	49.8
Eight-Twelve	W	110.9	1,500	11,347	10.5	-	49.4
Merlin	S, HB, Wx	62.7	737	9,728	14.2	-	58.4
Salute	S, Wx, HL	60.8	831	9,924	13.0	-	51.3
LSD (0.05)		15.7	209	515	1.2	-	0.7

[a]W = winter, S = spring, HB = high beta-glucan, Wx = waxy starch, HL = hull-less.
[b]Yield is corrected to a 12 percent moisture basis, bu = 48 lb.

EVALUATION OF WAXY WHEAT CULTIVARS PLANTED IN THE FALL AND THE SPRING

O. Steven Norberg
Malheur County Extension Service
Clinton C. Shock, Lamont D. Saunders, and Eric P. Eldredge
Malheur Experiment Station
Oregon State University
Ontario, OR

Steve Petrie, Jeron Chatelain, and Karl Rhinhart
Columbia Basin Agricultural Research Center
Pendleton, OR

Introduction

Sustainable wheat production throughout the Pacific Northwest (PNW) is important to the economic viability of the region. One method of increasing the value of wheat and the potential return to growers is through the introduction of high value traits. Waxy starch is such a trait. Waxy starch absorbs more water, swells to a larger volume, and is crispier when baked than normal starch. Because of these characteristics the snack food industry may prefer waxy starch for the production of items such as "power bars" and breakfast foods.

Normal wheat starch has two components, amylopectin (75 percent) and amylose (25 percent). Amylose is an essentially linear molecule of α-(1→4)-linked glucose, while amylopectin is a highly branched molecule of α-(1→4)-linked glucose chains connected by α-(1→6)-linkages (Fig. 1). A full waxy wheat has no amylose. Partially waxy wheat has a mix of amylose (1-24 percent) and amylopectin (76-99 percent). Currently there are some cultivars of waxy wheat in commercial production. However, little is known about how these and other experimental waxy wheat lines will perform in the Treasure Valley of Oregon and Idaho.

A research project was initiated in the fall of 2006 to evaluate the agronomic performance and characteristics of several waxy wheat varieties under irrigation. Similar research under dryland conditions was conducted at the Columbia Basin Agricultural Research Center (CBARC) under the direction of Steve Petrie, and will be reported in their Special Report for 2007.

Methods

The study was established in the fall of 2006 at the Malheur Experiment Station in Ontario, Oregon. The soil type at the site was an Owyhee silt loam. The field was fallow the previous year. Seedbed preparation included disking, cultivating, and furrowing. Soil samples were collected prior to fall tillage and showed 128 lb/acre nitrogen (N) in the top 2 ft of soil. Urea was applied in the spring at 75 lb/N per acre on February 23, 2007. The wheat was planted with a plot drill on 30-inch beds with 3 rows per bed. Plot size was 5 by 20 ft.

The treatment design was a split-plot design. Three planting dates were the main plots and consisted of October 19, 2006 (normal fall seeding), November 10, 2006 (dormant seeding), and March 6, 2007 planting dates. The subplot treatment was wheat variety and consisted of 14 wheat varieties. These 'Waxy Pen', 'IDO629', 'IDO630', seven hard red advanced lines from Nebraska (Robert Graybosch, ARS; '459', '114', '115', '205', '315', '395', and '489'), and the check varieties 'Stephens', 'Goetze', 'Alturas', and 'WB936'. The experimental design was a randomized complete block design with three replications.

Field management included furrow irrigations on October 30 (Oct. 19 planting only), April 19, May 10, May 24, June 5, June 19, and July 5 (Mar. 6 planting only). Weeds were controlled with Buctril® at 1 qt/acre on March 15 and Bronate® at 1 qt/acre on April 3.

Agronomic characteristics measured were emergence, spring plant vigor, plant height, and lodging. Emergence data were collected by counting plants in a 3-ft section of the middle row in the bed on November 21, March 2, and March 23 for the October 19, November 10, and March 6 plantings, respectively. Spring plant vigor was evaluated on April 27 using a scale of 1-10, with 10 being excellent. Plant height was measured in four places in the plot using a measuring stick on June 13. Lodging was estimated on July 12 by determining the percentage of the plot leaning more than 45 degrees.

Plots were trimmed to size with a sickle bar mower to help eliminate border effects after heading. At maturity, wheat was harvested using a Hege combine on July 20. Response variables were compared using ANOVA and least significant differences at the 5 percent probability, LSD (0.05). Differences between response variables should be equal to or greater than the corresponding LSD (0.05) value before any variety is considered different from another in this trial.

Results

Data, averaged over all planting dates, were analyzed and a significant planting date by variety interactions were found. Therefore, each planting date was further analyzed individually.

"Normal" Fall Seeding, October 19

Stephens, a soft white winter check variety, had the highest average yield, 154.3 bu/acre (Table 1). It was significantly higher than all the other varieties and lines evaluated at this planting date. Among the waxy wheat varieties, IDO630, IDO629, Waxy Pen, and the experimental lines 459, 114, and 315 all performed well. IDO630 had the highest waxy wheat yield at 124.5 bu/acre. While these waxy varieties and lines performed well, they did have significantly less yield than Stephens, 29.8-42.3

bu/acre less. Similarly, the waxy wheat varieties also showed no yield advantage compared to the winter check variety Goetze or the spring check variety Alturas.

Dormant Seeding, November 10

Goetze, a soft white winter wheat check variety, had the highest average yield at 141.3 bu/acre (Table 2). The varieties Stephens, Alturas, and Waxy Pen all had similar yields compared to Goetze. Among the waxy wheat varieties and lines, only Waxy Pen, IDO630, and IDO629 performed well. The winter waxy lines from Nebraska did not perform well in this planting and several also had severe lodging due to their height.

Spring Seeding, March 6

Waxy Pen had the highest average yield at 123.9 bu/acre (Table 3). However, the spring check varieties Alturas and WB936 had similar yields compared to Waxy Pen. Both IDO629 and IDO630 performed poorly compared to the other varieties.

When comparing waxy varieties, one thing to keep in mind is that Waxy Pen, like it's parent 'Penawawa', is susceptible to stripe rust. IDO630 and IDO629 are considered moderately resistant to stripe rust. If a producer was planting in the spring, Waxy Pen would be the waxy variety of choice if stripe rust is not a problem. If it is a concern, IDO629 or IDO630 would be a better choice for a waxy wheat variety.

Conclusion

Waxy wheat can be successfully grown in the Treasure Valley region of Oregon and Idaho. Among the waxy wheat varieties evaluated, Waxy Pen and IDO630 performed the most consistently across the planting dates. However, Waxy Pen like its parent Penawawa, is susceptible to stripe rust. This makes IDO630, which is moderately resistant to stripe rust, a better overall waxy wheat variety for this region.

There was a significant yield reduction when fall planting IDO630 waxy wheat compared to the soft white winter check variety Stephens. Yield reductions ranged from 29.8 bu/acre in the "normal" fall planting to 5.7 bu/acre in the dormant fall planting. The lower yields of waxy wheat imply that there must be a premium for waxy wheat before growers will choose to plant it. Fall planted spring wheat also increases risk and needs compensation. Planting IDO630 as a dormant seeding improved spring vigor rating and increased yield 5 bu/acre over the October planting. Many acres in the Treasure Valley in eastern Oregon are often dormant seeded as irrigation water is turned off and soils are typically very dry at planting.

In the spring, yield reductions for IDO630 and IDO629 compared to spring check variety Alturas were 13.3 and 9.1 bu/acre, respectively.

Further research needs to be conducted to confirm these results. For waxy wheat to be at its full potential in this region, a high yielding, disease resistant winter waxy wheat needs to be developed.

Acknowledgements

This research was supported by a grant from the Oregon Wheat Commission. The seven advanced winter waxy wheat lines were supplied by Dr. Robert Graybosch, ARS Research Geneticist (Plants) Lincoln, Nebraska. Waxy Pen was supplied by Dr. Craig Morris, ARS Supervisory Research Chemist, Pullman, Washington. IDO629 and IDO630 were supplied by Ed Souza with the University of Idaho.

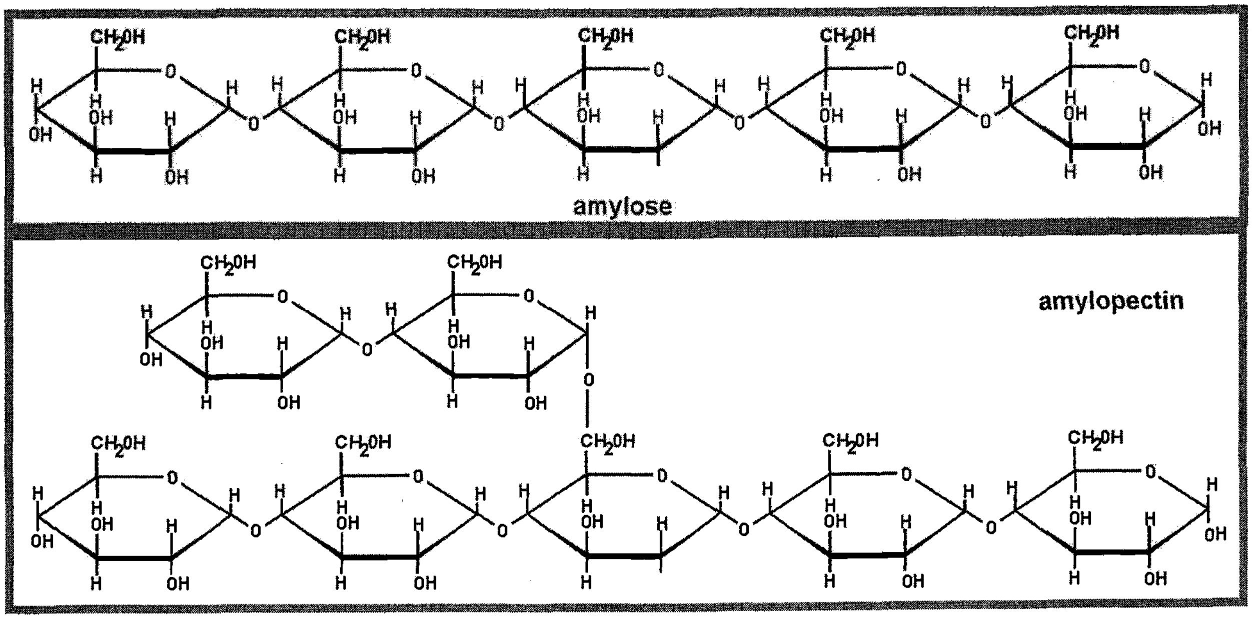


Figure 1. Molecular arrangement of amylose and amylopectin in wheat starch.

Table 1. Yield, protein, test weight, 1,000-kernel weight, and lodging of waxy wheat varieties and advanced lines seeded on October 19, 2006 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Harvestable yield	Grain protein	Test weight	Kernel weight	Lodging	Population at emergence	Head density	Plant vigor on 4/27/07	Plant height	50% heading date
	bu/acre	%	lb/bu	g/1,000 kernels	%	plants/acre	head no./ft^2	rating 1-10	inches	May
Stephens	154.3	10.1	61.3	54.3	0.0	737,000	51	10.0	35.4	17
459	122.7	11.1	63.6	37.4	11.7	1,237,000	76	9.0	37.0	12
114	115.6	12.3	63.3	36.6	21.7	1,144,000	75	9.7	42.2	13
115	97.9	11.7	62.3	39.6	71.7	1,179,000	85	9.0	40.8	13
205	89.1	13.9	61.2	33.3	3.3	1,179,000	63	9.7	41.4	15
315	112.0	10.7	63.1	38.9	0.0	1,155,000	79	8.5	34.9	15
395	108.5	12.0	61.8	34.9	0.3	998,000	64	8.5	36.2	11
489	107.0	10.9	61.1	36.6	11.7	1,028,000	74	9.3	40.4	15
Waxy Pen	112.8	9.8	63.3	41.7	0.0	987,000	68	6.5	31.2	13
IDO629	118.6	9.6	63.5	44.1	0.0	1,202,000	55	6.7	33.4	14
IDO630	124.5	10.4	63.1	42.3	0.0	1,138,000	64	6.3	32.1	13
Goetze	135.2	10.1	60.9	45.2	0.0	981,000	53	9.5	32.1	14
Alturas	115.1	10.2	63.3	43.4	0.0	1,266,000	72	7.0	34.0	14
WB936	102.0	12.5	63.7	47.7	0.0	964,000	60	6.2	30.9	13
Avg.	115.4	11.1	62.5	41.1	20.1	1,165,000	67	8.2	35.9	14
LSD (0.05)	13.4	0.5	0.5	3.4	12.8	256,000	18	1.3	1.9	2

Table 2. Yield, protein, test weight, 1,000-kernel weight, and lodging of waxy wheat varieties and advanced lines seeded on November 10, 2006 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Variety	Harvestable yield	Grain protein	Test weight	Kernel weight	Lodging	Population at emergence	Head density	Plant vigor on 4/27/07	Plant height	50% heading date
	bu/acre	%	lb/bu	g/1,000 kernels	%	plants/acre	head no./ft^2	rating 1-10	inches	May
Stephens	135.2	10.7	61.1	55.1	0.0	836,000	59	8.0	38.7	26
459	105.0	11.5	63.4	38.6	3.3	1,004,000	85	9.3	42.0	17
114	92.6	13.3	62.7	36.6	37.7	1,045,000	62	10.0	44.9	18
115	88.5	12.8	61.5	36.7	82.0	1,097,000	83	10.0	45.2	18
205	86.1	14.1	61.1	32.7	13.3	1,016,000	73	9.7	44.1	19
315	112.8	11.5	63.3	37.8	0.0	1,051,000	73	9.5	38.2	19
395	111.7	12.6	61.5	34.0	1.7	1,057,000	67	9.7	38.4	15
489	100.8	12.0	60.6	33.7	41.7	946,000	78	9.8	42.9	19
Waxy Pen	131.8	9.9	62.6	42.2	0.0	1,103,000	75	8.3	34.5	15
IDO629	121.2	9.9	62.8	41.3	3.3	1,161,000	77	9.0	38.4	17
IDO630	129.5	10.1	63.0	50.8	0.0	1,173,000	72	8.0	33.8	16
Goetze	141.3	10.5	61.0	42.3	0.0	946,000	58	9.7	35.1	20
Alturas	135.8	10.4	63.5	45.2	0.0	1,295,000	77	10.0	35.9	14
WB936	126.0	14.1	63.5	53.4	0.0	784,000	57	9.7	32.9	13
Avg.	115.6	11.7	62.3	41.5	26.1	1,036,000	71	9.3	38.9	18
LSD (0.05)	11.2	0.6	0.7	4.7	22.9	NS	NS	1.4	2.5	2

Table 3. Yield, protein, test weight, 1,000-kernel weight, and lodging of waxy wheat varieties and advanced lines seeded on March 6, 2007 at the Malheur Experiment Station, Ontario, OR, 2007.

Variety	Harvestable yield	Grain protein	Test weight	Kernel weight	Lodging	Population at emergence	Head density	Plant vigor on 4/27/07	Plant height	50% heading date
	bu/acre	%	lb/bu	g/1,000 kernels	%	plants/acre	head no./ft^2	rating 1-10	inches	May
Waxy Pen	123.9	10.1	63.4	41.6	0	842,000	46	9.7	34.1	26
Alturas	121.8	10.5	63.4	44.0	0	993,000	46	9.7	35.4	22
IDO629	112.5	10.6	63.1	42.6	0	1,184,000	47	9.5	37.5	27
IDO630	108.2	11.0	63.4	47.9	0	1,033,000	47	10.0	35.2	26
Goetze	109.4	10.6	59.1	39.0	0	1,010,000	44	9.7	32.3	32
WB936	115.2	13.6	63.7	49.3	0	1,196,000	40	9.7	31.7	20
Avg.	115.2	11.1	62.7	44.1	0	1,043,000	45	9.7	34.4	26
LSD (0.05)	10.2	0.5	0.6	4.1	NS	NS	NS	NS	2.5	2
LSD (0.05)[a]	18.2	NS	0.2	NS	NS	NS	16	2.0	4.2	1
LSD (0.05)[b]	29.8	0.9	1.2	6.5	NS	362,600	NS	2.7	NS	5

[a]LSD to compare between planting dates for tables 1, 2, and 3.

[b]LSD to compare between varieties and planting dates for tables 1, 2, and 3.

