Special Report 1075
July 2007

Malheur Experiment Station Annual Report 2006

Oregon State University | Agricultural Experiment Station

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Agricultural Experiment Station
Oregon State University

Special Report 1075
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Malheur Experiment Station Annual Report 2006

The information in this report is for the purpose of informing cooperators in industry, colleagues at other universities, and others of the results of research in field crops. Reference to products and companies in this publication is for specific information only and does not endorse or recommend that product or company to the exclusion of others that may be suitable. Nor should information and interpretation thereof be considered as recommendations for application of any pesticide. Pesticide labels should always be consulted before any pesticide use.

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.

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- 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

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2006 WEATHER REPORT

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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-inch-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.

2006 Weather

The total precipitation for 2006 (12.79 inches) was higher than the 10-year (10.38 inches) and 63-year (10.07 inches) averages (Table 1). Precipitation in March (3.33 inches) was over three times higher than the 10-year and 63-year averages, whereas April (2.0 inches) was two and a half times higher. Total snowfall for 2006 (12 inches) was lower than the 10-year (14.0 inches) and 63-year (18.2 inches) averages (Table 2).

The highest temperature for 2005 was 106°F on July 23 (Table 3). The lowest temperature for the year was 10°F on February 18,19, and 20.

March and April had fewer growing degree days (50° to 86°F) than the 20-year average (Table 4, Fig. 1). May, June, and August had more growing degree days (50° to 86°F) than the 20-year average. The total number of degree days in the above-optimal range (86° to 104°F) in 2006 was higher than the average (Table 5). July had twice as many above-optimal degree days as the 16-year average.

June and July had total wind runs higher than the 10-year and 58-year averages (Table 6). Total pan-evaporation for June and July was higher than the 10-year and 58-year averages (Table 7). Total accumulated ET_c for most crops in 2006 was higher than the 14-year average (Table 8).

The average monthly maximum and minimum 4-inch soil temperatures in 2006 were close to the 10-year and 39-year averages (Table 9).

The last spring frost (≤32°F) occurred on April 19, 9 days earlier than the 29-year average date of April 28; the first fall frost occurred on October 22, 17 days later than the 29-year average date of October 5 (Table 10).

No weather records were broken in 2006 (Table 11).

References

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

Table 1. Monthly precipitation at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2006.

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
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	10.38
63-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	10.07

Table 2. Annual snowfall totals at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2006.

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	10-yr avg	63-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	14.0	18.2

Table 3. Monthly air temperature, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	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	50	36	59	40	66	44	81	50	94	59	99	69	106	73	101	68	95	61	81	52	75	53	55	41
Lowest	27	20	30	10	35	20	49	28	58	36	75	46	85	55	73	43	62	36	47	16	29	13	29	13
2006 avg	41	29	44	24	52	33	64	40	76	47	85	56	97	64	90	55	80	47	66	37	51	33	38	22
10-yr avg	38	25	45	27	57	32	64	38	72	45	81	51	93	59	91	56	80	47	67	38	48	29	38	25
63-yr avg	35	20	43	25	55	31	64	37	74	45	82	52	92	58	90	56	80	46	66	36	48	28	37	22

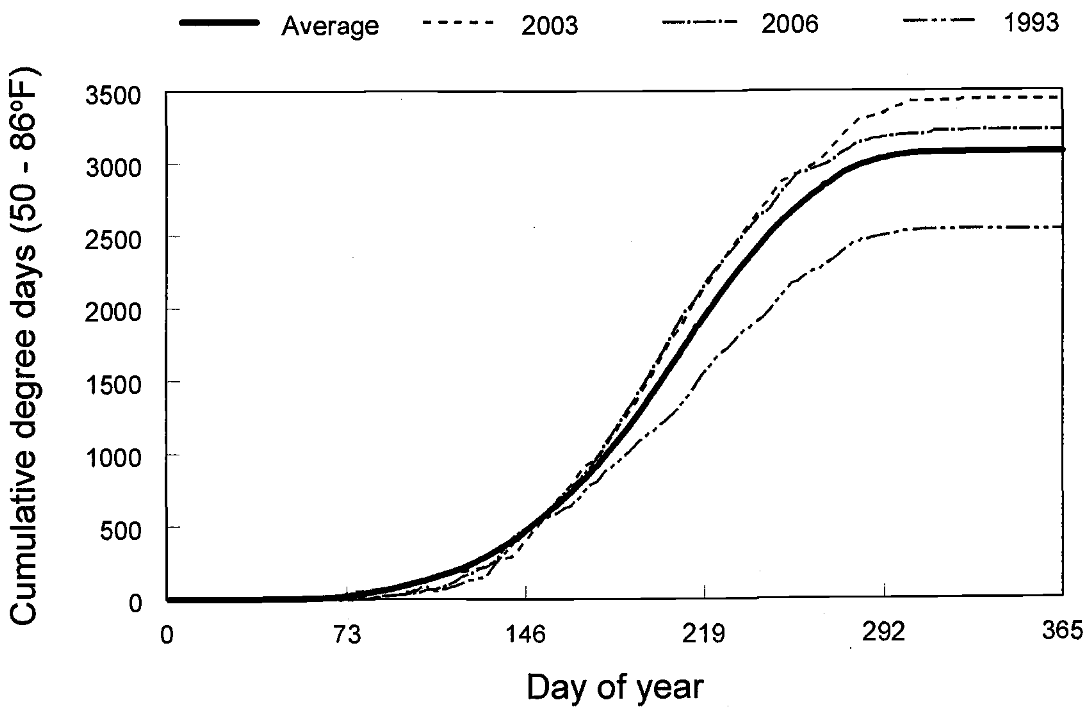

Figure 1. Cumulative growing degree days (50-86°F) over time for selected years compared to 16-year average, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 4. Monthly total growing degree days (50-86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2006.

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
20-year avg	0	5	57	152	323	519	730	686	432	173	12	1	3,092

Table 5. Monthly total degree days in the above-ideal (86-104°F) range, Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2006.

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
16-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, 2006.

Daily	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						miles						
Mean	47	44	90	85	68	72	62	48	37	52	55	31
Max	128	165	265	236	140	119	105	123	156	198	151	143
Min	4	3	14	37	30	38	35	15	10	4	8	3
Annual total						miles						
2006	1,408	1,219	2,778	2,555	2,113	2,154	1,928	1,485	1,110	1,608	1,643	970
10-yr average	1,533	1,857	2,416	2,466	2,132	1,834	1,603	1,585	1,499	1,599	1,494	1,756
58-yr average				2,153	1,915	1,563	1,466	1,326	1,255	1,275		

Table 7. Pan-evaporation totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Totals	April	May	Jun	Jul	Aug	Sep	Oct	Total
Daily				inches				
Mean	0.20	0.29	0.35	0.44	0.34	0.23	0.15	
Max	0.42	0.44	0.52	0.57	0.47	0.45	0.34	
Min	0.05	0.06	0.18	0.33	0.23	0.12	0.02	
Annual				inches				
2006	6.05	8.90	10.45	13.70	10.67	6.92	4.69	61.4
10-yr avg	6.10	8.24	9.90	11.68	10.58	7.12	4.37	58.3
58-yr avg	5.64	7.70	8.98	11.19	9.66	6.34	3.29	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, 1992-2006.

										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
Average	55.2	42.4	24.3	26.4	34.5	29.5	27.6	20.9	27.7	24.3	37.8	45.6
mm	1,402.6	1,075.8	616.9	670.9	876.1	749.5	701.9	530.4	704.6	616.7	960.4	1,158.0

Table 9. Monthly soil temperature at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	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	37	36	39	37	47	44	60	55	69	65	77	72	81	74	78	69	72	66	62	58	52	51	40	37
Lowest	30	28	31	30	37	35	45	42	55	49	65	56	74	67	68	63	58	52	45	41	34	33	30	28
2006 avg	34	33	35	33	41	39	51	47	62	56	70	63	77	71	73	66	65	60	54	50	44	42	33	32
10-yr avg	34	33	37	35	46	41	54	47	63	56	72	63	77	69	76	69	68	62	56	52	44	42	36	35
39-yr avg	33	32	38	34	50	41	60	47	72	58	81	66	88	74	86	73	76	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, 1990-2006.

Year	Date of last frost Spring	Date of first frost Fall	Total frost-free days
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	October 22	186
1976-2004 Avg	April 28	October 5	160

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

Record event	Measurement	Date
---------- Since 1943 ----------		
Greatest annual precipitation	16.87 inches	1983
Greatest monthly precipitation	4.55 inches	May 1998
Greatest 24-hour precipitation	1.52 inches	Sep 14, 1959
Greatest annual snowfall	40 inches	1955
Greatest 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	58.8 inches	2002

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

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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, eight proprietary varieties 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. A soil sample taken on September 6, 2005 showed 57 lb N/acre in the top 2 ft of soil. The soil in the top foot had pH 7.7, 1.3 percent organic matter, 18 ppm P, 437 ppm K, 10 ppm sulphate, 1,851 ppm Ca, 351 ppm Mg, 1.4 ppm Zn, 0.5 ppm Cu, 4 ppm Mn, 4 ppm Fe, and 0.5 ppm B. The field was plowed, and fertilizer was applied to supply 100 lb P_2O_5/acre, 300 lb S/acre, 5 lb Zn/acre, 8 lb Mn/acre, 4 lb Cu/acre, and 1 lb B/acre.

The field was groundhogged and corrugated on 30-inch furrow spacing using a spike-tooth bed harrow. Eptam® at 4 pt/acre plus Balan® at 1.5 lb/acre was applied on September 19 and incorporated with two additional passes, in opposite directions, with the bed harrow. On September 20, 2005, seed of each variety was planted in plots 60 inches wide by 20 ft long, replicated five times. Seed was planted at a rate of 20 lb/acre using a cone seeder with a spinner divider feeding three double-disk furrow openers per 30-inch bed.

This trial was established and grown with furrow irrigation from gated pipe. The field was irrigated for 24 hours on September 21, 2005 to promote rapid, uniform emergence, and cotyledons emerged on September 26, 2005. The field was hand weeded on April 20, 2006 and alleys were cut between plots on May 21. The first irrigation in 2006 was applied on June 1, after the first cutting. Irrigation was applied for approximately 24 hours once per week with the final irrigation applied on September 1. The field was recorrugated on October 24.

The entire trial area was mowed and the clippings were removed to reduce rodent cover and expose more of the soil for herbicide application, and Maki® rodenticide pellets were applied in vole ("field mice") tunnels using a probe type applicator on

November 15. On November 16, the soil-active selective herbicides Kerb® 50WP at 1.5 lb/acre and Sinbar® 80WP at 1.5 lb/acre were applied, and a follow-up treatment of Maki rodenticide was made on December 5.

In 2006, the first cutting was taken on May 31. A 32-inch by 20-ft swath was cut from the center of each plot with a flail mower, and the alfalfa was weighed. The alfalfa was harvested three more times, on June 30, August 8, and September 25. Ten samples of alfalfa were cut by hand from border areas of plots over the entire field on the same day just before each cutting; they were quickly weighed, dried, 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 from approximately 1 ft of row per plot were taken mid-morning on August 8, before the third cutting, to measure forage quality. The forage quality samples were dried, 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. Relative forage quality (RFQ) was calculated by the formula:

$$RFQ = (DMI * TDNL) / 1.23$$

where:
DMI = Dry Matter Intake (for alfalfa hay), and
DMI = (((0.120 * 1350) / (NDF/100)) + (NDFD - 45) * 0.374)) / 1350 * 100, and
NDFD = dNDF48 / NDF * 100, and
dNDF48 = Digestible NDF as a percentage of Dry Matter, as determined by a 48-hour in vitro digestion test,
TDNL = Total Digestible Nutrients [for Legume (alfalfa hay)]
TDNL = (NFC * 0.98) + (Protein * 0.93) + (Fat * 0.97 * 2.25) + ((NDF-2) * (NDFD/100))
NFC = 100 - ((NDF - 2) + Protein + 2.5 + Ash), and 1.23 was chosen as the denominator to adjust the scale to match the RFV scale at 100 = full bloom alfalfa.