OPTIMIZING NITROGEN USE AND EVALUATING ETHEPHON USE IN WAXY BARLEY

O. Steven Norberg
Malheur County Extension Service
Clinton C. Shock, Lamont D. Saunders, and Eric P. Eldredge
Malheur Experiment Station
Oregon State University
Ontario, OR

Brad Brown
University of Idaho
Parma, ID

Andrew Ross, Pat Hayes, and Juan Rey
Oregon State University
Corvallis, OR

Introduction

The Food and Drug Administration has ruled that barley could have the same health food claim as oats, in that, if enough beta-glucan soluble fiber was consumed, it would reduce the risk of coronary heart disease (Federal Register 2005). A high beta-glucan variety, 'Salute', is available from Western Plant Breeders. Western Plant Breeders applied for plant variety protection on February 26, 2007, which is currently pending (U.S. Plant Variety Protection Office). Waxy starch (lower amylase, more amylopectin) is another favorable trait that may increase demand for food barley and is currently available in released varieties. It has properties that may benefit the snack food industry, such as longer shelf life and crispier texture. Higher protein barley may also be beneficial as it would increase the nutritional value of the grain.

'Merlin' and Salute, spring genotypes developed by WestBred (Bozeman, MT), are among the best adapted waxy cultivars available for the Treasure Valley (Brown 2006). Whereas spring genotypes are currently available, a fall barley genotype would be considerably more productive in the Treasure Valley system. Unfortunately, there are currently no fall waxy barley cultivars available. The fall planting of spring genotypes has been evaluated, but fall planting involves considerable risk of winter kill.

Little research has evaluated nitrogen (N) management for growing waxy barley varieties to optimize both higher protein and beta-glucan soluble fiber content. Research is needed to help producers know how to apply N for optimum yield, protein and soluble fiber, yet prevent groundwater contamination from excessive nitrate. This report summarizes trials over 2 years to determine winter survival of 2 fall-planted spring waxy barley varieties, compare yield and quality under different N treatments applied in late winter and at heading, and to evaluate Ethephon growth regulator to reduce lodging.

Methods

Experimental methods for the first year of the experiment have been published (Norberg et al. 2007). The experiment in 2007 was planted on an Owyhee silt loam at the Malheur Experiment Station following potatoes in 2006. A similar experiment was planted at the University of Idaho, Parma Research and Extension Center, but is not reported here. Soil samples were collected prior to fall tillage and showed 55 ppm phosphorus (P) (Olson method), 310 ppm potassium (K), 14 ppm sulfate (SO_4), 2,765 ppm calcium (Ca), 337 ppm magnesium (Mg), 2 ppm zinc (Zn), 3 ppm iron (Fe), 2 ppm manganese (Mn), 0.5 ppm copper (Cu), 0.6 ppm boron (B), 1.72 percent organic matter, and 44, 20, and 24 lb/acre available N in the first, second, and third foot of soil, respectively. In the fall prior to tillage, 2 lb/acre B and 200 lb/acre elemental sulfur fertilizer were applied to the field. Soil mineralization bags were placed in the control plots at the 0- to 1- and 1- to 2-ft depths on April 11, 2007 as described by Westermann and Crothers (1980). One set of mineralization bags was pulled at the same time that the flag leaves were sampled. The second set was pulled at harvest time.

Seedbed preparation included disking, cultivating, and furrowing. The field was planted on October 20, 2006 with a plot drill on 30-inch beds with 3 drill rows per bed. The plant stand was estimated visually on March 12, 2007. We determined at that time that replanting was required and that occurred on March 14 and 15. To eliminate the old stand, Roundup® was sprayed at 1.5 qt/acre in conjunction with Buctril® herbicide at 1 qt/acre for weeds on March 15, 2007.

The experimental design was a randomized complete block design with three replications. The treatment design was a split, split, factorial plot design. Year was considered as the whole plot, with variety being the subplot. Within variety, there was an incomplete factorial design consisting of combinations of late winter N rate and heading stage N treatments. To overcome the confounding effects of late winter N applications on the experiment, only the control heading treatment were included in the analysis. A complete analysis of all factors was also done to determine heading treatment effects and interactions with heading treatments. Late winter applications consisted of 0, 60, 120, or 180 lb N/acre applied by hand on February 20 and 23. Where Merlin and Salute received late winter application of 180 lb N/acre, the grain did not receive any further treatments.

Spring applications at 50 percent heading were made on May 30 at 0, 40 lb N/acre as topdressed dry urea, 40 lb N/acre as foliar liquid urea, or 40 lb N/acre as foliar liquid urea plus ethephon. Ethephon 2 (ethephon) Micro Flo Co. LLC) was applied at the boot stage at a rate of 2.0 pt/acre on May 12 prior to head emergence.

Thirty flag leaves were sampled from each plot on May 24 and sent to Brookside Laboratory, New Knoxville, Ohio, for analysis. Twenty of those flag leaves were measured individually with a SPAD meter (chlorophyll meter) for greenness on the same day.

The trial was furrow irrigated for 24 hours on April 26, May 15, May 30, and June 14. Plant height was measured on June 13, 2007. Plots were cut to size and harvested with a Hege combine on July 18 and 19. Yield and protein were corrected to a 12 percent moisture basis, using 48 lb = bushel.

Response variables were compared using GLM ANOVA and least significant differences at the 5 percent probability, LSD (0.05). Differences between response variables should be equal to or greater than the corresponding LSD (0.05) value before means are considered different from others.

Results

Planting spring genotypes in fall of 2006 resulted in failed plant stands coming out of the winter. Merlin had a 12 percent stand, whereas Salute had only 3 percent stand. Spring replanting after eliminating the fall planted barley resulted in excellent stands. Results for 2007 are based on this spring planting.

Yield of barley varieties was affected differently by interactions of years and late winter N rates (Fig. 1), combinations of years and varieties (Table 1), and by combinations of years, varieties, and N rate (Fig. 2). In 2007, the average yield of Merlin was 39.6 bu/acre more than Salute. Averaged over years, Salute's yield peaked at 60 lb N/acre, whereas Merlin peaked at 120 lb N/acre. In 2007, the application of Ethephon increased Salute yield by 24.9 bu/acre. This increase in Salute yield occurred as lodging was near 100 percent in many of the higher N-rate plots (Table 2). The lodging decreased test weight and increased the number of seeds per pound. Lodging was not eliminated by Ethephon treatments but it was reduced from 37 to 22 percent (Table 4).

Seeds per area responded to increasing N rate very similarly to yield (Fig. 1). Seeds per area followed trends in yield for different combinations of years and varieties (Table 1). Applying 40 lb N/acre at heading increased the number of seeds per area by 7 percent compared to the control (Table 3). Applying Ethephon increased the seed number per area 8 percent over foliar N alone. Merlin responded to Ethephon by a decreasing seed weight (increased number of seeds per pound) whereas Salute did not (Fig. 3). Test weight was also decreased by the fluid urea plus ethephon application treatment and the dry N treatments when N rate is increased (Fig. 4).

Merlin plant height increased 8.2 inches by increasing N rate from 0 to 180 lb/acre, compared to only 3 inches of increased growth for Salute over the same range of supplemental N. Averaged over years and N rates, Merlin was 26.3 inches tall compared to Salute at 40.4 inches tall. Applying N at heading actually slightly reduced plant height for Salute, but not for Merlin (Table 6). Applying Ethephon to Salute reduced plant height on average 3.2 inches compared to 2 inches for Merlin (Table 5).

Grain protein was influenced by year, variety, N rate and N at heading, and Ethephon application (Table 3). Grain protein was 2.2 percent higher in 2006 than 2007. Merlin was 0.8 percent higher in protein content than Salute. Increasing the N rate from 0 to 180 lb/acre increased grain protein from 10.0 to 12.9 percent. Applying 40 lb/acre N dry or fluid at heading increased protein consistently about 1 percent. Applying Ethephon decreased grain protein content by 0.4 percent.

Beta-glucan content was increased by dry N at heading in 2006 compared to the control, but not significantly in 2007 (Table 4). The combination of fluid N plus Ethephon decreased beta-glucan compared to the control (Fig. 5). In 2007, fluid N plus Ethephon increased beta-glucan content compared to the control.

Total leaf N and SPAD (chlorophyll) were impacted by the interaction of variety by year and N rate (Fig. 6). Both total leaf N and SPAD had a more linear response in 2007. The response may have been more linear since leaf concentrations were lower in 2007. Soil samples show less N was available in 2007 (Table 7). In 2007, grain proteins were lower than in 2006. Total leaf N had a strong significant relationship with grain protein ($R^2 = 0.79$) (Fig. 7).

Conclusion

As shown in 2006-2007, neither Merlin nor Salute had enough winter hardiness to be planted in the fall in the Treasure Valley without risking significant winter kill. Merlin has more desirable agronomic characteristics than Salute. Merlin is shorter than Salute and exhibits less lodging in higher fertility conditions. Grain protein content and test weight of Merlin was consistently higher than Salute. In this experiment Merlin out-yielded Salute at higher fertility levels. Total N fertilizer required to maximize yield for Merlin in the 2 years of this study was 120 lb N/acre while only 0 to 60 lb N/acre were needed for Salute. Ethephon reduced lodging and can potentially increase yields when lodging is present. More research should be done before recommendations can be made for producing high protein barley based on total leaf N and flag leaf. Our data show that the total leaf N content was a good indicator of grain protein at harvest.

Acknowledgements

This research was supported by grants from the Oregon Grains Commission and USDA, Barley for Rural Development.

References

Brown, B. 2006. Cereal Sentinel Newsletter. 2-26-2006. 41:8-9. http://agweb.ag.uidaho.edu/swidaho/Newsletters/Sentinel41.pdf

Federal Register. 2005. Food labeling: health claims; soluble dietary fiber from certain foods and coronary heart disease. December 23, 2005 (Volume 70, Number 246): Pages 76150-76162.

Norberg, O., C. Shock, L. Saunders, E. Eldredge, A. Ross, P. Hayes, and J. Ray. 2007. Optimizing nitrogen use and evaluating Ethephon use in waxy barley. Oregon State University Agriculture Experiment Station Special Report 1075:150-156. http://www.cropinfo.net/AnnualReports/2006/WaxyBarleyN2006.html

Westermann, D.T., and S.E. Crothers. 1980. Measuring soil nitrogen mineralization under field conditions. Agronomy Journal 72:1009-1012.

Table 1. Barley yield and seeds per area as influenced by years and varieties and averaged over late winter nitrogen rate, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Year	Variety	Yield	Seeds per area
		bu/acre	Seeds ft^2
2006	Merlin	97.3	1,336
	Salute	103.4	1,324
2007	Merlin	123.2	1,336
	Salute	83.6	947
LSD (0.05)		11.3	147

Table 2. Barley lodging, test weight, and seed weight as influenced by years, varieties, and late winter nitrogen rate, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Year	Variety	N rate	Lodging	Test weight	Seed weight
		lb N/acre	%	lb/bu	no. seeds/lb
2006	Merlin	0	0	61.9	9,476
		60	0	61.4	9,790
		120	0	61.8	10,081
		180	0	61.4	10,436
2006	Salute	0	0	53.3	9,187
		60	0	53.5	9,216
		120	0	53.5	9,447
		180	0	53.0	9,288
2007	Merlin	0	0	59.4	10,049
		60	0	60.7	9,592
		120	3	61.2	9,825
		180	35	61.1	9,972
2007	Salute	0	30	50.8	10,174
		60	98	50.4	9,749
		120	100.0	49.3	10,692
		180	100.0	48.7	10,677
	LSD $_{Y \times Var \times N}$ (0.05)		16	1.2	546

Table 3. Barley yield, grain moisture, SPAD meter reading, plant height, lodging, test weight and seed weight as influenced by years, varieties, and late winter nitrogen rate, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Main effect		Yield	Seeds per area	Seed weight	Test weight	Protein	Moist-ure	Spad	Plant height	Lodging	Total leaf N	Beta-glucan
		bu/acre	no./ft^2	no. seeds/lb	lb/bu	%	%		inches	%	%	%
Year:	2006	100.3	1,330	9,915	57.5	12.5	7.6	47.6	33.9	0.0	3.9	5.6
	2007	103.4	1,142	10,091	55.2	10.3	8.7	43.4	32.8	45.8	3.3	5.3
	LSD (0.05)	NS	NS	NS	0.4	0.7	0.3	1.1	NS	5.6	0.1	NS
Variety:	Merlin	110.2	1,336	9,903	61.1	11.8	9.1	48.4	26.3	4.8	3.7	5.4
	Salute	93.5	1,135	9,804	51.6	11.0	7.2	42.7	40.4	41.0	3.5	5.4
	LSD (0.05)	7.7	91.4	NS	0.4	0.7	0.3	1.1	0.8	5.6	0.1	NS
Late winter N rate:	0 lb/acre	89.5	1,062	9,722	56.3	10.0	8.2	40.0	29.8	7.5	2.8	5.3
	60 lb N/acre	107.8	1,278	9,587	56.5	10.7	8.1	44.3	33.2	24.6	3.5	5.3
	120 lb N/acre	108.2	1,337	10,011	56.4	11.9	8.3	47.1	35.0	25.8	3.9	5.9
	180 lb N/acre	101.9	1,266	10,093	56.1	12.9	8.0	50.7	35.5	33.8	4.2	5.5
	LSD (0.05)	10.9	129.2	273.1	NS	1.0	NS	1.6	1.2	7.9	0.2	NS
Heading trt:	Control	101.8	1,226	9,773	56.4	10.9	8.2	N/A[a]	32.7	19.3	N/A	5.4
	40 lb N/acre dry urea	109.4	1,307	9,683	56.6	11.9	8.1	N/A	32.0	14.4	N/A	5.7
	40 lb N/acre liquid urea	108.9	1,311	9,722	56.4	12.0	8.0	N/A	32.0	18.3	N/A	5.7
	40 lb N/acre liquid urea plus Ethephon	115.0	1,411	9,952	56.5	11.6	8.2	N/A	29.4	11.2	N/A	5.4
	LSD (0.05)	5.6	74	131	NS	0.4	NS	N/A	0.8	6.5	N/A	0.3

[a]N/A = Not appropriate since treatment came after measurement.

Table 4. Barley lodging, seed weight, and beta-glucan as influenced by years and heading applications, and averaged over varieties and late winter nitrogen rate, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Year	Heading applications	Lodging	Seed weight	Beta-glucan
		%	no. seeds/lb	%
2006	Heading trt: Control	0.0	9,533	5.6
	40 lb N/acre dry urea	0.0	9,568	6.1
	40 lb N/a liquid urea	0.0	9,644	5.8
	40 lb N/a liquid urea plus ethephon	0.0	9,922	5.2
2007	Heading trt: Control	38.6	10,014	5.2
	40 lb N/acre dry urea	28.8	9,798	5.4
	40 lb N/a liquid urea	36.6	9,801	5.5
	40 lb N/a liquid urea plus ethephon	22.3	9,981	5.6
	$LSD_{Y \times Trt}$ (0.05)	9	186	0.4

Table 5. Barley grain moisture and plant height as influenced by varieties and late winter nitrogen rate, and averaged over years, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Variety	Late winter N rate	Grain moisture	Plant height
	lb/acre	%	inches
Merlin	0	9.4	21.5
	60	8.7	25.7
	120	9.3	28.6
	180	9.2	29.7
Salute	0	7.1	38.2
	60	7.5	40.7
	120	7.3	41.5
	180	6.9	41.2
	LSD (0.05) $_{V \times N}$	0.5	1.7

Table 6. Barley plant height as influenced by varieties and heading applications and averaged over years and late winter nitrogen rate, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Variety	Heading application	Plant height
		inches
Merlin	Control	25.2
	40 lb N/acre dry urea	25.1
	40 lb N/acre liquid urea	25.3
	40 lb N/acre liquid urea plus Ethephon	23.3
Salute	Control	40.1
	40 lb N/acre dry urea	38.9
	40 lb N/acre liquid urea	38.7
	40 lb N/acre liquid urea plus Ethephon	35.5
	LSD (0.05) $_{V \times Trt}$	1.2

Table 7. Nitrogen available to the experiment from soil tests and mineralization bags. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

Available N in the top 2 ft	2006		2007	
	lb/acre	date	lb/acre	date
A. At fall planting to 2 ft	72	1/10/05	64	10/04/06
B. Amount mineralized early mid-April to 50% heading (flag-leaf sampling)	60	4/17/06 to 5/31/06	8	4/11/07 to 5/30/07
C. Amount mineralized from 50% heading to harvest	56	5/31/06 to 7/10/06	24	5/30/07 to 7/18/07
Total mineralized (B+C)	116		32	
Total available (A + total mineralized)	188		96	

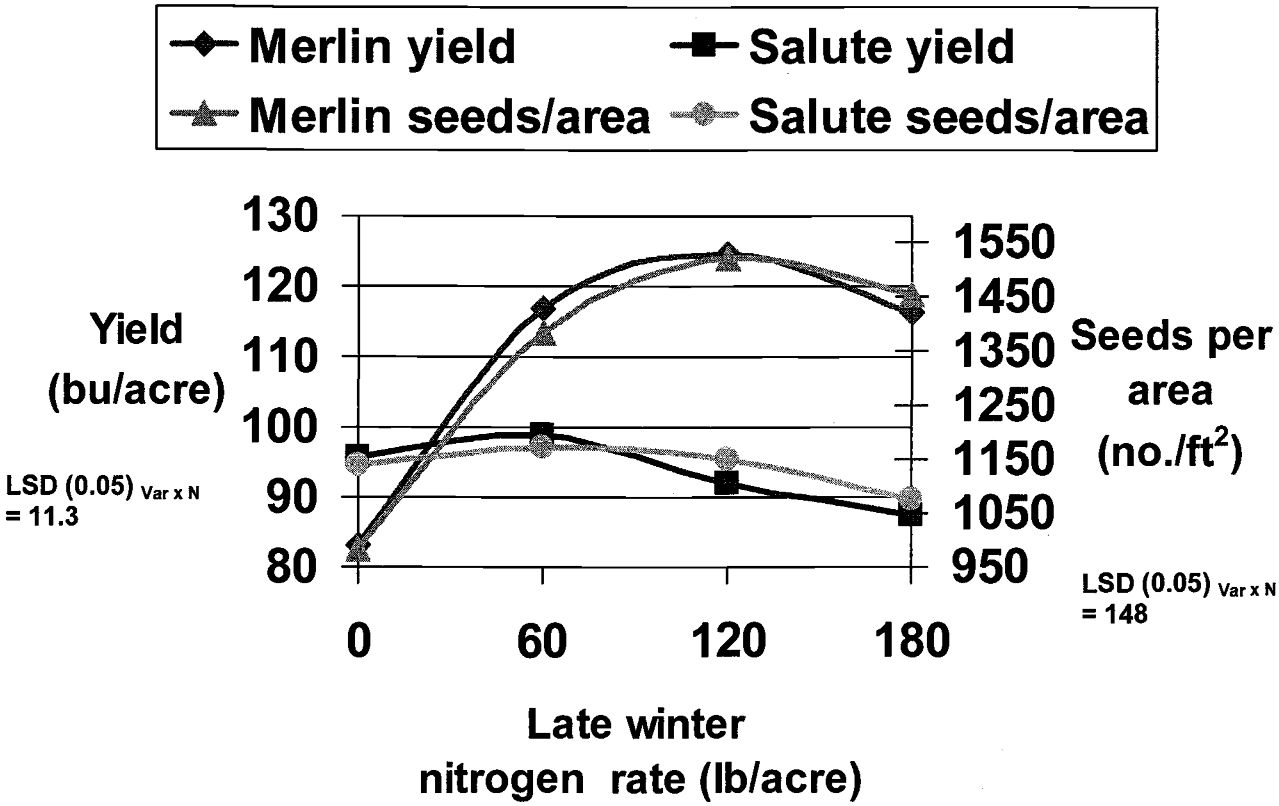


Figure 1. Yield and seeds per area of barley as influenced by variety and late winter N application rate (lb N/acre urea), and averaged over years, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

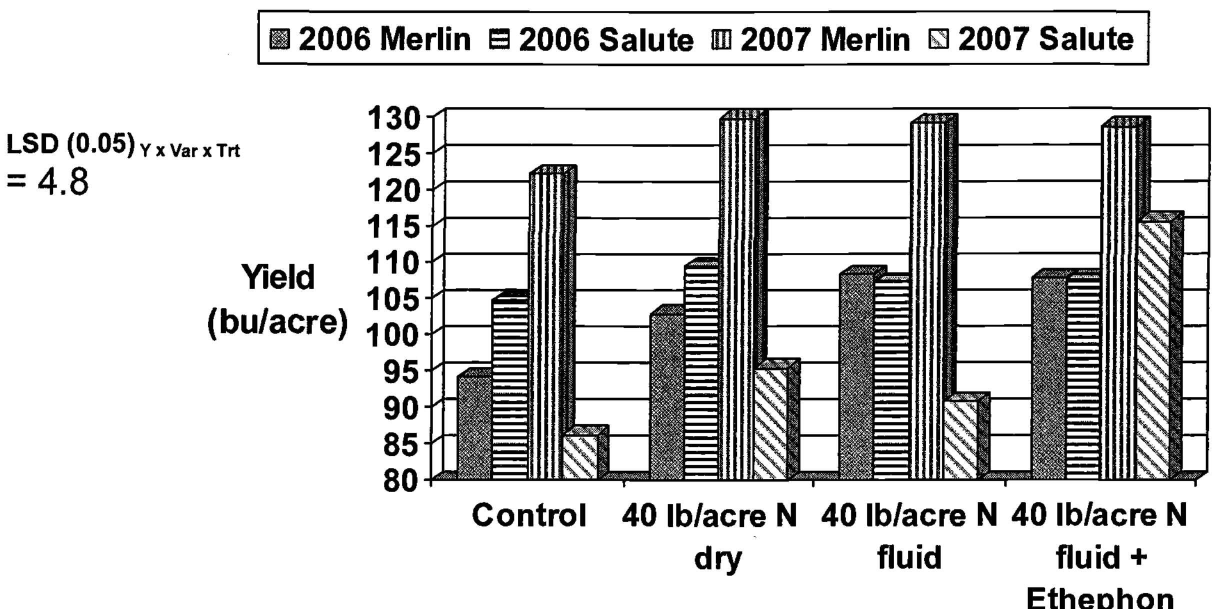


Figure 2. Barley yield as influenced by year, variety and heading nitrogen rates (dry and fluid urea, and Ethephon) averaged over late winter N rate at Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

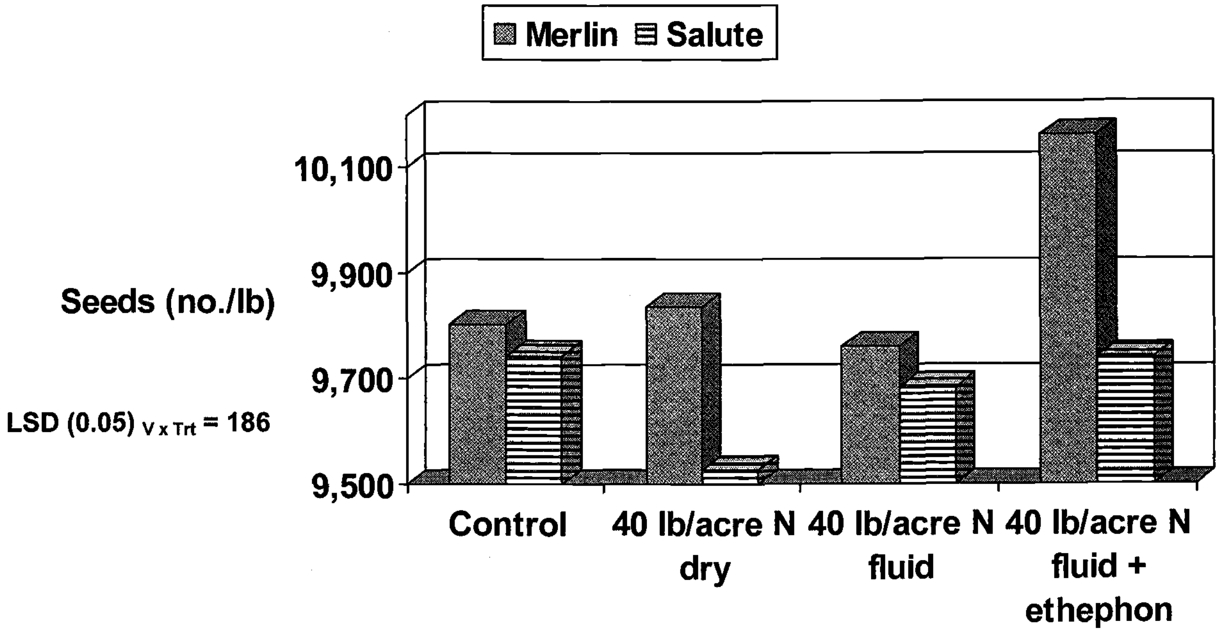


Figure 3. Seed weight (seed no./lb) of barley as influenced by heading applications of nitrogen and ethephon and averaged over years, varieties, and late winter N application rate (lb N/acre urea), Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

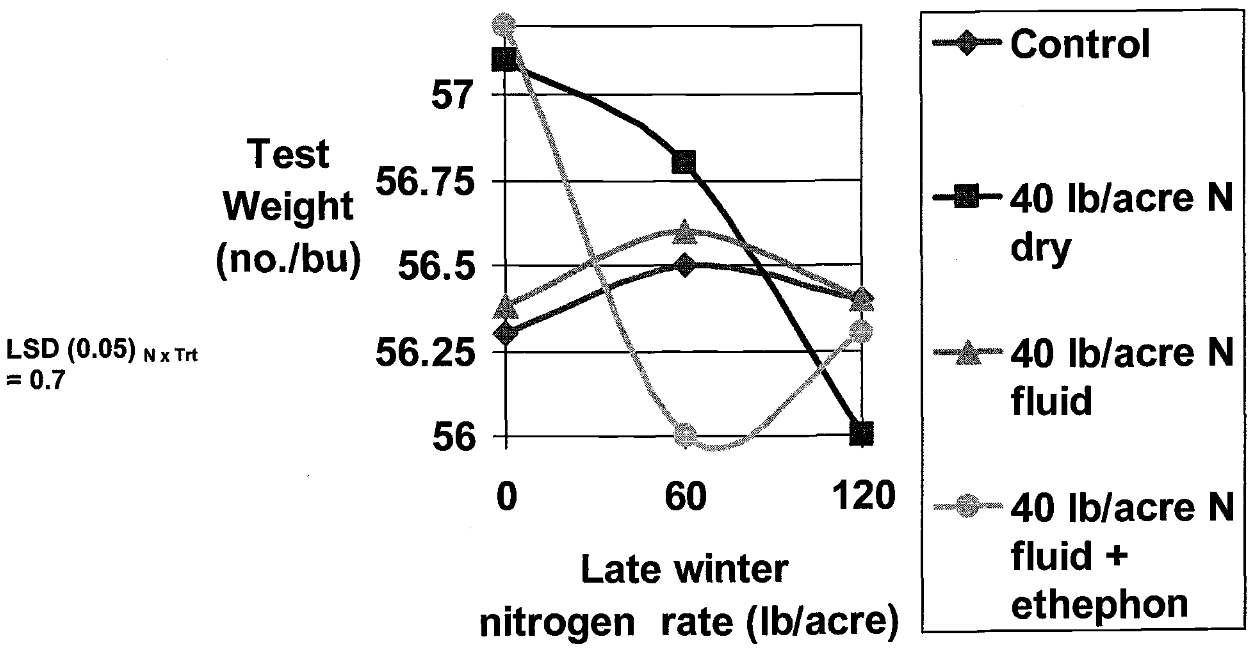


Figure 4. Test weight (seed no./lb) of barley as influenced by late winter N application rate (lb N/acre urea), heading applications of nitrogen, ethephon and averaged over years and varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

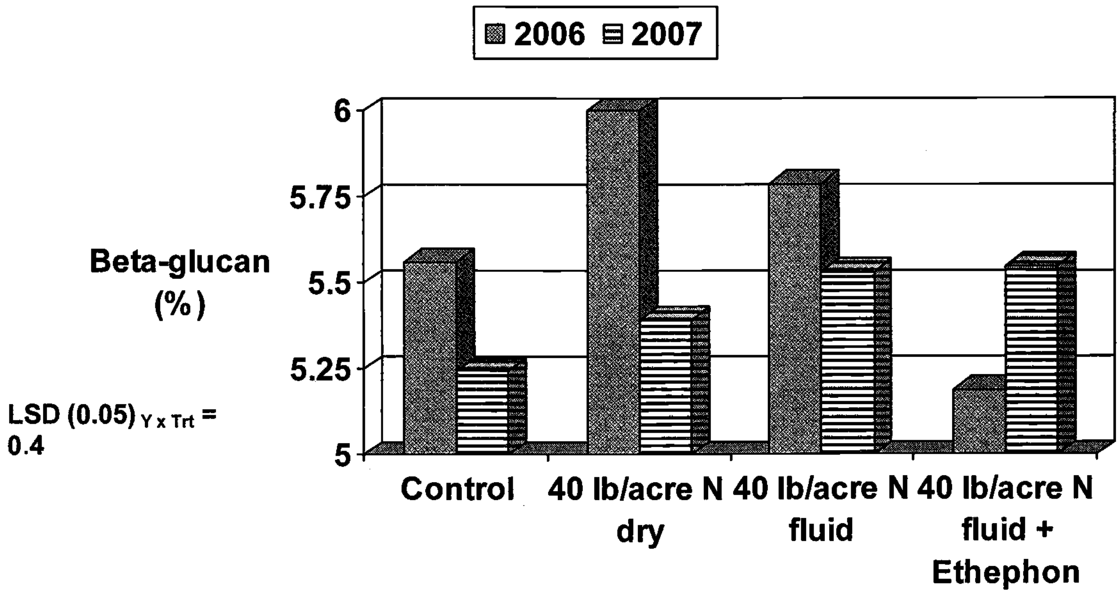


Figure 5. Beta-glucan content of barley as influenced by heading applications of nitrogen and ethephon and averaged over years and varieties, and late winter N application rate (lb N/acre urea), Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

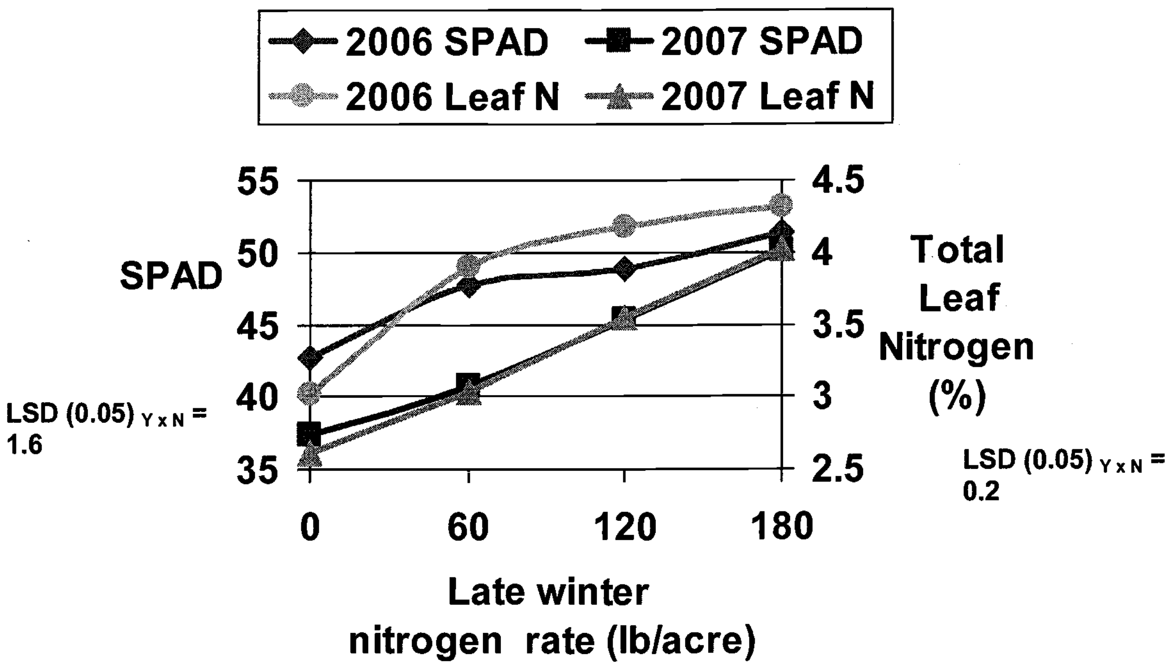


Figure 6. Total leaf nitrogen content and SPAD meter readings of barley as influenced by late winter N application rate (lb N/acre urea) and averaged over years and varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

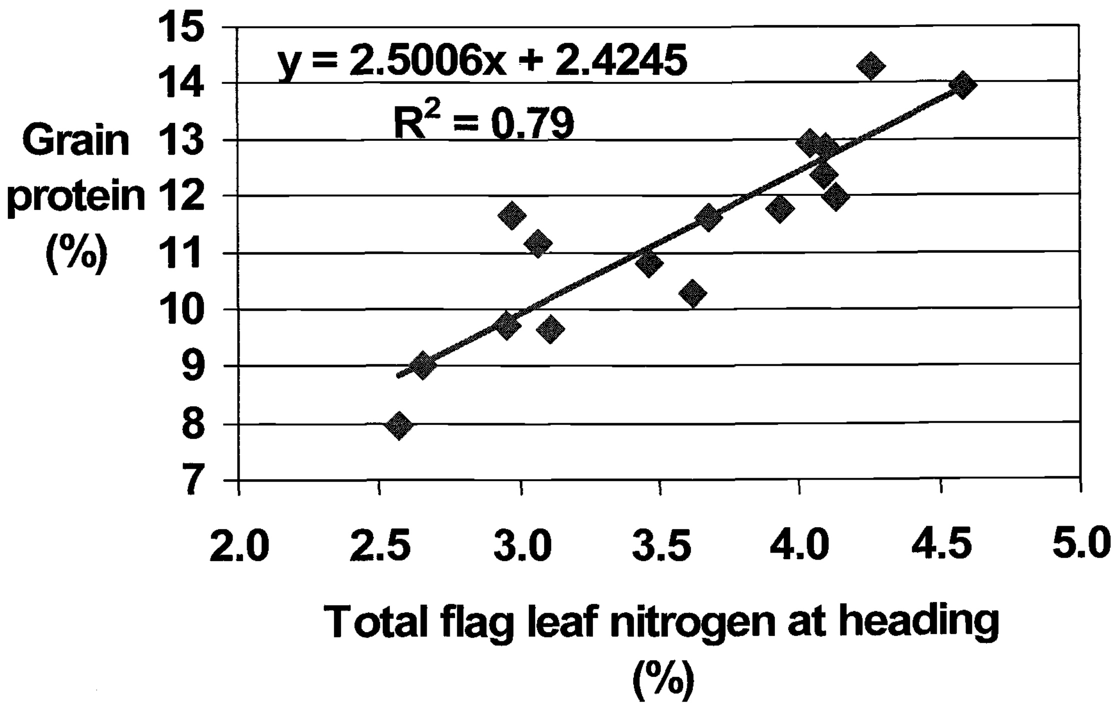


Figure 7. Relationship of total leaf nitrogen content with grain protein in barley. The means from the year and N rate means averaged over varieties was used, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006 and 2007.