Quality standards 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. RFQ estimates voluntary energy intake when the hay is the only source of energy and protein for ruminants. Hay with a higher RFQ requires less grain or feed concentrate to formulate dairy rations.

Results and Discussion

During winter the seedlings were dormant and did not achieve much additional growth. March was cool and exceptionally wet with 3.57 inches of rain. The rain hammered the alfalfa seedlings and covered some seedlings with mud. The first cutting was delayed by rainy weather in May to bloom stage on May 31. The second cutting was taken June

30 at late bud to early bloom stage. Third cutting, when forage quality samples were taken, was on August 8, at early bloom stage. The fourth cutting was taken on September 25, at late bud to early bloom stage.

The average first year total hay yield was 6.9 ton/acre, with no significant differences in hay yield among the entries (Table 1). The first-cutting average yield was 2.5 ton/acre. In the second cutting the average yield was 1.7 ton/acre. In the third cutting, the average yield was 2.2 ton/acre. The average yield was 1.5 ton/acre for the fourth cutting.

The crude protein averaged 20.6 percent in the third cutting, and ranged from 19 percent for 'Lahontan' to 21.8 percent for 'WL 319 HQ'. Acid detergent fiber, ADF, averaged 34.8 percent, and ranged from 32 percent for WL 319 HQ to 38 percent for Lahontan. Neutral detergent fiber, NDF, averaged 40 percent, and ranged from 36 percent for WL 319 HQ to 44 percent for Lahontan. Relative feed quality averaged 147, in the "Fair" quality category and ranged from RFQ = 129, "Low" for Lahontan to RFQ = 167, "Good" for WL 319 HQ.

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 2). 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 yields and third cutting crude protein, ADF, NDF, and relative forage quality for 2006. Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	Cutting date 5/31	6/30	8/8	9/25	2006 total	Crude protein	ADF[a]	NDF[b]	Relative forage quality
	---ton/acre[c]---					-------% of DW[d]-------			RFQ
DKA-42-15	1.50	1.75	2.28	1.54	7.08	20.0	36.2	41.6	135.8
Rustler II	1.58	1.75	2.17	1.57	7.06	21.6	34.0	39.0	152.0
Masterpiece	1.60	1.75	2.17	1.52	7.04	21.4	33.4	38.6	155.8
WL 319 HQ	1.57	1.83	2.23	1.37	7.00	21.8	32.0	36.4	167.2
FC 2055	1.49	1.67	2.13	1.64	6.92	21.0	34.6	39.6	148.6
WL 357 HQ	1.46	1.69	2.29	1.46	6.91	20.4	35.0	40.6	143.8
FC 1045	1.49	1.73	2.08	1.55	6.85	20.0	36.0	41.2	140.4
Lahontan	1.46	1.65	2.12	1.56	6.80	18.8	37.6	43.6	129.4
FC 1055	1.46	1.63	2.17	1.46	6.72	21.0	34.0	38.4	153.6
Wrangler	1.52	1.55	2.14	1.30	6.51	20.2	35.4	41.0	143.8
Mean	1.51	1.7	2.18	1.50	6.89	20.6	34.8	40.0	147.0
LSD (0.05)	NS[e]	NS	NS	NS	NS	NS	NS	NS	NS

[a]ADF: acid detergent fiber.
[b]NDF: neutral detergent fiber.
[c]Yield at 88 percent dry matter.
[d]DW: dry weight.
[e]NS: Not significant at the alpha = 0.05 level.

Table 2. 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, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

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	Eureka Seeds	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.

SEED PRODUCTION OF NATIVE FORBS SHOWS LITTLE RESPONSE TO IRRIGATION IN A WET YEAR

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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 seed set and development. Excessive water stress during seed set and development is known to compromise yield and quality of other seed crops.

Native forbs are not competitive with crop weeds. Both sprinkler and furrow irrigation promote seed production, but risk encouraging weeds. Furthermore, sprinkler and furrow irrigation can lead to the loss of plant stand and seed production 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 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 2005. To ensure germination the seed was submitted to a cold stratification treatment. The seed was soaked overnight in distilled water on January 26, 2005. After soaking, 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 the seed moisture. In late February, seed of *Lomatium grayi* and *L. triternatum* had started sprouting.

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	2004
Penstemon acuminatum	Sand penstemon	Bliss Dam	2004
Penstemon deustus	Hotrock penstemon	Black Cr. Rd.	2003
Penstemon speciosus	Royal or sagebrush penstemon	Leslie Gulch	2003
Lomatium dissectum	Fernleaf biscuitroot	Mann Creek	2003
Lomatium triternatum	Nineleaf desert parsley	Hwy 395	2004
Lomatium grayi	Gray's lomatium	Weiser R. Road	2004

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. 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.

The trial was conducted in a field of Nyssa silt loam with a pH of 8.3 and 1.1 percent organic matter. 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 using 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. *L. 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. In the *Eriogonum umbellatum* and *Penstemon* spp. plots the blank lengths of row were replanted by hand. 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*.

Irrigation for Seed Production
In April, 2006, the field was divided into plots 30 ft long. Each plot contained four rows of each of the seven forb species. The experimental design was a randomized complete block with four replicates. The three irrigation treatments were: a nonirrigated 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 2). At the first irrigation on May 19, *Penstemon acuminatum* had ended flowering, *P. deustus* and *P. speciosus* were flowering, and *Eriogonum umbellatum* was just starting to flower.

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.