SUBSURFACE DRIP IRRIGATION FOR NATIVE WILDFLOWER SEED PRODUCTION

Clint Shock, Erik Feibert, and Lamont Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR 2007

Nancy Shaw
U.S. Forest Service
Rocky Mountain Research Station
Boise, ID

Introduction

Native forb seed is needed to restore rangelands of the Intermountain West. Commercial seed production is necessary to provide the quantity of seed needed for restoration efforts. A major limitation to economically viable commercial production of native forb seed is stable and consistent seed productivity over years. Variations in spring rainfall and soil moisture result in highly unpredictable water stress at flowering, seed set, and seed development, which for other seed crops is known to compromise seed yield and quality.

Native forbs are not competitive with crop weeds. Both sprinkler and furrow irrigation could promote seed production, but risk encouraging weeds. Furthermore, sprinkler and furrow irrigation can lead to the loss of plant stand and seed production due to fungal pathogens. By burying drip tapes at 12-inch depth, and avoiding wetting of the soil surface, we hope to assure flowering and seed set without encouraging weeds or opportunistic diseases. This trial tested the effect of three irrigation intensities on the seed yield of seven native forb species.

Materials and Methods

Plant Establishment

Seed of the seven Intermountain West forb species (Table 1) was received in late November in 2004 from the Rocky Mountain Research Station (Boise, ID). The plan was to plant the seed in the fall of 2004, but due to excessive rainfall in October, the ground preparation was not completed and planting was postponed to early 2005. To ensure germination the seed was submitted to a cold stratification treatment. The seed was soaked overnight in distilled water on January 26, 2004. After seeds were soaked, the water was drained and the seed soaked for 20 minutes in a 10 percent by volume solution of 13 percent bleach in distilled water. The water was drained and the seed placed in a thin layer in plastic containers. The plastic containers had lids with holes drilled to allow air movement. The seed containers were placed in a cooler set at approximately 34°F. Every few days the seed was mixed and, if necessary, distilled water added to maintain moist seed. In late February, seed of *Lomatium grayi* and *L. triternatum* had started sprouting.

Table 1. Forb species planted at the Malheur Experiment Station, Ontario, OR.

Species	Common name
Eriogonum umbellatum	Sulfur buckwheat
Penstemon acuminatus	Sand penstemon
Penstemon deustus	Hotrock penstemon
Penstemon speciosus	Royal or sagebrush penstemon
Lomatium dissectum	Fernleaf biscuitroot
Lomatium triternatum	Nineleaf desert parsley
Lomatium grayi	Gray's lomatium
Sphaeralcea parvifolia	Smallflower globe mallow
Sphaeralcea grossularifolia	Gooseberry leafed globe mallow
Sphaeralcea coccinea	Red globe mallow
Dalea searlsiae	Seals' prairie clover
Dalea ornata	Western prairie clover
Astragalus filipes	Basalt milkvetch

In late February, 2005, drip tape (T-Tape TSX 515-16-340) was buried at 12-inch depth between two rows (30-inch rows) of a Nyssa silt loam with a pH of 8.3 and 1.1 percent organic matter. The drip tape was buried on alternating inter-row spaces (5 ft apart). The flow rate for the drip tape was 0.34 gal/min/100 ft at 8 psi with emitters spaced 16 inches apart, resulting in a water application rate of 0.066 inch/hour.

On March 3, seed of all species was planted in 30-inch rows using a custom-made plot grain drill with disk openers. All seed was planted at 20-30 seeds/ft of row. The *Eriogonum umbellatum* and the *Penstemon* spp. were planted at 0.25-inch depth and the *Lomatium* spp. at 0.5-inch depth. The trial was irrigated with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment from March 4 to April 29. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart and the water application rate was 0.10 inch/hour. A total of 1.72 inches of water was applied with the minisprinkler system. *Eriogonum umbellatum*, *Lomatium triternatum*, and *L. grayi* started emerging on March 29. All other species, except *L. dissectum*, emerged by late April. Starting June 24, the field was irrigated with the drip system. A total of 3.73 inches of water was applied with the drip system from June 24 to July 7. Thereafter the field was not irrigated.

Plant stands for *Eriogonum umbellatum*, *Penstemon* spp., *Lomatium triternatum*, and *L. grayi* were uneven. *Lomatium dissectum* did not emerge. None of the species flowered in 2005. In early October, 2005, more seed was received from the Rocky Mountain Research Station for replanting. The blank lengths of row were replanted by hand in the *Eriogonum umbellatum* and *Penstemon* spp. plots. The *Lomatium* spp. plots had the entire row lengths replanted using the planter. The seed was replanted on October 26, 2005. In the spring of 2006, plant stand of the replanted species was excellent, except for *Penstemon deustus*.

Flowering, Harvesting, and Seed Cleaning in 2006

Eriogonum umbellatum flowering started on May 19, peaked on June 24, and ended on July 28. *Penstemon acuminatus* flowering started on May 2, peaked on May 10, and ended on May 19. *Penstemon speciosus* flowering started on May 10 and peaked on May 19. *Penstemon deustus* flowering started on May 10, and peaked on May 22.

The *Eriogonum umbellatum* and *Penstemon* spp. plots produced seed in 2006, probably because they had emerged in the spring of 2005. In these plots, only the lengths of row that had consistent stand and seed production were harvested. The plant stand for *P. deustus* was too poor to result in reliable seed yield estimates. The middle two rows of each plot were harvested using a Wintersteiger Nurserymaster small plot combine. *Penstemon acuminatus* was harvested on July 7, *P. speciosus* was harvested on July 13, E. *umbellatum* was harvested on August 3, and *P. deustus* was harvested on August 4.

Eriogonum umbellatum seeds did not separate from the flowering structures in the combine; the unthreshed seed was taken to the U.S. Forest Service Lucky Peak Nursery (Boise, ID) and run through a dewinger to separate seed. The seed was further cleaned in a small clipper seed cleaner.

Penstemon deustus seed pods were too hard to be opened in the combine; the unthreshed seed was precleaned in a small clipper seed cleaner and then seed pods were broken manually by rubbing the pods on a ribbed rubber mat. The seed was then cleaned again in the small clipper seed cleaner.

Penstemon acuminatus and *P. speciosus* were threshed in the combine and the seed was further cleaned using a small clipper seed cleaner.

Expansion and Fertilization of the Trials

On April 11, 2006 seed of three globe mallow species (*Sphaeralcea parvifolia, S. grossularifolia, S. coccinea),* two prairie clover species *(Dalea searlsiae, D. ornata)*, and basalt milkvetch (*Astragalus filipes*) was planted at 30 seeds/ft of row. The field was sprinkler irrigated until emergence. Emergence was poor. In late August of 2006 seed of the three globe mallow species was harvested by hand. On November 9, 2006 the six forbs were flailed. On November 10, 2006 the six forbs were replanted.

On October 27, 2006, 50 lb P/acre and 2 lb Zn/acre were injected through the drip tape to all plots of *Eriogonum umbellatum*, *Penstemon spp.*, and *Lomatium spp.* On November 11, 100 lb N/acre as urea was broadcast to all *Lomatium spp.* plots. On November 11, the *Penstemon deustus* plots were replanted at 30 seeds/ft of row. On November 17, all plots of *Eriogonum umbellatum*, *Penstemon spp.* (except *P. deustus*), and *Lomatium spp*, had Prowl® at 1 lb ai/acre broadcast on the soil surface.

Irrigation for Seed Production in 2006

In April, 2006, the field was divided into plots 30 ft long. Each plot contained 4 rows of each of *Eriogonum umbellatum, P. acuminatus, P. speciosus, P. deustus, L. dissectum, L. triternatum, and L. grayi*. The experimental design was a randomized complete block with four replicates. The 3 irrigation treatments were: a non irrigated check, 1 inch per irrigation for a total of 4.8 inches, and 2 inches per irrigation for a total of 8.7 inches. Four irrigations were applied approximately every 2 weeks starting on May 19. The amount of water applied to each plot was measured by a water meter for each plot and recorded after each irrigation (Table 3). At the first irrigation on May 19, *Penstemon acuminatus* had ended flowering, *P. deustus* and *P. speciosus* were flowering, and *Eriogonum umbellatum* was just starting flowering.

Soil volumetric water content was measured by neutron probe. The neutron probe was calibrated by taking soil samples and probe readings at 8-, 20-, and 32- inch depths during installation of the access tubes. The soil water content was determined volumetrically from the soil samples and regressed against the neutron probe readings, separately for each soil depth. The regression equations were then used to transform the neutron probe readings during the season into volumetric soil water content.

Irrigation for Seed Production in 2007

In March of 2007, the drip-irrigation system was modified to allow separate irrigation of the species due to differing growth habits. The three *Lomatium spp.* were irrigated together and *Penstemon deustus* and *P. speciosus* were irrigated together, but separately from the others. *Penstemon acuminatus* and *Eriogonum umbellatum* were irrigated individually. In early April, 2007 the three globe mallow species, two prairie clover species, and basalt milkvetch were divided into plots with a drip-irrigation system to allow the same irrigation treatments as the other forbs.

Soil volumetric water content was measured in 2007 as in 2006.

On April 5, irrigations for the three Lomatium spp. were started. On April 19, irrigations for *Penstemon deustus* and *P. speciosus* were started. On May 2, irrigations for *P. acuminatus* and *Eriogonum umbellatum* were started. Irrigation treatments were the same as in 2006. The three globe mallow species, two prairie clover species, and basalt milkvetch were irrigated together according to the treatments starting on May 16. Inadvertently, irrigation treatments were not stopped after four irrigations were applied, as in 2006. Irrigation treatments for all species were continued until the last irrigation on June 24.

Cultural Practices, Harvest, and Seed Cleaning in 2007

Penstemon acuminatus and *P. speciosus* were sprayed with Aza-Direct® at 0.0062 lb ai/acre on May 14 and May 29 for lygus bug control.

Lomatium grayi seed was hand harvested on May 30 and June 29. *Lomatium triternatum* was hand harvested on June 29 and July 16. The seed was separated from the stalks by hand and cleaned with a small clipper seed cleaner. Because the seed harvest and cleaning varied by species, the details are reported in Table 2.

The three *Sphaeralcea* species were hand harvested on June 20, July 10, and August 13. The harvested seed pods were threshed in the small plot combine with an alfalfa seed concave. The two prairie clover species were hand harvested on June 20 and July 10.

Penstemon acuminatus was harvested on July 9 with the small plot combine with an alfalfa seed concave. The seed was further cleaned with a small clipper seed cleaner. *Penstemon speciosus* was hand harvested on July 23. Hand harvest for *P. speciosus* was necessary due to poor seed set. *Penstemon speciosus* seed was separated by hand and cleaned with a small clipper seed cleaner.

Eriogonum umbellatum was harvested on July 31 using the small plot combine with a dry bean concave. The seed was threshed by hand and cleaned with a small clipper seed cleaner.

Table 2. Native forb seed harvest and cleaning by species in 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Species	Number of harvests	Harvest method	Pre-cleaning	Threshing method	Cleaning method
Eriogonum umbellatum	1	combine[a]	none	dewinger[d]	mechanical
Penstemon acuminatus	1	combine[b]	none	combine	mechanical
Penstemon deustus	1	combine[a]	mechanical[c]	hand[e]	mechanical
Penstemon speciosus[f]	1	combine[b]	none	combine	mechanical
Lomatium dissectum	0				
Lomatium triternatum	2	hand	hand	none	mechanical
Lomatium grayi	2	hand	hand	none	mechanical
Sphaeralcea parvifolia	3	hand	none	combine	none
Sphaeralcea grossulariifolia	3	hand	none	combine	none
Sphaeralcea coccinea	3	hand	none	combine	none
Dalea searlsiae	2	hand	none	dewinger	mechanical
Dalea ornata	2	hand	none	dewinger	mechanical

[a]Dry bean concave.
[b]Alfalfa seed concave.
[c]Clipper seed cleaner.
[d]Specialized seed threshing machine at USDA Lucky Peak Nursery. In 2007, due to travel constraints, an adjustable hand-driven corn grinder was used to thresh seed.
[e]Hard seed pods were broken by rubbing against a ribbed rubber mat.
[f]Harvested by hand in 2007 due to poor seed set.

Results and Discussion

Precipitation in the fall of 2005 and spring of 2006 was higher than normal at the Malheur Experiment Station (Fig. 1). Precipitation from October 2005 through June 2006 was 15.9 inches. The 64-year average precipitation from October through June is 9.1 inches. Precipitation from March through June was 6.4 inches in 2006. The 64-year average precipitation from March through June is 3.6 inches. The wet weather could have attenuated the effects of the irrigation treatments in 2006 (Shock et al. 2007). Of the 7 species tested, only *Eriogonum umbellatum* and *Penstemon speciosus* showed seed yield responses to irrigation rate in 2006 (Table 4).

Precipitation from October 2006 through June 2007 was 6.2 inches, lower than the 64-year average. Precipitation from March through June was 2.0 inches in 2007. The total amount of water applied to the forbs was higher than planned in 2007 (Table 3). The biweekly irrigations were continued until June 24, instead of being terminated after four irrigations. The soil volumetric water content responded to the irrigation treatments (Figs. 2-6).

Emergence for the two prairie clover (*Dalea* spp.) species in the spring of 2007 was again poor. Emergence for *Penstemon deustus* and for basalt milkvetch (*Astragalus filipes*) was extremely poor; *A. filipes* produced negligible amounts of seed in 2007.

Flowering and Seed Set in 2007

Lomatium grayi started flowering in late March and ended in mid-May. *Lomatium triternatum* started flowering in mid-April and ended in early June. *Lomatium dissectum* did not flower. *Penstemon acuminatus* and *P. deustus* started flowering in early May and ended in late June. *P. speciosus* started flowering in early May and ended in late June. *Eriogonum umbellatum* started flowering in early May and ended in late July. The three *Sphaeralcea* species (globe mallow) started flowering in early May and continued flowering through September. The two *Dalea* species (prairie clover) started flowering in early May and ended in late June.

The three *Sphaeralcea* species (globe mallow) showed a long flowering period (early May through September). Multiple harvests were necessary because the seed falls out of the pods once the pods are mature.

Penstemon acuminatus and *P. speciosus* had poor seed set partly due to a heavy lygus bug infestation that was not adequately controlled by the applied insecticides. Poor seed set for *P. acuminatus* and *P. speciosus* was also related to poor vegetative growth in 2007 compared to 2006.

Seed Yields

In 2006, seed yield of *Eriogonum umbellatum* was highest with the 2-inch irrigation rate (Table 4). In 2007, seed yield of *E. umbellatum* with the 1-inch irrigation rate was significantly higher than with the nonirrigated check. Seed yield with the 2-inch rate was not significantly higher than with the 1-inch rate.

Seed yields of *Penstemon acuminatus* and *P. speciosus* in 2007 were substantially lower than in 2006, possibly due to poor vegetative growth and lygus bug damage to flowering structures (Table 4). There was no significant difference in seed yield between irrigation treatments for *P. acuminatus* in 2006. In 2007, seed yield of *P. acuminatus* was highest with the 1-inch irrigation rate. Seed yields with either the 2-inch irrigation rate or the nonirrigated check were similar and substantially lower.

For *P. speciosus* in 2006 and 2007, seed yields were increased with the 1-inch irrigation rate compared to the nonirrigated check. Seed yields with the 2-inch irrigation rate were lower, but not significantly different than for the 1-inch rate.

There was no significant difference in seed yield between irrigation treatments for *P. deustus* in 2006 and 2007. For *P. deustus*, the replanting of the low stand areas in October of 2005 and the replanting of the whole area in October 2006 resulted in very poor emergence and in plots with very low and uneven stands.