Eriogonum umbellatum flowering started on May 19, peaked on June 24, and ended on July 28. *Penstemon acuminatum* flowering started on May 2, peaked on May 10, and ended on May 19. *P. speciosus* flowering started on May 10 and peaked on May 19. *P. 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 *Penstemon 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. *P. acuminatum* 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. *E. umbellatum* unthreshed seed was taken to the U.S. Forest Service Lucky Peak Nursery 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 acuminatum and *P. speciosus* seeds were threshed in the combine and the seed was further cleaned using a small clipper seed cleaner.

Results and Discussion

Precipitation in 2005 and 2006 was higher than normal at the Malheur Experiment Station (Fig. 1). Precipitation from October 2004 through June 2005 totaled 11.1 inches and from October 2005 through June 2006 totaled 15.9 inches. The 62-year average precipitation for October through June is 9.2 inches. The wet weather could have attenuated the effects of the irrigation treatments. The actual amount of water applied for each irrigation treatment was relatively close to the planned amounts (Tables 2 and 3). The soil volumetric water content responded to the irrigation treatments (Figs. 2-4 and Table 4).

There was no significant difference in seed yield between irrigation treatments for *Penstemon acuminatum*, *P. deustus,* and *P. speciosus* (Table 3). *Eriogonum umbellatum* showed a trend for increasing seed yield with increasing irrigation, with the 2-inch irrigation rate resulting in higher seed yield than the 1-inch irrigation rate or the non-irrigated check. Compared to the *Penstemon* spp., *E. umbellatum* started flowering later, at about the same time as the start of the irrigation treatments. *P. acuminatum* had ended flowering at the start of the irrigation treatments. *P. speciosus* and *P. deustus* were in mid flowering at the start of the irrigation treatments. The later reproductive stage of *E. umbellatum* might explain the response to the irrigation treatments.

The lack of seed yield response to irrigation of the *Penstemon* spp. in this trial is consistent with substantial rainfall over the winter and spring of 2006 and consistent with the rangelands showing vigorous growth of native plants in the spring of 2006.

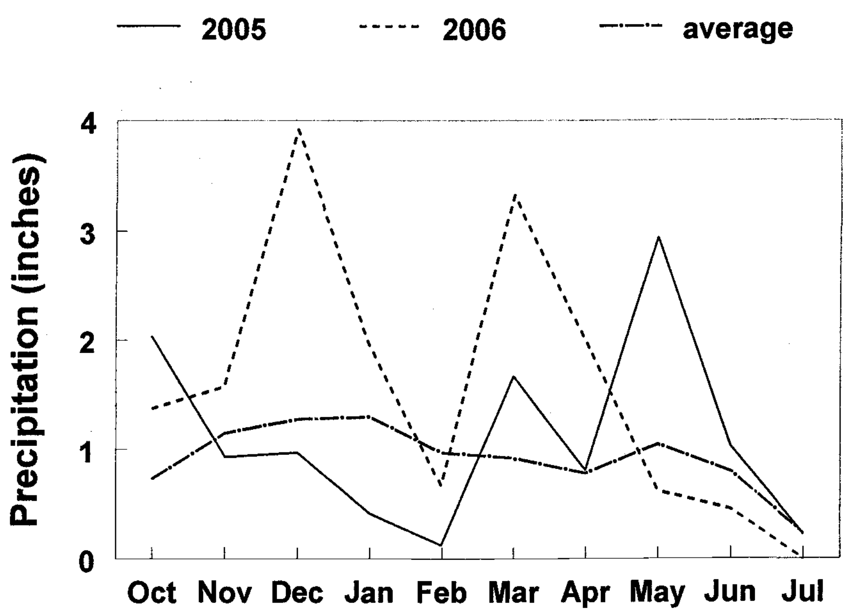

Figure 1. Monthly precipitation from October of the previous year through July for the displayed years. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Table 2. Irrigation treatments and actual amounts of water applied to native forbs. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Irrigation rates (inches per irrigation)	
Date	Planned	Actual
May 19	2	2.2
	1	1.3
June 2	2	2.2
	1	1.2
June 20	2	2
	1	1.2
June 30	2	2.3
	1	1.1
Total	8	8.7
	4	4.8

Table 3. Native forb seed yield response to irrigation rate. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Total irrigation applied	*Eriogonum umbellatum*	*Penstemon acuminatum*	*Penstemon deustus*[a]	*Penstemon speciosus*
inches	----------	---------- lb/acre	----------	----------
8.7	371.6	544.0	1,068.6	213.6
4.8	214.4	611.1	1,200.8	285.4
0	155.3	538.4	1,246.4	163.5
LSD (0.05)	92.9	NS	NS	NS

[a]Yields might overestimate potential commercial yields due to small areas harvested.

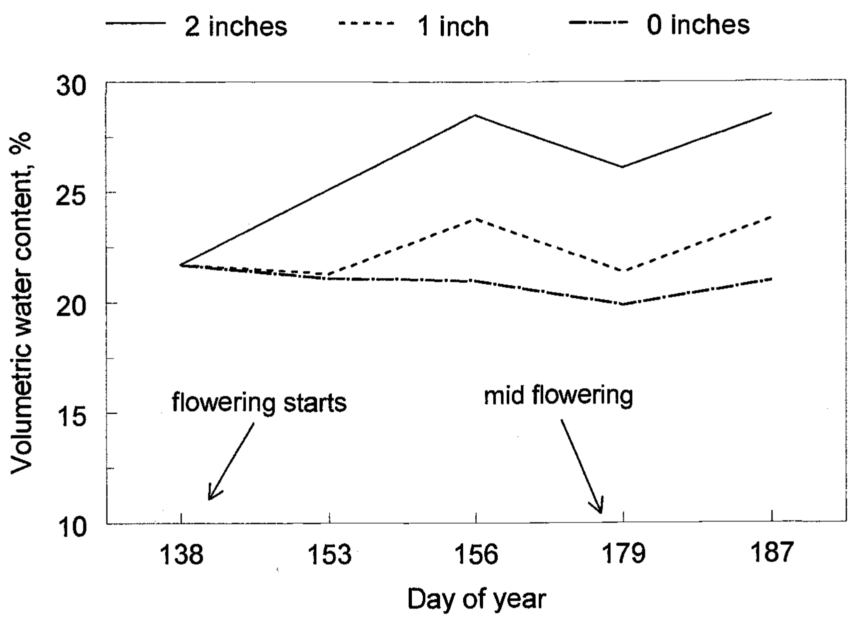

Figure 2. Soil volumetric water content for *Eriogonum umbellatum* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *E. umbellatum* was harvested on August 3 (day 215). Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