Of the three *Lomatium* species, *L. grayi* had the most vigorous vegetative growth in 2007; *L. dissectum* had the poorest vegetative growth in 2006 and 2007 and did not flower in either year. *Lomatium grayi* and *L. triternatum* showed a trend for increasing seed yield with increasing irrigation rate in 2007. The highest irrigation rate resulted in significantly higher seed yield than the nonirrigated check. The much greater *Lomatium* growth in 2007 shows promise for higher seed yields in future years.

There was no significant difference in seed yield between irrigation treatments for the three *Sphaeralcea* species, with *S. parvifolia* having the highest seed yield. The *Sphaeralcea* species seed yields ranged from 279 to 1,062 lb/acre in 2007 without irrigation.

There was no significant difference in seed yield between irrigation treatments for the two *Dalea* species, with *D. ornata* having the highest seed yield. Emergence for the two *Dalea* species was poor with plots having poor and uneven stand.

Summary and Comparison of 2006 and 2007

Precipitation from March through June was 6.4 inches in 2006 and 2.0 inches in 2007. The 64-year average precipitation from March through June is 3.6 inches.

For *Eriogonum umbellatum*, seed yield was maximized with the 2-inch irrigation rate in 2006 and with the 1- or 2-inch irrigation rate in 2007. For *Penstemon acuminatus*, seed yield was not responsive to irrigation in 2006 and was maximized with the 1-inch irrigation rate in 2007. For *P. speciosus*, seed yields were maximized with the 1-inch irrigation rate in 2006 and 2007. For *P. deustus*, seed yield was not responsive to irrigation in 2006 and 2007. None of the three *Lomatium* species flowered in 2006. *Lomatium dissectum* has been very slow to develop on the experimental site and has not flowered. Seed yield for *L. triternatum* and *L. grayi* were maximized by the highest irrigation rate of 2 inches in 2007. The three *Sphaeralcea* species and the two *Dalea* species did not respond to irrigation in 2007.

The poor emergence and resulting poor stand cast doubt on the accuracy of the seed yield response to irrigation for *Penstemon deustus*, the three *Sphaeralcea* species, and the two *Dalea* species

Conclusions

Subsurface drip irrigation systems are being tested for native seed production because they have two potential strategic advantages, a) low water use, and b) the buried drip tape provides water to the plants at depth, out of reach of stimulating weed seed germination on the soil surface and away from the plant tissues that are not adapted to a wet environment.

Knowledge about native forb seed production would help make commercial production of this seed feasible. Irrigation methods are being developed at the Oregon State University Malheur Experiment Station to help assure reliable seed production with reasonably high seed yields. Growers need to have economic return on their seed plantings, but forbs may not produce seed every year. Due to the arid environment, supplemental irrigation may be required for successful flowering and seed set many years because soil water reserves may be exhausted before seed formation. The total irrigation water requirements for these arid land species has been shown to be low, but it varied by species.

References

Shock, C.C., E.B.G. Feibert, L.D. Saunders, N. Shaw, and A. DeBolt. 2007. Seed Production of Native Forbs Shows Little Response to Irrigation in a Wet Year. Oregon State University Agricultural Experiment Station Special Report 1075:13-20.

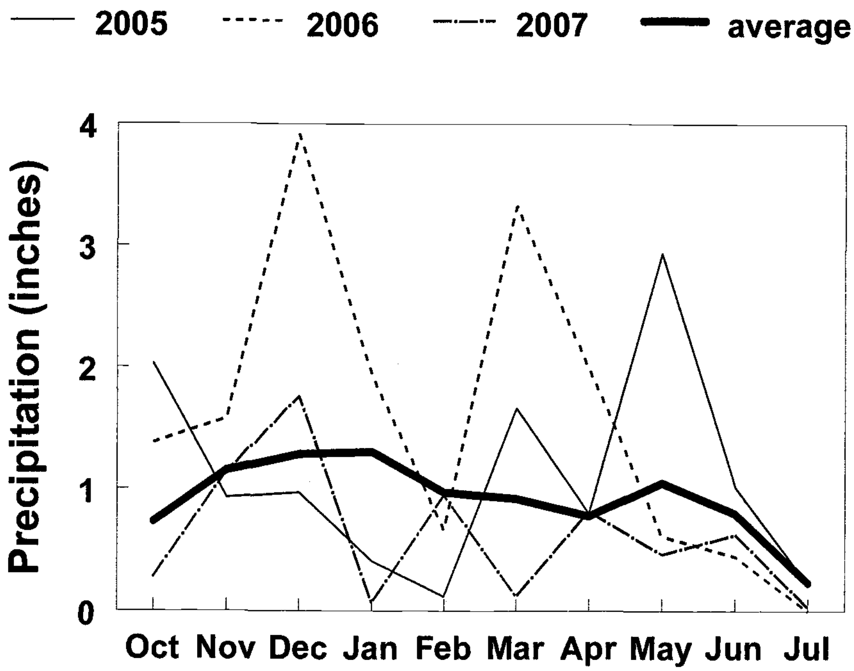


Figure 1. Monthly precipitation from October of the previous year through July for the last 3 years, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Table 3. Irrigation treatments and actual amounts of water applied to native forbs in 2006 and 2007. Precipitation from March through June was 6.4 inches in 2006 and 2.0 inches in 2007. The 64-year average is 3.6 inches. Malheur Experiment Station, Oregon State University, Ontario, OR.

		Actual amount of water applied			
Date	Irrigation rates (inches per irrigation)	*Lomatium spp.*	*Penstemon deustus, P. speciosus*	*Penstemon acuminatus, Eriogonum umbellatum*	*Sphaeralcea spp., Dalea spp.*
		---------------------------- acre inches/acre ----------------------------			
			2006		
19 May	2	2.23	2.23	2.23	
19 May	1	1.31	1.31	1.31	
2 Jun	2	2.16	2.16	2.16	
2 Jun	1	1.23	1.23	1.23	
20 Jun	2	2.04	2.04	2.04	
20 Jun	1	1.23	1.23	1.23	
30 Jun	2	2.26	2.26	2.26	
30 Jun	1	1.12	1.12	1.12	
total	2	8.69	8.69	8.69	
total	1	4.89	4.89	4.89	
			2007		
5 Apr	2	2.00			
5 Apr	1	1.28			
19 Apr	2	2.78	2.78		
19 Apr	1	1.34	1.34		
2 May	2	2.70	2.70	2.70	
2 May	1	1.40	1.40	1.40	
16 May	2	2.62	2.62	2.62	2.62
16 May	1	1.42	1.42	1.42	1.42
30 May	2	2.49	2.49	2.49	2.49
30 May	1	1.22	1.22	1.22	1.22
10 Jun	2	2.46	2.46	2.46	2.46
10 Jun	1	1.09	1.09	1.09	1.09
24 Jun	2	2.59	2.59	2.59	2.59
24 Jun	1	1.41	1.41	1.41	1.41
total	2	17.6	15.6	12.9	10.2
total	1	9.2	7.9	6.5	5.1

Table 4. Native forb seed yield response to irrigation rate (inches/irrigation) in 2006 and 2007, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Species	Planting date	2006				2007			
		0 inch	1 inch	2 inch	LSD(0.05)	0 inch	1 inch	2 inch	LSD(0.05)
		---------- lb/acre ----------							
Eriogonum umbellatum	Mar 05, Oct 05[a]	155.3	214.4	371.6	92.9	79.6	164.8	193.8	79.8
Penstemon acuminatus	Mar 05, Oct 05[a]	538.4	611.1	544	NS	19.3	50.1	19.1	25.5[f]
Penstemon deustus	Mar 05, Oct 05[b]	1246.4	1200.8	1068.6	NS	120.3	187.7	148.3	NS
Penstemon speciosus	Mar 05, Oct 05[a]	163.5	346.2	213.6	134.3	2.5	9.3	5.3	4.7[f]
Lomatium dissectum	October 05[c]	---- no flowering ----				---- no flowering ----			
Lomatium triternatum	October 05[c]	---- no flowering ----				2.3	17.5	26.7	16.9[f]
Lomatium grayi	October 05[c]	---- no flowering ----				36.1	88.3	131.9	77.7[f]
Sphaeralcea parvifolia	November 06[d]					1062.6	850.7	957.9	NS
Sphaeralcea grossularifolia	November 06[d]					442.6	324.8	351.9	NS
Sphaeralcea coccinea	November 06[d]					279.8	262.1	310.3	NS
Dalea searlsiae[e]	November 06[d]					11.5	10.2	16.4	NS
Dalea ornata[e]	November 06[d]					47.4	27.3	55.6	NS

[a]Areas of low stand replanted by hand in October 2005.
[b]Areas of low stand replanted by hand in October 2005 and whole area replanted in October 2006. Yields in 2006 are based on small areas with adequate stand. Yields in 2007 are based on whole area of very poor and uneven stand.
[c]Whole area replanted in October 2005.
[d]Whole area replanted in November 2006.
[e]Poor and uneven stand.
[f] LSD (0.10).

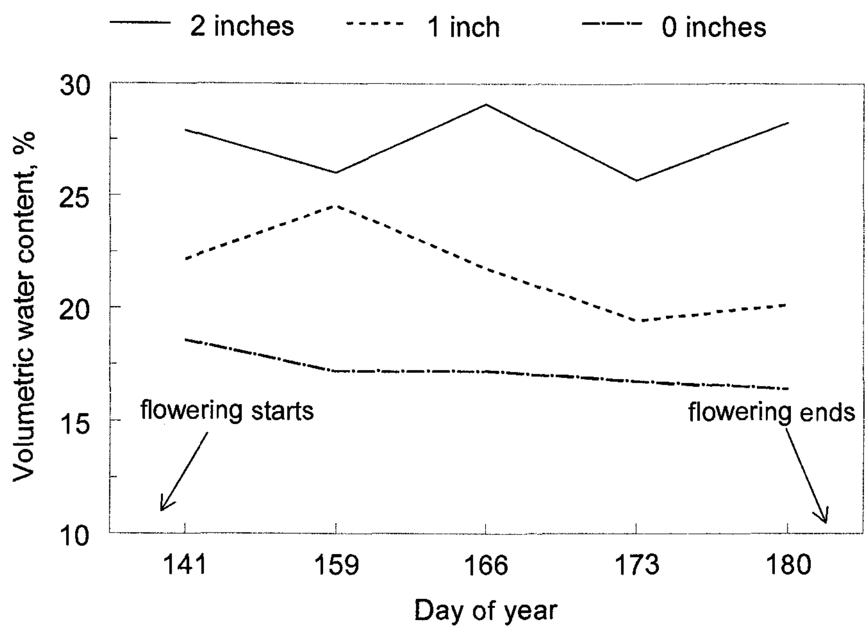


Figure 2. Soil volumetric water content for *Eriogonum umbellatum* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *E. umbellatum* was harvested on July 31 (day 212). Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

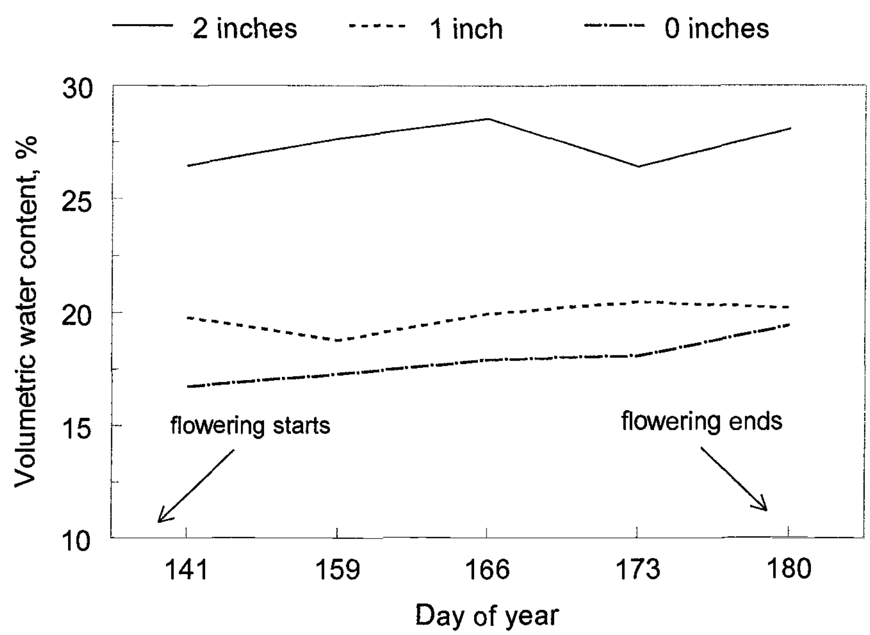


Figure 3. Soil volumetric water content for *Penstemon acuminatus* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

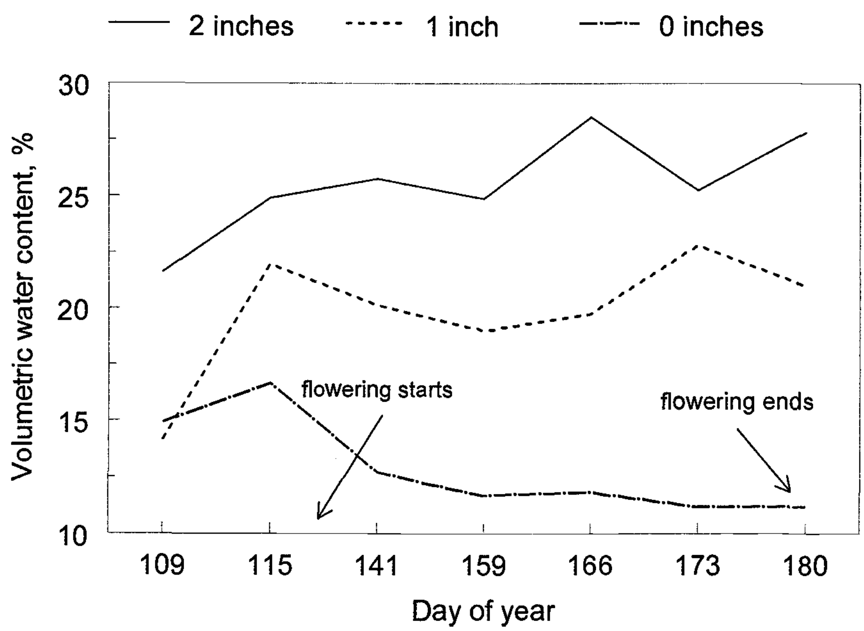


Figure 4. Soil volumetric water content for *Penstemon speciosus* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *P. speciosus* was harvested on July 23 (day 204). Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

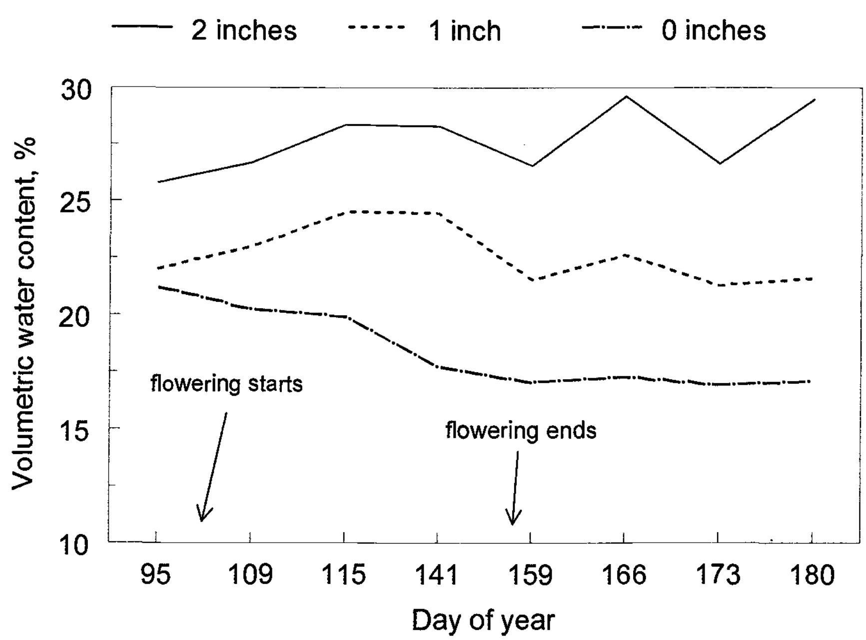


Figure 5. Soil volumetric water content for *Lomatium triternatum* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *L. triternatum* was harvested on June 29 (day 180) and July 16 (day 197). Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

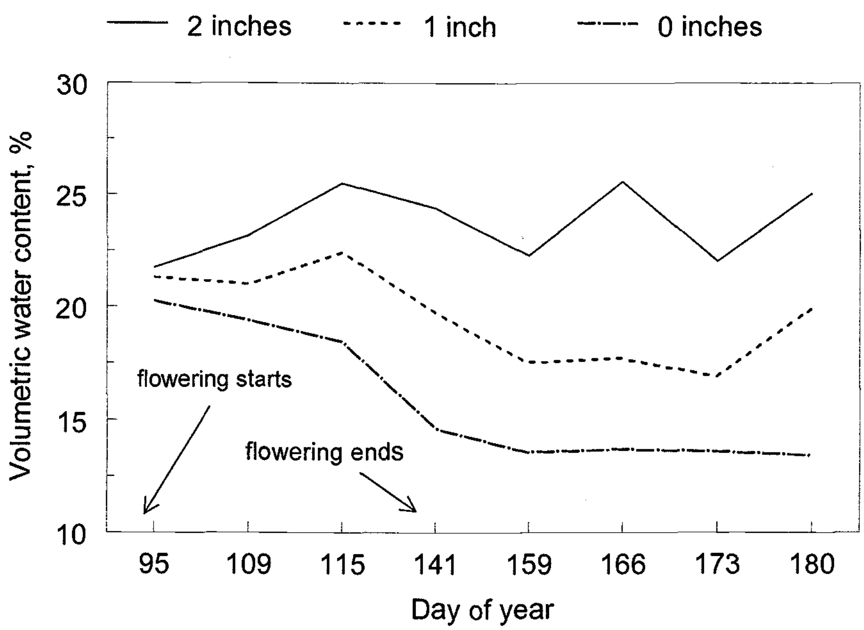


Figure 6. Soil volumetric water content for *Lomatium grayi* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *L. grayi* was harvested on May 30 (day 151) and June 29 (day 180). Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

NATIVE WILDFLOWERS GROWN FOR SEED PRODUCTION SHOW TOLERANCE TO CONVENTIONAL POSTEMERGENCE HERBICIDES

Clinton C. Shock, Joey Ishida, and Erik Feibert
Malheur Experiment Station
Oregon State University
Ontario, OR 2007

Introduction

Native forb seed is needed to restore rangelands of the Intermountain West. Commercial seed production is necessary to provide the quantity of seed needed for restoration efforts. A major limitation to economically viable commercial production of native forb seed is weed competition. Weeds are adapted to growing in disturbed soil, and native forbs are not competitive with these weeds. There is a considerable body of knowledge about the relative efficacy of different herbicides to control target weeds, but few trials have tested the tolerance of native forbs to commercial herbicides.