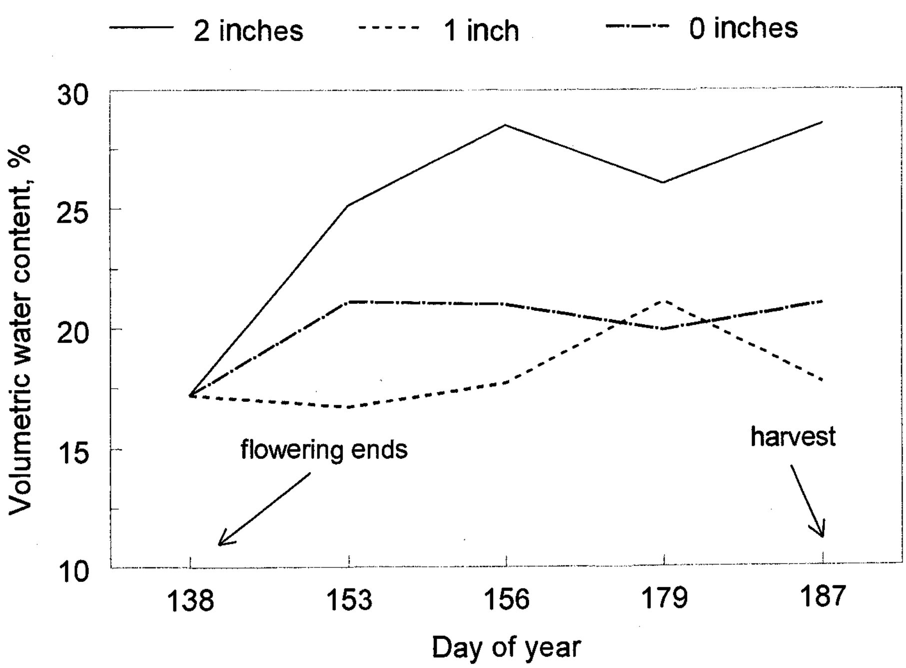

Figure 3. Soil volumetric water content for *Penstemon acuminatum* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

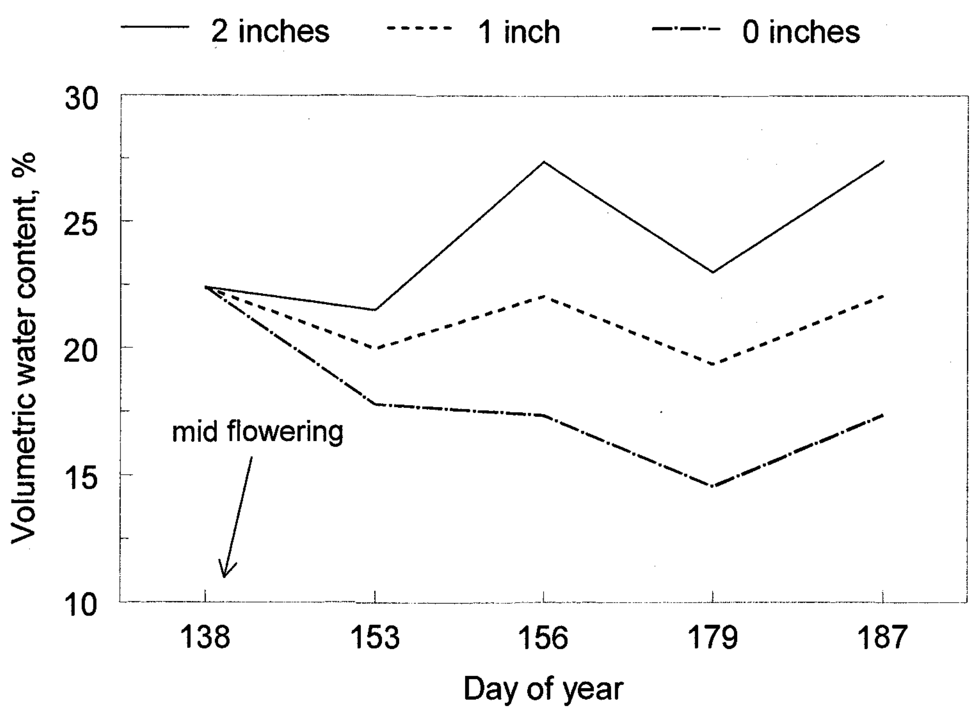

Figure 4. Soil volumetric water content for *Penstemon speciosus* over time. Soil volumetric water content is the combined average at the 8-, 20-, and 32-inch depths. *P. speciosus* was harvested on July 13 (day 194). Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Table 4. Soil volumetric water content for native forb species submitted to three irrigation intensities, Malheur Experiment Station, Oregon State University, Ontario, OR.

	18-May			2-Jun			5-Jun			28-Jun			6-Jul		
Depth	2 inches[a]	1 inch	0 inches	2 inches	1 inch	0 inches	2 inches	1 inch	0 inches	2 inches	1 inch	0 inches	2 inches	1 inch	0 inches
	Eriogonum umbellatum														
0.2 m	16.4	16.4	16.4	17.9	15.6	14.1	22.3	19.1	14.0	19.8	13.6	12.4	21.0	14.7	5.1
0.5 m	24.5	24.5	24.5	28.7	24.2	25.4	32.1	26.6	25.3	29.7	22.8	24.1	30.1	24.2	16.4
0.8 m	24.2	24.2	24.2	28.6	24.1	23.7	31.1	25.6	23.7	28.8	27.7	23.1	29.3	26.2	22.5
Average	21.7	21.7	21.7	25.1	21.3	21.1	28.5	23.8	21.0	26.1	21.4	19.9	28.5	23.8	21.0
	Penstemon acuminatum														
0.2 m	11.2	11.2	11.2	17.9	10.7	14.1	22.3	11.7	14.0	19.6	16.1	12.4	21.5	12.8	7.0
0.5 m	19.0	19.0	19.0	28.7	18.7	25.4	32.1	20.5	25.3	30.5	23.7	24.1	32.2	22.5	17.2
0.8 m	21.3	21.3	21.3	28.6	20.7	23.7	31.1	20.8	23.7	27.9	23.6	23.1	28.6	21.8	21.0
Average	17.2	17.2	17.2	25.1	16.7	21.1	28.5	17.7	21.0	26.0	21.1	19.9	28.5	17.7	21.0
	Penstemon speciosus														
0.2 m	13.1	13.1	13.1	12.1	13.7	9.8	18.0	17.0	9.5	13.6	13.2	7.3	17.3	14.6	7.1
0.5 m	30.3	30.3	30.3	25.2	22.6	22.1	32.4	25.1	21.5	26.8	22.4	18.1	29.5	23.2	17.4
0.8 m	23.9	23.9	23.9	27.4	23.6	21.6	31.8	24.1	21.2	28.7	22.8	18.4	29.8	23.1	17.8
Average	22.4	22.4	22.4	21.5	20.0	17.8	27.4	22.1	17.4	23.0	19.4	14.6	27.4	22.1	17.4

[a]Inches of water per irrigation.

TOLERANCE OF SEVEN NATIVE FORBS TO PREEMERGENCE AND POSTEMERGENCE HERBICIDES

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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 native forbs for their tolerance to commercial herbicides.

The trials reported here tested the tolerance of seven native forb species to conventional preemergence and 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 for 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 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).

Preemergence Treatments
The weather was wet and windy, delaying the application of preemergence herbicide treatments. The field was staked out to make 5-ft-wide plots perpendicular to the forb rows, crossing all seven species using the upper 200 ft of the field. Eight treatments (Table 2) including the untreated check were replicated four times in a randomized complete block design. Treatments were applied 5 January 2006 at 30 psi, 2.63 mph, in 20 gal/acre using 8002 nozzles with three nozzles spaced 20 inches apart.

By early January the planted area had volunteer wheat and blue mustard. Roundup® UltraMax at 1.01 lb ai/acre was sprayed 6 January 2006 over the entire area to control the volunteer wheat and other weeds that had emerged. The Roundup was applied at 30 psi, 2.63 mph, in 20 gal/acre using 8002 nozzles with three nozzles spaced 20 inches apart.

On 16 March there was good emergence of the *Lomatium* species. The forbs were cultivated April 13. Cultivation of adjoining areas damaged part of the *Eriogonum umbellatum* that had emerged. Starting April 17 emerged plants were counted in 6 inches of row. Plants were evaluated subjectively for injury on a scale of 0 = no injury to 100 = plants dead.

Postemergence Treatments
Postemergence treatments (Table 3) were applied in the same fashion as the preemergence 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. Treatments were applied May 24 at 30 psi, 2.63 mph, in 20 gal/acre using 8002 nozzles with three nozzles spaced 20 inches apart. Plant injury was rated on May 31, June 15, and June 30.

General Considerations
The focus of the evaluations was forb tolerance to the herbicides, not weed control. Therefore, weeds were removed as needed. In 2006 the trial was irrigated very little with the drip irrigation system because of ample rainfall.

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 had no statistical differences between the preemergence treatments (Table 2) due to the considerable cultivation injury. Very few of the plants that survived cultivation injury survived the preemergence treatment with Outlook® or Lorox®. Plant stunting was observed in plants where the soil was treated with Kerb® and Outlook. None of the sulfur buckwheat plants receiving Kerb preemergence survived.

Sulfur buckwheat was subject to foliar burn and chlorosis (yellowing) with several postemergence herbicides (Table 3). The buckwheat was sensitive to postemergence applications of Buctril®, Goal®, Caparol®, and Lorox as evidenced by statistically significant foliar damage.

Table 2. Tolerance of *Eriogonum umbellatum* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

			Plant stand			Injury		
	Treatment	Rate	4/26	5/31	6/15	5/31	6/15	7/5
		lb ai/acre	----- counts -----		%		----------- % -----------	
1	Untreated check	--	14.5	14	46	0	0	0
2	Prefar 4.0 EC	5.0	25.5	20	65	0	10	10
3	Kerb 50 WP	1.0	0	0	0		No plants	
4	Treflan HFP	0.375	23.5	20.5	52.5	0	20	17.5
5	Prowl 3.8 SC	0.75	11	10	37.5	0	0	5
6	Balan 60 DF	1.2	25	24	80	0	0	0
7	Outlook 6.0 EC	0.656	2.5	2.5	2	0	35	22.5
8	Lorox 50 DF	1.0	1	1	1	0	0	20
	Mean		12.9	11.4	34.8	0	10.8	10.8
	LSD (0.05)		NS	NS	NS	NS	NS	NS

Table 3. Tolerance of *Eriogonum umbellatum* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	70	0	0	0
2	Buctril 2.0 EC	0.125	60	36.3	37.5	23.8
3	Goal 2XC	0.125	62.5	67.5	42.5	23.8
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	52.5	2.5	2.5	16.3
5	Prowl H_2O 3.8 C	1.0	85	6.3	7.5	0
6	Caparol FL 4.0	0.8	55	40	33.8	28.8
7	Outlook 6.0 EC	0.656	48.8	0	0	3.8
8	Lorox 50 DF	0.5	70	33.8	33.8	27.5
	Mean		63.0	24.0	20.3	16.0
	LSD (0.05)		NS	18.7	12.7	17.4

Penstemon acuminatus (Sand penstemon)
Plant stands of sand penstemon were reduced by preemergence treatments of Prefar®, Kerb, Prowl® and Balan® (Table 4). Where Kerb or Prowl was applied preemergence, almost all sand penstemon plants died during the first growing season. Plant stands were best where Treflan®, Outlook, and Lorox were applied. Scattered areas of stunted plants occurred in several treatments. Foliar damage was minimal by July 5 where Treflan or Lorox had been applied.