The trials reported here tested the tolerance of seven native forb species in successive years to conventional postemergence herbicides in the field. **This work seeks to discover products that could eventually be registered for use for native forb seed production.** The information in this report is for the purpose of informing cooperators and colleagues in other agencies, universities, and industry of the research results. Reference to products and companies in this publication is for the specific information only and does not endorse or recommend that product or company to the exclusion of others that may be suitable. Nor should any information and interpretation thereof be considered as recommendations for the application of any of these herbicides. **Pesticide labels should always be consulted before any pesticide use. Considerable efforts may be required to register these herbicides for use in native forb seed production.**

Materials and Methods

Plant Establishment

Seed of seven Great Basin forb species (Table 1) received in October 2005 was planted November 1, 2005. The field had been disked, ground hogged, and marked out in rows 30 inches apart. The seven forb species were planted in individual rows 435 ft long and 30 inches apart. Planting depths were similar to those used in the irrigation trial (Shock et al. 2007) and varied by species. The crop preceding forbs was wheat. Prior to planting, one drip tape was inserted 12 inches deep equidistant between pairs of rows to be planted. The drip tape was supplied with irrigation water using filtration and other common drip irrigation practices (Shock 2006).

2006 Postemergence Treatments

The field was staked out to make 5-ft-wide plots perpendicular to the forb rows, crossing all seven species using the lower 200 ft of the field. Eight treatments including the untreated check were replicated four times in a randomized complete block design (see Tables 2-8). Treatments were applied May 24, 2006 at 30 psi, 2.63 mph, in 20 gal/acre using 8002 nozzles with 3 nozzles spaced 20 inches apart. Plant injury in 2006 was rated visually on May 31, June 15, and June 30.

In 2006 the trial was irrigated very little with the drip irrigation system because of ample rainfall. Very few plants flowered and seed was not harvested in 2006.

Spring of 2007

By March 30, 2007 it was difficult if not impossible to distinguish any effects of the 2006 postemergence herbicide applications on any of the seven forb species. These observations suggest that some degree of phytotoxic damage may be acceptable in establishing native forb seed fields if effective weed control is achieved.

2007 Postemergence Treatments

The same treatments as 2006 were applied again to the same plots on April 24, 2007. The same application specifications as in 2006 were used in 2007. Plant injury was rated visually on May 1, May 11, May 25, and June 12.

Drip irrigations were applied every 2 weeks starting on April 5 and ending on June 24. Each irrigation applied 2 inches of water.

Seed of *Eriogonum umbellatum, Penstemon acuminatus, P. deustus,* and *P. speciosus* was harvested by hand as the seed reached maturity. The seed was cleaned and weighed. *Lomatium dissectum, L. triternatum,* and *L. grayi* did not flower in 2007.

General Considerations

The focus of the evaluations was forb tolerance of the herbicides, not weed control. Therefore, weeds were removed as needed.

The effects of herbicides for each species on plant stand and injury were evaluated independently from the effects on other species. Treatment differences were compared using ANOVA and protected least significant differences at the 95 percent confidence LSD (0.05) using NCSS Number Cruncher software (NCSS, Kaysville, UT).

Table 1. Forb species planted at the Malheur Experiment Station, Oregon State University, Ontario, OR, and their origins.

Species	Common name	Origin	Year
Eriogonum umbellatum	Sulfur buckwheat	Shoofly Road (ID)	2004
Penstemon acuminatus	Sand penstemon	Bliss Dam (ID)	2004
Penstemon deustus	Hotrock penstemon	Blacks Cr. Rd. (ID)	2003
Penstemon speciosus	Royal or sagebrush penstemon	Leslie Gulch (OR)	2003
Lomatium dissectum	Fernleaf biscuitroot	Mann Creek (ID)	2003
Lomatium triternatum	Nineleaf desert parsley	Hwy 395 (OR)	2004
Lomatium grayi	Gray's lomatium	Weiser R. Rd. (ID)	2004

Results and Discussion

All observations made on the herbicides tested are strictly preliminary observations. Herbicides that were observed to be damaging to the forbs as reported here might be helpful if used at a lower rate or in a different environment. Herbicides that were relatively safe for the forbs in these trials might be harmful if used at higher rates or in a different environment. Nothing in this report should be construed as a recommendation.

Eriogonum umbellatum (Sulfur buckwheat)
Sulfur buckwheat showed herbicide injury on the May 1 evaluation with Goal® and Caparol® as postemergence treatments (Table 2). There were no significant differences in injury between herbicide treatments on the other evaluation dates. Select® and Prowl® had among the lowest injury symptoms on the May 11, May 25, and June 12 evaluations.

There were no significant differences in seed yield between herbicide treatments (Table 2). Prowl, the untreated check, and Outlook® had among the highest seed yields with no statistical differences between any of the treatments.

Table 2. Tolerance of *Eriogonum umbellatum* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were 50 percent dormant. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %				Seed yield
	lb ai/acre	May 1	May 11	May 25	June 12	lb/acre
Untreated	--	0.0	0.0	0.0	0.0	91.7
Buctril 2.0 EC	0.125	12.5	22.5	20.0	15.0	38.1
Goal 2XC	0.125	45.0	27.5	17.5	13.8	42.6
Select 2.0 EC + Herbimax	0.094 + 1% v/v	11.7	6.7	3.3	1.7	57.6
Prowl H2O 3.8 C	1	10.0	6.3	3.8	3.8	115.0
Caparol FL 4.0	0.8	28.8	41.3	33.8	26.3	27.3
Outlook 6.0 EC	0.656	2.5	18.8	15.0	15.0	75.1
Lorox 50 DF	0.5	15.0	27.5	27.5	26.3	35.6
LSD (0.05)		19.4	NS	NS	NS	NS

Penstemon acuminatus (Sand penstemon)
No injury symptoms were observed on the May 1 evaluation. On May 11, only Caparol resulted in significantly higher injury symptoms than the check (Table 3). On May 25, Caparol and Buctril® resulted in significantly higher injury symptoms than the check. On June 12, Caparol, Buctril, and Select resulted in significantly higher injury symptoms than the check.

Seed yields for Buctril, Select, Caparol, and Lorox® were significantly lower than the untreated check (Table 3). Plots treated with Prowl, Outlook, and the untreated check had among the highest seed yields.

Table 3. Tolerance of *Penstemon acuminatus* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were beginning to flower. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %				Seed yield
	lb ai/acre	May 1	May 11	May 25	June 12	lb/acre
Untreated	--	0.0	0.0	0.0	0.0	520.4
Buctril 2.0 EC	0.125	0.0	11.3	16.3	17.5	305.7
Goal 2XC	0.125	0.0	2.5	2.5	7.5	417.8
Select 2.0 EC + Herbimax	0.094 + 1% v/v	0.0	2.5	5.0	17.5	304.6
Prowl H2O 3.8 C	1	0.0	0.0	0.0	0.0	509.4
Caparol FL 4.0	0.8	0.0	18.8	30.0	27.5	162.9
Outlook 6.0 EC	0.656	0.0	0.0	2.5	8.8	502.6
Lorox 50 DF	0.5	0.0	13.8	11.3	17.5	264.9
LSD (0.05)		NS	5.4	8.2	NS	183.4

Penstemon deustus (Hotrock penstemon)
On the first three evaluation dates, Buctril, Goal, Caparol, and Lorox resulted in significantly higher injury symptoms than the check (Table 4). On the last evaluation (June 12), plants treated with Caparol and Lorox still showed injury symptoms.

Seed yields for the Buctril, Goal, Caparol, and Lorox treatments were significantly lower than the untreated check (Table 4). Plots treated with Select, Outlook, Prowl, and the untreated check had among the highest seed yields.

Table 4. Tolerance of *Penstemon deustus* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were growing vegetatively. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %				Seed yield
	lb ai/acre	May 1	May 11	May 25	June 12	lb/acre
Untreated	--	0.0	0.0	0.0	0.0	903.1
Buctril 2.0 EC	0.125	18.3	26.3	18.8	10.0	348.5
Goal 2XC	0.125	18.0	23.8	18.8	17.5	333.0
Select 2.0 EC + Herbimax	0.094 + 1% v/v	1.3	2.5	0.0	2.5	927.3
Prowl H2O 3.8 C	1	0.0	2.5	1.3	2.5	747.6
Caparol FL 4.0	0.8	21.3	48.3	50.0	47.5	86.8
Outlook 6.0 EC	0.656	0.0	1.3	7.5	10.0	835.1
Lorox 50 DF	0.5	21.3	52.5	50.0	38.8	108.5
LSD (0.05)		8.7	14.9	16.4	18.4	334.8

Penstemon speciosus (Royal or sagebrush penstemon)
There were no significant injury symptoms for any of the treatments on the first evaluation (Table 5). Only Caparol and Lorox treatments showed significant injury symptoms, with Caparol having the most severe injury symptoms.

Seed yields for the Buctril, Goal, Caparol, and Lorox treatments were significantly lower than the check (Table 5). Plots treated with Select, Outlook, Prowl, and the untreated check had among the highest seed yields.

Table 5. Tolerance of *Penstemon speciosus* to postemergence herbicides applied on April 24, 2007. At time of herbicide applications, plants were beginning to flower. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %				Seed yield
	lb ai/acre	May 1	May 11	May 25	June 12	lb/acre
Untreated	--	0.0	0.0	0.0	0.0	55.3
Buctril 2.0 EC	0.125	1.3	2.5	2.5	1.3	24.6
Goal 2XC	0.125	0.0	0.0	0.0	2.5	20.9
Select 2.0 EC + Herbimax	0.094 + 1% v/v	0.0	0.0	0.0	0.0	51.2
Prowl H2O 3.8 C	1	0.0	0.0	0.0	0.0	52.9
Caparol FL 4.0	0.8	0.0	26.3	37.5	42.5	15.7
Outlook 6.0 EC	0.656	0.0	0.0	0.0	0.0	56.6
Lorox 50 DF	0.5	0.0	10.0	6.3	11.3	20.0
LSD (0.10)		NS	4.2	4.1	6.2	29.7

Lomatium dissectum (Fernleaf biscuitroot)
Only plants treated with Buctril showed significant injury symptoms on the first evaluation (Table 6). There were no significant differences in injury between treatments on the last three evaluations.

Lomatium dissectum had a very short growing period before going dormant and did not flower in 2007.

Table 6. Tolerance of *Lomatium dissectum* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were growing vegetatively. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %			
	lb ai/acre	May 1	May 11	May 25	June 12
Untreated	--	0	0	0	0
Buctril 2.0 EC	0.125	5	2.5	3.75	5
Goal 2XC	0.125	1.25	1.25	1.25	0
Select 2.0 EC + Herbimax	0.094 + 1% v/v	0	0	0	0
Prowl H2O 3.8 C	1	0	0	0	5
Caparol FL 4.0	0.8	1.25	1.25	3.75	7.5
Outlook 6.0 EC	0.656	1.25	1.25	1.25	2.5
Lorox 50 DF	0.5	0	0	1.25	0
LSD (0.05)		2.2	NS	NS	NS

Lomatium triternatum (Nineleaf desert parsley)
Only plants treated with Buctril showed injury symptoms (Table 7).

No seed was produced by *Lomatium triternatum* in 2007.

Table 7. Tolerance of *Lomatium triternatum* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were growing vegetatively. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Visual estimates of foliar injury, %			
	lb ai/acre	May 1	May 11	May 25	June 12
Untreated	--	0	0	0	2.5
Buctril 2.0 EC	0.125	20	63.75	88.75	92.5
Goal 2XC	0.125	0	0	0	0
Select 2.0 EC + Herbimax	0.094 + 1% v/v	0	0	0	0
Prowl H2O 3.8 C	1	0	0	0	0
Caparol FL 4.0	0.8	0	0	0	0
Outlook 6.0 EC	0.656	0	0	0	0
Lorox 50 DF	0.5	0	0	0	0
LSD (0.05)		2.1	2.5	1.3	2.9

Lomatium grayi (Gray's lomatium)
On the May 1, May 25, and June 12 evaluations, only Buctril resulted in injury symptoms significantly higher than the check (Table 8). On the May 11 evaluation, Buctril and Caparol resulted in injury symptoms significantly higher than the check.

No seed was produced by *Lomatium grayi* in 2007.

Table 8. Tolerance of *Lomatium grayi* to postemergence herbicides applied on April 24, 2007. At the time of herbicide applications, plants were growing vegetatively. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Treatment	Rate	Injury %			
	lb ai/acre	May 1	May 11	May 25	June 12
Untreated	--	0	0	0	0
Buctril 2.0 EC	0.125	15	37.5	41.25	28.75
Goal 2XC	0.125	2.5	6.25	1.25	3.75
Select 2.0 EC + Herbimax	0.094 + 1% v/v	0	0	0	0
Prowl H2O 3.8 C	1	0	0	0	0
Caparol FL 4.0	0.8	2.5	11.25	7.5	6.25
Outlook 6.0 EC	0.656	0	0	0	0
Lorox 50 DF	0.5	0	0	0	0
LSD (0.05)		2.7	8.8	8.8	6.7

Summary

All seven species tested were tolerant to Prowl and Outlook applied as postemergence treatments at the rate, timing, and soils used in these trials. *Penstemon deustus, P. specious,* and the *Lomatium* species were also tolerant to postemergence applications of Select at the rate, timing, and soils used in these trials. Prowl and Outlook are broad spectrum, soil-active herbicides that will prevent weed emergence during the season. Select is a foliar-contact, grass herbicide. The use of these three herbicides may provide the basis for an effective weed control program for seed production of these five species. Further tests are warranted to describe the range of safety for these herbicides and whether or not they have any undesirable interactions.

References

Shock, C.C. 2006. Drip irrigation: an introduction. Sustainable Agriculture Techniques, Oregon State University Extension Service. EM8782-E Revised October 2006.

Shock, C.C., E.B.G. Feibert, L.D. Saunders, N. Shaw, and A. DeBolt. 2007. Seed production of native forbs shows little response to irrigation in a wet year. Oregon State University Agricultural Experiment Station Special Report 1075:13-20.

SCARIFICATION OF BASALT MILKVETCH (*Astragalus filipes*) SEED FOR IMPROVED EMERGENCE

Clinton C. Shock, Erik B. Feibert, and Lamont D. Saunders
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Basalt milkvetch (*Astragalus filipes*) is a forb (non woody perennial) native to western North America. Basalt milkvetch is a legume forb species of interest for revegetating rangelands of the intermountain northwest; it can contribute high quality feed, valuable seed for wildlife, and nitrogen fixation to help maintain range productivity. Basalt milkvetch has a hard seed coat that makes the seed impermeable to water and difficult to germinate. Low seed germination can contribute to low plant stand when seed is used to plant areas for seed increase. This trial tested basalt milkvetch emergence in response to seed scarification intensity.