Few negative effects were noted on sand penstemon from most of the herbicides used as postemergence applications (Table 5). Symptoms of damage were yellowing and leaf burn. Leaf burn and plant stunting occurred with Caparol, a photosynthetic inhibitor. Less dramatic and temporary leaf damage was noted following the application of Buctril.

Penstemon deustus (Hotrock penstemon)
Hotrock penstemon plant stands were reduced by all the products tested except Treflan (Table 6). No hotrock penstemon plants were observed where the soil was treated with Kerb. The most common damage symptoms were yellowing and stunting.

Hotrock penstemon plant stands were reduced by postemergence applications of Caparol and Outlook (Table 7). Plants treated with Select® and Prowl had no phytotoxic symptoms. Burnt and yellowing foliage were common with Caparol, Lorox, Buctril, and Goal. Burnt and stunted symptoms on plants persisted until June 30 following the application of Caparol and Lorox.

Table 4. Tolerance of *Penstemon acuminatus* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

			Plant stand			Injury		
	Treatment	Rate	4/26	5/31	6/15	5/31	6/15	7/5
		lb ai/acre	----- counts -----		%	----------- % -----------		
1	Untreated check	--	21.5	20.5	20.0	0	0	0
2	Prefar 4.0 EC	5.0	5	3.5	8.3	31.3	25	0
3	Kerb 50 WP	1.0	0.3	0.3	0.5	0	0	no plants
4	Treflan HFP	0.375	17.8	18.3	43.7	13.3	10	3.3
5	Prowl 3.8 SC	0.75	3	0.75	0.75	87.5	95	no plants
6	Balan 60 DF	1.2	7.8	7.5	22.5	17.5	10	3.3
7	Outlook 6.0 EC	0.656	17.3	15.5	61.7	25	28.8	17.5
8	Lorox 50 DF	1.0	15.5	12.8	40.0	22.5	15	3.8
	Mean		11.0	9.9	23.1	23.1	20.6	5.3
	LSD (0.05)		12.0	11.2	43.0	27.5	29.6	NS

Table 5. Tolerance of *Penstemon acuminatus* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	83.8	0	0	0
2	Buctril 2.0 EC	0.125	81.3	18.8	5	0
3	Goal 2XC	0.125	77.5	7.5	0	0
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	46.3	2.5	0	0
5	Prowl H_2O 3.8 C	1.0	77.5	5	5	0
6	Caparol FL 4.0	0.8	71.3	35	55	50
7	Outlook 6.0 EC	0.656	65	0	0	0
8	Lorox 50 DF	0.5	67.5	6.3	7.5	0
	Mean		71.25	9.375	9.0625	6.25
	LSD (0.05)		NS	8.4	6.6	2.1

Table 6. Tolerance of *Penstemon deustus* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand			Injury		
			4/26	5/31	6/15	5/31	6/15	7/5
		lb ai/acre	----- counts -----		%	----------- % ----------		
1	Untreated check	--	37.3	25	68.8	0	0	0
2	Prefar 4.0 EC	5.0	3	2.5	5.0	0	0	7.5
3	Kerb 50 WP	1.0	0	0	0		No plants	
4	Treflan HFP	0.375	27.8	20.3	59.3	0	12.5	0
5	Prowl 3.8 SC	0.75	6.3	4.3	15.3	0	23.3	20
6	Balan 60 DF	1.2	4.8	4.3	10.8	0	16.3	12.5
7	Outlook 6.0 EC	0.656	2	1.5	1.8	0	53	70
8	Lorox 50 DF	1.0	0.8	0.5	1.0	0	20	10
	Mean		10.2	7.3	20.2	0	17.3	13.9
	LSD (0.05)		21.2	14.8	30.6	NS	NS	22.5

Table 7. Tolerance of *Penstemon deustus* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	98.8	0	0	0
2	Buctril 2.0 EC	0.125	82.5	32.5	11.3	10
3	Goal 2XC	0.125	83.8	21.3	13.8	7.5
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	91.3	0	0	0
5	Prowl H_2O 3.8 C	1.0	95	0	0	0
6	Caparol FL 4.0	0.8	56.3	48.8	55	42.5
7	Outlook 6.0 EC	0.656	70	0	0	0
8	Lorox 50 DF	0.5	86.3	38.8	48.8	42.5
	Mean		83.0	17.7	16.1	12.8
	LSD (0.05)		24.5	11.2	17.7	19.5

Penstemon speciosus (Royal or sagebrush penstemon)
Royal penstemon plant stands were not affected by Treflan, Balan, or Outlook, among others (Table 8). Phytotoxic effects of most herbicides were moderate and diminished with time. Prowl and Balan applied preemergence caused significant negative effects, and there was marked stunting with Prowl. No royal penstemon survived to 2007 where Kerb was applied preemergence.

None of the postemergence herbicides tested reduced the stands of royal penstemon (Table 9). Royal penstemon was sensitive to Lorox and extremely sensitive to Caparol. Symptoms of Caparol damage included yellowing, yellow-purple foliage, and plant death. Where other products damaged plants, symptoms were yellowing, stunting, and leaf burn.

Lomatium dissectum (Fernleaf biscuitroot)
Fernleaf biscuitroot had a very brief growing season, so observations on the effects of preemergence herbicides were ended on May 31. No significant decreases in plant counts were noted due to preemergence herbicides (Table 10); however, phytotoxic symptoms on the foliage were commonly noted. Prefar had significantly more foliar symptoms that the untreated check on April 17, while Kerb, Outlook, Prowl, and Lorox had significantly more symptoms that the untreated check on both April 17 and May 31. None of the herbicides applied preemergence appeared to be totally safe at the rates used in this trial.