Materials and Methods

Basalt milkvetch seed was collected from a highly productive plant that was planted at the Malheur Experiment Station. A scarification device was built by attaching two pieces of car tire inner tube to opposing sides of a drill bit. The drill bit was inserted into a cylinder made of 3-inch-diameter PVC. The cylinder was lined with 220-grit sandpaper. The inner tube pieces were long enough to rub the sandpaper. The drill was rated at 2,500 RPM, but testing measured 2,050 RPM. The seed was placed in the cylinder and submitted to four treatments of scarification (Table 1).

After the scarification treatments, 188 seeds were hand counted and planted manually in each plot at 0.25-inch depth on December 6, 2006. Each plot was 1 row 6.25 ft long. The plots were arranged in a randomized complete block design with four replicates. The plots were sprinkler irrigated to keep the soil surface moist from early April to early May 2007. On June 18, 2007, the emerged plants in each plot were counted.

Results and Discussion

The shortest scarification treatment of 7.5 seconds resulted in the highest emergence, 10.8 percent (Table 1). The unscarified seed or seed scarified for 15 or 30 seconds resulted in significantly lower emergence than the seed scarified for 7.5 seconds. Emergence was low for all treatments.

When examined under a microscope, the seed was found to have many uneven edges. Scarification appeared to smooth some of the edges to different degrees, depending on the duration.

Table 1. Emergence of basalt milkvetch *(Astragalus filipes)* seed in response to scarification duration. Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Scarification duration seconds	Emergence %
no scarification	4.0
7.5	10.8
15	5.3
30	3.5
LSD (0.05)	2.3

EFFECT OF TUBER PLACEMENT ON YELLOW NUTSEDGE REPRODUCTION

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Yellow nutsedge has become a major problem weed in agricultural land in the Treasure Valley of eastern Oregon and western Idaho. Yellow nutsedge is difficult to control because it reproduces mainly by rhizomes and nutlets (tubers) that are produced by the millions per acre each growing season. Tillage and irrigation tend to favor yellow nutsedge growth, and crops like onions that lack extensive canopy are especially vulnerable to competition. Control of yellow nutsedge will require multiple strategies including mechanical operations, destruction of tubers by using soil fumigants, timing of herbicides at vulnerable stages of growth, and synergistic use of fumigation and herbicides. Understanding the soil depth at which most tubers are produced and the maximum depth from which tubers will emerge is essential for managing tillage and fumigation operations. Also, it is important to understand yellow nutsedge emergence patterns in eastern Oregon in response to temperature and weather changes. This trial tested tuber emergence by depth, tuber production, and distribution of tubers produced from mother tubers planted at different depths.

Materials and Methods

The study was laid out in a randomized complete block design with four replications. The treatments were composed of 9 tuber planting depths ranging from 2 to 18 inches. Each plot consisted of a 10-inch-diameter PVC pipe, 24 inches long. In order to facilitate recovery of intact soil columns at harvest, the PVC pipes were cut lengthwise in half and reassembled using industrial strength duct tape before burying them. The PVC pipes were placed in a previously dug trench and arranged in 2 parallel rows with 18 pipes in each row with 12-inch spaces between them. Then the trench was filled with soil so the top of the PVC pipes were at ground level. The pipes were filled with soil and then drip irrigated on March 14 for 30 minutes to allow the soil to settle. Each PVC pipe was irrigated with one emitter capable of delivering 1 gal water/hour.

On May 5, 2007, tubers were collected from a field (within 1,000 ft of the study site) severely infested with yellow nutsedge. Two tubers were planted in each pipe center, 3 inches apart at respective treatment depth. Planting holes were made with a soil probe (4.25 inches diameter) to the specified depth. After planting, the pipes were irrigated for 15 minutes to allow the soil to settle. Thereafter the pipes were irrigated weekly to maintain soil moisture to a 2-ft depth. A total of 94.1 inches of water was applied from March 14 to the last irrigation on September 14, 2007. On November 6, the pipes were dug by carefully removing the surrounding soil. Each pipe was opened along the precut sides and the soil column was cut vertically in 2-inch increments and the soil placed in labeled zip-lock bags. The tubers from each 2-inch depth increment were separated by washing the soil and sieving. Immediately after washing, the tubers from each 2-inch depth increment were counted and weighed.

The data were subjected to analysis of variance using agricultural research data management (ARM 7.0) software by depth and means separated by the least significant difference (LSD) at 5 percent level of significance.

Results and Discussion

Many yellow nutsedge tubers were produced in each pipe regardless of the initial tuber placement (Fig. 1). The number of tubers produced in each 2-inch increment varied greatly, with most of the tubers concentrated in the top 4 inches of the soil profile (Table 1). The number of tubers declined with depth, but the 4- to 6-inch depth had lots of tubers and overall, most of the tubers were produced in the top 12 inches regardless of the original tuber placement. The total number of tubers produced was not significantly different between initial tubers placed at 2 to 16 inches (Table 1). Variation in tuber weight in the 2-inch depth increments depended on the number of tubers produced (Table 2). Tuber production below 12 inches decreased sharply with depth (Table 1 and Fig. 1).

The results show that yellow nutsedge tuber production is concentrated in the top 12 inches of the soil profile regardless of the depth of emergence. Therefore, moldboard plowing to depths deeper than 12 inches will not provide yellow nutsedge control. Herbicides requiring soil incorporation will be more effective if incorporated at 4- to 6-inches depth to affect the tubers as they germinate.

Table 1. Total number of yellow nutsedge tubers produced in 2-inch increments when the original tuber was planted at 2- to 18-inches depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Soil depth (inches)	Original tuber placement (inches)								
	2	4	6	8	10	12	14	16	18
	Number of tubers/ft^2								
0-2	429.2	476.1	488.4	411.6	334.1	424.4	445.7	360	408.3
2-4	666.0	774.9	650.8	642.3	611.4	627.2	715.3	650.5	459.5
4-6	446.7	581.7	448.6	428.7	519.2	443.4	453.3	402.3	224.5
6-8	224.1	291.3	184.7	162.5	250.7	252.9	249.6	211.6	93.8
8-10	120.8	124.1	77.2	80.5	118.1	111.8	164.4	101.1	35.1
10-12	57.3	62.5	34.1	31.7	66.3	44.5	74.8	63.8	23.7
12-14	21.3	27.5	14.2	7.1	18.3	14.2	41.2	29.7	18.0
14-16	15.2	14.7	12.8	3.8	15.2	8.5	18.9	11.4	3.8
16-18	4.3	3.3	4.7	1.9	3.2	2.8	6.6	4.4	2.8
16-18	1.9	1.9	9.9	1.4	1.3	0	3.8	3.8	2.8
Total	1,987	2,358	1,925	1,772	1,938	1,930	2,174	1,839	1,272

Table 2. Total yellow nutsedge tuber weight (g) produced in 2-inch increments when the original tuber was planted at 2- to 18-inches depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2007.

Soil depth (inches)	Original tuber placement (inches) 2	4	6	8	10	12	14	16	18
	Tuber weight (g/ft^2)								
0-2	35.6	41.5	41.2	33.4	26.9	32.3	35.0	28.5	39.4
2-4	71.6	92.0	82.3	81.0	65.3	75.8	84.9	80.6	67.3
4-6	66.8	89.4	64.7	75.1	86.0	67.8	68.9	69.3	44.6
6-8	37.0	52.2	37.1	31.4	49.0	47.2	44.3	42.0	22.4
8-10	22.5	22.2	15.0	16.2	24.7	22.6	29.7	20.0	8.2
10-12	10.9	11.5	6.5	6.7	14.8	8.9	15.4	11.4	6.5
12-14	4.2	4.8	2.6	1.2	4.3	3.1	8.9	5.3	2.4
14-16	2.6	3.3	1.5	0.7	3.1	1.7	3.7	2.3	0.4
16-18	1.0	0.5	0.9	0.2	0.8	0.4	1.4	0.6	0.5
16-18	0.5	0.3	1.8	0.1	0.3	0.0	0.8	1.0	0.5
Total	253	318	254	246	275	260	293	261	192.2

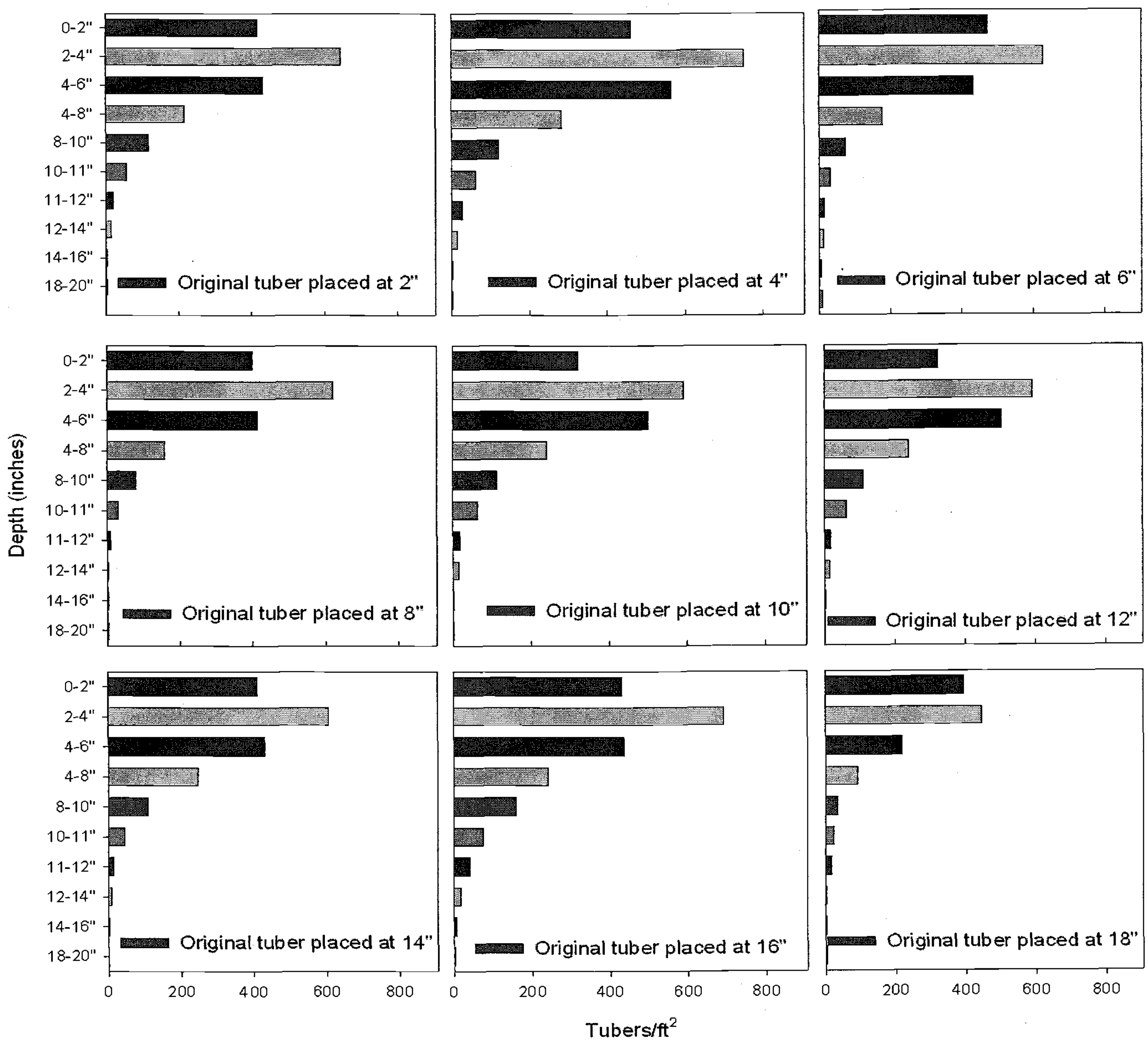


Figure 1. Distribution of yellow nutsedge tubers by depth (in 2 inch increments) when the mother tubers were placed at different depths, Malheur Experiment Station, Ontario, OR, summer 2007.

YELLOW NUTSEDGE TUBER VIABILITY IN RESPONSE TO FUMIGATION

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Yellow nutsedge has become a major problem weed in agricultural land in the Treasure Valley, especially in fields planted to onion. Control of yellow nutsedge presents a major challenge because of its ability to reproduce by rhizomes and tubers. Yellow nutsedge can produce millions of tubers per acre in a single season if not properly controlled. Successful control of yellow nutsedge will partly rely on tuber destruction by effective fumigation procedures. Some growers and other weed managers have suggested that use of Telone® C-17 soil fumigant could enhance the control of yellow nutsedge if applied prior to application of Vapam®. Some researchers have also suggested that supplementing the fumigants with fall application of Dual Magnum® herbicide could provide synergistic effects and enhance nutsedge control. Consequently, this study was established to study the effectiveness of Telone C-17, Vapam, and Dual Magnum applied alone and in combinations to test their synergistic effects in reducing tuber viability.

Materials and Methods

The trial was conducted in a field severely infested with yellow nutsedge along Oregon Hwy 201, approximately 2 miles from the Malheur Experiment Station. The field was furrow irrigated on September 1, 2006 and disked on September 7 to create a smooth seedbed to enhance fumigant penetration into the soil and sealing after application. The experiment was laid out in a randomized complete block design with four replications. The seven treatments evaluated were individual fumigant or fumigant combinations and an untreated check (Table 1). ***It is important to recognize that these treatment combinations are for experimental purposes only and are not endorsed by respective product labels or manufacturers.*** Individual plots were 16 ft wide and 60 ft long. Soil sampling for tuber quantification was done immediately after fumigation by taking 5 cores each measuring 4.25 inches in diameter and 12 inches deep from each plot. The soil cores were processed to recover yellow nutsedge tubers using the washing and sieving procedure. The recovered tubers were placed in ziplock plastic bags and stored in a dark cooler at 40°F until counted and weighed.

In order to further degrade the tubers, the study area was fallowed in 2007, and the integrity of individual plots was maintained by corner triangulation and working the soil in one direction to avoid cross contamination of different treatments. Plots were monitored for yellow nutsedge emergence and counts done on May 3 when seedlings were small to enable identification of individual plants. Additionally, five soil cores from each plot were taken on March 27 to characterize tuber population density and were processed using the methodology described above. The plots were treated with Roundup Original® at 32 fl oz/acre plus ammonium sulfate (AMS) at 3.2 pt/acre beginning May 25, 2007 and repeated on June 13, 2007. The study area was disked on July 20, bedded, and irrigated to encourage yellow nutsedge emergence. The final Roundup plus AMS was applied on August 20, 2007 for a total of three applications during the summer. Outlook® at 21 fl oz/acre was applied on June 12, 2007 to enhance yellow nutsedge control.

The study area was disked, roller harrowed twice, bedded and irrigated during the fall of 2007, and will be planted to onions in 2008. Five soil samples, each measuring 4.25 inches in diameter and 12 inches deep, were taken from each plot on November 19, 2007 and processed for tuber recovery by washing and sieving. The tubers were counted and weighed for each plot and placed in ziplock plastic bags and stored in a dark cooler at 40°F for use in emergence studies.

Results and Discussion

Since the 2006 results indicated substantially more tubers were produced in the 0- to 12-inch depth than at the 12- to 16-inch depth (Shock et al. 2006), all soil samples for tuber characterization in 2007 were taken to the 12-inch depth. The data for yellow nutsedge tubers before and after fumigation in 2006 are presented in Table 1 to indicate changes over time. Yellow nutsedge seedling counts during spring 2007 indicated a significantly lower density in plots treated with Telone C-17, followed by Vapam and Dual Magnum (Table 1), compared to other treatments. Similarly, the synergistic effect of Telone, Vapam, and Dual Magnum resulted in a pronounced reduction in the number of tubers produced. Telone in combination with Vapam or Dual Magnum resulted in significantly fewer tubers than each product used alone. Similar results were observed when Vapam was used in combination with Dual Magnum. Soil samples taken during fall 2007 indicated similar trends, with a combination of Telone, Vapam, and Dual Magnum having the lowest number of tubers.

The plot integrity has been maintained and the study area will be planted to onions during 2008. We expect the treatment effects will show more pronounced differences in yellow nutsedge infestation during the 2008 cropping season. Plots will be sampled again for tuber population density during spring 2008 and onions will be grown to maturity. Herbicides recommended for use in onions including Outlook, Nortron®, and Dual Magnum will be used in 2008.

This study will be repeated at a different site using the same fumigant treatments during fall 2007 and evaluation of yellow nutsedge control will begin in the spring of 2008. The study site will be fallowed in 2008 and planted to onions in 2009.

Currently, Dual Magnum is not a registered treatment for plow down preceding onion in Oregon. However, it received a label for fall plow down in Idaho and Syngenta is still working on the label for Oregon. The use of this treatment does not constitute a recommendation to use this product in Oregon until a label is received.

References

Shock, C.C., J. Ishida, and E. Feibert. 2006. Yellow nutsedge nutlet production in response to nutlet planting depth. Oregon State University Agricultural Experiment Station Special Report 1075:160-162.

Table 1. Yellow nutsedge seedling counts and tuber population during spring 2007 in plots fumigated in fall 2006, Malheur Experiment Station, Oregon State University, Ontario, OR, summer 2006 and 2007.

		2006		2007			
		Count before	Count after	Seedling	Tubers	Tuber count	Weight
Treatment	Rate/acre	0-12 inch depth		Spring		Fall	
		------- nutlets/ft^2 -------		- count/yd^2 -	- tubers/ft^2 -	- tubers/ft^2 -	---- g ----
Telone C-17	23 gal	1,505.3	1,837.2	437.3	184.9	97.8	8.9
Vapam	50 gal	1,319.5	1,649.4	280.1	286.2	172.4	12.4
Dual Magnum plowed down[a]	2 pt	2,129.5	2,562.9	226.3	238.2	154.7	12.4
Telone C-17, Vapam	23 gal, 50 gal	1,835.2	992.7	122.2	117.3	83.6	7.1
Telone C-17, Dual Magnum[a]	23 gal, 2 pt	1,139.9	1,322.6	128.8	154.7	55.1	5.3
Vapam, Dual Magnum	50 gal, 2 pt	1,091.1	1,424.1	33.8	376.9	142.2	12.4
Telone C-17, Vapam, Dual Magnum[a]	23 gal; 50 gal, 2 pt	535.9	218.2	12.7	74.7	49.8	5.3
Untreated check		845.5	1,799.6	367.7	2,167.1	2,725.8	519.6
LSD (0.05)		1,145.4	1,803.7	98.6	176.0	85.2	7.5

[a]Not a registered application method.

DEVELOPING EFFECTIVE CROP ROTATION SYSTEMS TO MANAGE YELLOW NUTSEDGE EXPANSION

Joel Felix and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, OR, 2007

Introduction

Yellow nutsedge has become a major crop production threat in many agricultural fields in the Treasure Valley of eastern Oregon. The gravity of this problem is especially noticeable when the land is planted to onions. Thus, development of effective yellow nutsedge strategies is viewed by many as priority number one for researchers. Control of yellow nutsedge presents a challenge because of its ability to reproduce by rhizomes and tubers that are able to survive in the soil for years. Research results at the Malheur Experiment Station indicate that millions of tubers are produced per acre each season in heavily infested fields (Shock et al. 2006). Successful control of yellow nutsedge will partly require development of elaborate crop rotation schemes that include multiple tactics including tillage, fumigation, and herbicides to destroy those pesky tubers. It has been reported that farming activities play a significant role in yellow nutsedge distribution in infested fields (Schippers et al. 1993). This study is a first step in developing crop rotation schemes that will demonstrate the effect of tillage and rotation on yellow nutsedge control.

Materials and Methods

A multi-year study was initiated during summer 2007 in a field heavily infested with yellow nutsedge along Hwy 201 near the Malheur Experiment Station, Ontario, Oregon. The study was laid out in a split-split-plot design with tillage (reduced and conventional tillage) forming the main plots, rotational crops as the first subplot, and herbicides as the sub-subplots. The terminal crop in each of the planned rotations will be onion. Rotations are: 1) corn/corn/sugar beet/dry beans/onions; 2) corn/sugar beet/dry bean/wheat/onions; and 3) corn/dry bean/potato/sugar beet/onions. Conventionally tilled plots were moldboard plowed and disked twice before beds were formed to facilitate furrow irrigation. Reduced tillage plots were disked only twice to avoid deep tillage that dilutes tubers within the soil profile. Following soil analysis, a compound fertilizer to provide 120 lbs nitrogen (N), 30 lbs phosphorus (P), 13 lbs sulfate (SO_4), 2 lbs zinc (Zn), and 1 lb boron (B) per acre was applied on May 4, 2007. The entire study was planted to Dekalb Roundup Ready® corn hybrid 6668751 at 26,000 plants/acre in the first year as a measure to drive down the tubers before introducing other crops in year two.

Herbicide treatments used on corn included: 1) untreated; 2) Dual Magnum® 1.67 pt/acre Pre-emergence (PRE); 3) Dual Magnum 1.67 pt/acre PRE followed by 1.67 pt/acre Post-emergence (POST); 4) Dual Magnum 2.5 pt/acre plus Basagran® 1.5

pt/acre PRE; and 5) Dual Magnum 3 pt/acre plus Basagran 2 pt/acre PRE. Treatments 2-5 were also treated with two sequential applications of POST application of Roundup OriginalMax® at 32 fl oz/acre plus ammonium sulfate (AMS).

Soil sampling for initial tuber quantification was done in spring after bed formation and irrigation by taking 5 cores each measuring 4.25 inches in diameter and 12 inches deep from each plot. The soil cores were processed to recover tubers using the washing and sieving procedure. Fall soil sampling was done on October 4 and processed to recover tubers on October 17, 2007. The tubers from each plot were placed in a ziplock plastic bag and stored in a dark cooler at 40°F until they were counted and weighed. The study was furrow irrigated as needed to maintain moisture in the top 12 inches of the soil profile. The corn was harvested for yield from 20 ft of the 2 center rows in each plot.

Results and Discussion

The study area had a relatively uniform distribution of yellow nutsedge tubers/ft^2 at the initiation of the study (Table 1). There was no difference in corn yield between treatments except for the untreated control that had very low yield due to excessive weed competition (Table 1). There was no difference between tillage for corn yield, which averaged 5 and 5.7 tons/acre for conventional and reduced tillage, respectively. This is not a surprise because it takes about 4 years for tillage effects to manifest themselves. However, when averaged across tillage, there was a significant difference between treatments, mainly with the untreated control producing the lowest yield.

Soil samples taken during the fall indicated significant reduction in the number of tubers in response to herbicide treatments used during summer 2007. There was no difference in the number of yellow nutsedge tubers between conventional and reduced till plots, which was expected because tillage effects do not manifest themselves until the fourth year of the practice. Soil sampling during fall indicated a trend for reduced tuber numbers in plots treated with sequential Dual Magnum at 1.67 pt/acre followed by Roundup OriginalMax at 32 fl oz/acre. Plots treated with Dual Magnum 1.67 pt/acre followed by a combination of Roundup plus Basagran at 1.5 pt/acre did not improve yellow nutsedge control. Weed control in each crop grown in a rotation will include herbicides known to control yellow nutsedge. We hope that in the final year of the rotation, yellow nutsedge tubers will have been degraded significantly to enable a successful onion crop.

References

Schippers, P., S.J. Ter Borg, J.M. Van Groenendael, and B. Habekotte. 1993. What makes *Cyperus esculentus* (yellow nutsedge) an invasive species? A spatial model approach. Proceedings Brighton Crop Protection Conference 495–504.

Shock, C.C., J. Ishida, and E. Feibert. 2006. Yellow nutsedge nutlet production in response to nutlet planting depth. Oregon State University Agricultural Experiment Station Special Report 1075:160-162.

Table 1. Yellow nutsedge tuber production and corn yield in response to tillage and herbicide treatments in Roundup Ready® field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, summer 2007.

Treatments	Rate unit	Conventional tillage					Reduced tillage				
		May 29, 2007		November 4, 2007		Corn yield	May 29, 2007		November 4, 2007		Corn yield
		Tubers/ft^2	Weight (g)	Tubers/ft^2	Weight (g)	Tons/acre	Tubers/ft^2	Weight (g)	Tubers/ft^2	Weight (g)	Tons/acre
1. Control		729.1	62.4	1088.0	96.7	1.2	614.0	52.5	1146.9	88.5	1.6
2. Dual II Magnum	1.67 pt/a	628.3	56.5	270.1	23.6	5.4	526.0	53.6	222.7	22.7	6.3
Roundup OMax	32.0 oz/a										
Ammonium Sulfate	2 % V/V										
3. Dual II Magnum	1.67 pt/a	640.5	65.3	214.6	21.8	5.5	657.7	62.0	359.5	33.6	6.1
Dual II Magnum	1.67 pt/a										
Roundup OMax	32.0 oz/a										
Ammonium Sulfate	2% V/V										
4. Dual II Magnum	2.5 pt/a	649.3	59.9	428.5	36.6	6.3	631.0	60.6	284.3	25.4	5.4
Basagran	1.5 pt/a										
Roundup OMax	32.0 oz/a										
Ammonium Sulfate	2 % V/V										
5. Dual II Magnum	3.0 pt/a	528.7	47.4	223.4	20.3	6.6	429.9	42.6	260.0	24.9	6.5
Basagran	2.0 pt/a										
Roundup OMax	32.0 oz/a										
Ammonium Sulfate	2 % V/V										
LSD (0.05)		345.9	28.8	422.9	39.5	1.5	345.9	28.8	422.9	39.5	1.5

APPENDIX A. HERBICIDES AND ADJUVANTS

Trade Name	Common or Code Name	Manufacturer
Basagran	bentazon	Arysta LifeScience
Betamix	desmedipham + phenmedipham	Bayer CropScience
Bronate, Bronate Advance	bromoxynil + MCPA	Bayer CropScience
Buctril	bromoxynil	Bayer CropScience
Callisto	mesotrione	Syngenta
Caparol	prometryn	Syngenta
Casoron 4G	dichlobenil	Crompton
Chateau	flumioxazin	Valent
Clarion	nicosulfuron + rimsulfuron	DuPont
Clarity	diglycolamine	BASF Ag Products
Distinct	diflufenzopyr + dicamba	BASF Ag Products
Dual, Dual Magnum, Dual II Magnum	*S*-metolachlor	Syngenta
Eradicane	EPTC	Gowen Company
Eptam	EPTC	Syngenta
Goal, Goaltender	oxyfluorfen	Dow AgroSciences
Karmex	diuron	Griffin LLC
Kerb	pronamide	Dow AgroSciences
Lorox	linuron	Griffin LLC
Matrix	rimsulfuron	Dupont
Micro-Tech	alachlor	Monsanto
Nortron	ethofumesate	Bayer CropScience
Option	foramsulfuron	Bayer CropScience
Outlook	dimethenamid-p	BASF Ag Products
Plateau	imazapic	BASF Ag Products
Poast, Poast HC	sethoxydim	BASF Ag Products
Prefar	bensulide	Gowen Company
Progress, Progress Ultra	desmedipham + phenmedipham + ethofumesate	Bayer CropScience
Prowl, Prowl H2O	pendimethalin	BASF Ag Products
Reglone	diquat dibromide	Syngenta
Roundup OriginalMax, Roundup WeatherMAX, Roundup UltraMax	glyphosate	Monsanto
Sandea	halosulfuron	Gowen Company
Select	clethodim	Valent
Sencor	metribuzin	Bayer CropScience
Sinbar	terbacil	DuPont
Stinger	clopyralid	Dow AgroSciences
Surround	kaolin	BASF Ag Products
Treflan	trifluralin	Dow AgroSciences
UpBeet	triflusulfuron	Dupont
V-10142	imazosulfuron	Valent
Yukon	halosulfuron-methyl	Gowen Company

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES

Trade Name	Common or Code Name	Manufacturer
Asana	esfenvalerate	DuPont
Assail	acetamiprid	UPI
Aza-Direct	azadirachtin	Gowan Company
Battalion	deltamethrin	Arysta LifeScience
Bravo, Bravo Ultrex	chlorothalanil	Syngenta
Carzol	formetanate hydrochloride	Gowan Company
Comite	propargite	Crompton
Counter 20 CR, Counter 15G	terbufos	BASF Ag Products
Diazinon AG500	diazinon	Helena Chemical
Diatect	pyrethrum	Diatect Int. Corp.
Dimethoate	dimethoate	Several
Dithane	mancozeb	Dow AgroSciences
EcoTrol EC	rosemary + peppermint oils	EcoSMART Tech.
Enable	fenbuconazole	Dow AgroSciences
Gaucho	imidacloprid	Gowan Company
Gem	trifloxystrobin	Bayer CropScience
Headline	pyraclostrobin	BASF Ag Products
Knack	pyriproxyfen	Valent
Kocide	copper hydroxide	Griffin
Lannate	methomyl	DuPont
Lorsban, Lorsban 15G	chlorpyrifos	Dow AgroSciences
Malathion	malathion	UAP
MSR	oxydemeton-methyl	Gowan Company
Mustang	zeta-cypermethrin	FMC
Pristine	pyraclostrobin + boscalid	BASF Ag Products
Quadris	azoxystrobin	Syngenta
Radiant	spinetoram	Dow AgriSciences
Regent	fipronil	BASF
Ridomil Gold MZ	metalaxyl	Syngenta
Success	spinosad	Dow AgroSciences
Super-Six	liquid sulfur	Plant Health Tech.
Tanos	famoxadone + cymoxanil	Du Pont
Telone C-17	dichloropropene + chloropicrin	Dow AgroSciences
Telone II	dichloropropene	Dow AgroSciences
Temik 15G	aldicarb	Bayer Cropscience
Thiodan	endosulfan	UCPA
Topsin M	thiophanate-methyl	Cerexagri, Inc.
Tops-MZ	thiophanate-methyl	UAP
Vapam	metham sodium	Amvac
Venom	dinotefuran	Valent
Vydate, Vydate L	oxamyl	DuPont
Warrior	cyhalothrin	Syngenta

APPENDIX C. COMMON AND SCIENTIFIC NAMES OF CROPS, FORAGES, AND FORBS

Common names	Scientific names
alfalfa	*Medicago sativa*
barley	*Hordeum vulgare*
basalt milkvetch	*Astragalus filipes*
bluebunch wheatgrass	*Pseudoroegneria spicata*
corn, sweet corn	*Zea mays*
dry edible beans	*Phaseolus spp.*
fernleaf biscuitroot	*Lomatium dissectum*
gooseberry leafed globe mallow	*Sphaeralcea grossularifolia*
Gray's lomatium	*Lomatium grayi*
Great Basin wildrye	*Leymus cinereus*
hicksii yew	*Taxus x media*
hotrock penstemon	*Penstemon deustus*
nineleaf desert parsley	*Lomatium triternatum*
onion	*Allium cepa*
Pacific yew	*Taxus brevifolia*
poplar trees, hybrid	*Populus deltoides* x *P. nigra*
potato	*Solanum tuberosum*
red globe mallow	*Sphaeralcea coccinea*
Russian wildrye	*Psathyrostachys juncea*
sagebrush penstemon	*Penstemon speciosus*
sand penstemon	*Penstemon acuminatus*
seals' prairie clover	*Dalea searlsiae*
Siberian wheatgrass	*Agropyron fragile*
smallflower globe mallow	*Sphaeralcea parvifolia*
soybeans	*Glycine max*
spearmint, peppermint	*Mentha spp.*
sugar beet	*Beta vulgaris*
sulfur buckwheat	*Eriogonum umbellatum*
teff	*Eragrostis tef*
triticale	*Triticum* x *Secale*
western prairie clover	*Dalea ornata*
western yarrow	*Achillea millifolium*
wheat	*Triticum aestivum*

APPENDIX D. COMMON AND SCIENTIFIC NAMES OF WEEDS

Common names	Scientific names
annual sowthistle	*Sonchus oleraceus*
barnyardgrass	*Echinochloa crus-galli*
blue mustard	*Chorispora tenella*
common lambsquarters	*Chenopodium album*
common mallow	*Malva neglecta*
dodder	*Cuscuta spp.*
downy brome	*Bromus tectorum*
field bindweed	*Convolvulus arvensis*
green foxtail	*Setaria viridis*
hairy nightshade	*Solanum sarrachoides*
kochia	*Kochia scoparia*
lady's thumb	*Polygonum persicaria*
Powell amaranth	*Amaranthus powellii*
prickly lettuce	*Lactuca serriola*
redroot pigweed	*Amaranthus retroflexus*
Russian knapweed	*Acroptilon repens*
whitetop, hoarycress	*Cardaria draba*
yellow nutsedge	*Cyperus esculentus*

APPENDIX E. COMMON AND SCIENTIFIC NAMES OF DISEASES AND INSECTS

Common names	Scientific names
Diseases	
onion black mold	*Aspergillus niger*
onion neck rot, (gray mold)	*Botrytis allii*
onion plate rot	*Fusarium oxysporum*
onion translucent scale	
powdery mildew	*Leveillula taurica*
potato late blight	*Phytophthora infestans*
Insects	
cereal leaf beetle	*Oulema melanopus*
lygus bug	*Lygus hesperus*
onion maggot	*Delia antiqua*
onion thrips	*Thrips tabaci*
pea aphid	*Acyrthosiphon pisum*
seed corn maggot	*Delia platura*
spidermite	*Tetranychus* spp.
stinkbug	*Pentatomidae* spp.
sugar beet root maggot	*Tetanops myopaeformis*
western flower thrips	*Franklinella occidentalis*
willow sharpshooter	*Graphocephala confluens* (Uhler)