Observations of the postemergence herbicides were begun in late May and continued until June 30. The postemergence herbicides had no significant effects on plant stands at the rates tested (Table 11). In contrast to the negative phytotoxic effects observed with the preemergence herbicide applications, none of the herbicides applied postemergence had significant phytotoxic effects on fernleaf biscuitroot at the rates tested.

Table 8. Tolerance of *Penstemon speciosus* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand counts		Injury %		
			4/26	5/31	5/31	6/15	7/5
		lb ai/acre	----- counts -----		----------- counts ----------		
1	Untreated check	--	22.5	20.3	0	0	0
2	Prefar 4.0 EC	5.0	10.3	9	11.7	6.7	0
3	Kerb 50 WP	1.0	0.3	0	------------ No plants ------------		
4	Treflan HFP	0.375	26.3	24.8	20	12.5	8.3
5	Prowl 3.8 SC	0.75	8.8	7	73.8	57.5	41.7
6	Balan 60 DF	1.2	20	20	30	26.3	8.3
7	Outlook 6.0 EC	0.656	19.5	17.3	18.8	7.5	0
8	Lorox 50 DF	1.0	19.8	16.3	2.5	2.5	0
	Mean		15.9	14.3	22.8	16.5	7.6
	LSD (0.05)		NS	15.2	32.2	24.4	16.5

Table 9. Tolerance of *Penstemon speciosus* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	71.3	0	0	0
2	Buctril 2.0 EC	0.125	82.5	7.5	7.5	5
3	Goal 2XC	0.125	83.8	3.8	2.5	2.5
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	92.5	3.8	0	2.5
5	Prowl H_2O 3.8 C	1.0	92.5	2.5	0	10
6	Caparol FL 4.0	0.8	83.8	45	83.3	81.3
7	Outlook 6.0 EC	0.656	76.3	0	0	0
8	Lorox 50 DF	0.5	73.8	25	28.8	33.8
	Mean		82.0	10.9	15.3	16.9
	LSD (0.05)		NS	12.1	7.4	9.6

Table 10. Tolerance of *Lomatium dissectum* preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand counts	Injury %	
		lb ai/acre	4/17	4/17	5/31
1	Untreated check	--	18.5	0	0
2	Prefar 4.0 EC	5.0	19.8	18.8	15
3	Kerb 50 WP	1.0	13.5	38.8	46.3
4	Treflan HFP	0.375	16	11.3	20
5	Prowl 3.8 SC	0.75	16	20	32.5
6	Balan 60 DF	1.2	16	13.8	20
7	Outlook 6.0 EC	0.656	9.5	35	41.3
8	Lorox 50 DF	1.0	14.8	15	27.5
	Mean		15.5	19.1	25.3
	LSD (0.05)		NS	13.9	26.5

Table 11. Tolerance of *Lomatium dissectum* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	96.3	0	0	0
2	Buctril 2.0 EC	0.125	100	3.8	5	2.5
3	Goal 2XC	0.125	95	12.5	7.5	5
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	97.5	3.8	7.5	8.8
5	Prowl H_2O 3.8 C	1.0	96.3	5	10	7.5
6	Caparol FL 4.0	0.8	90	0	7.5	7.5
7	Outlook 6.0 EC	0.656	100	5	2.5	0
8	Lorox 50 DF	0.5	100	2.5	2.5	5
	Mean		96.9	4.1	5.3	4.5
	LSD (0.05)		NS	NS	NS	NS

Lomatium triternatum (Nineleaf desert parsley)
Plant counts of nineleaf desert parsley were not affected by the preemergence herbicides at the rates tested (Table 12). Outlook caused significant foliar damage compared to the untreated check on all four observation dates. Symptoms included leaf burn, stunting, and plant death. Leaf burn and stunting were also noted for the plants with preemergence Lorox.

None of the postemergence herbicides reduced plant stands as of May 24 (Table 13). Burnt plants and plant death occurred where Buctril was applied postemergence. Other than the very marked damage observed with Buctril, none of the other postemergence herbicides had significant amounts of foliar damage except the Prowl treatment observed on June 30.

Lomatium grayi (Gray's lomatium)
Plant counts of Gray's lomatium were not affected by the preemergence herbicide treatments (Table 14). Stunting and plant death were severe where Kerb was applied preemergence. For the other preemergence treatments, mild stunting was noted but was not significantly different from the untreated check treatment.

As for the other two Lomatiums, none of the postemergence herbicides reduced plant stands of Gray's lomatium as of May 24 (Table 15). Like nineleaf desert parsley, Gray's lomatium showed significantly more damage following postemergence application of Buctril, which resulted in burnt foliage. Some significant foliage symptoms followed postemergence applications of Goal, Caparol, and Lorox, but the symptoms were significantly less than those observed with Buctril.

Table 12. Tolerance of *Lomatium triternatum* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand counts	Injury %			
		lb ai/acre	4/18	4/18	5/31	6/15	7/5
1	Untreated check	--	48.5	0	0	0	5
2	Prefar 4.0 EC	5.0	42.5	0	7.5	1.3	0
3	Kerb 50 WP	1.0	37.5	10	10	5	8.8
4	Treflan HFP	0.375	42.5	7.5	10	6.3	7.5
5	Prowl 3.8 SC	0.75	39.8	3.8	5	0	0
6	Balan 60 DF	1.2	48.8	6.3	3.8	6.3	0
7	Outlook 6.0 EC	0.656	41.3	30	40	35	38.8
8	Lorox 50 DF	1.0	43.8	10	11.3	11.3	11.3
	Mean		43.1	8.4	10.9	8.1	8.9
	LSD (0.05)		NS	10.4	14.8	13.7	14.1

Table 13. Tolerance of *Lomatium triternatum* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	93.8	0	0	0
2	Buctril 2.0 EC	0.125	96.3	28.3	73	82.5
3	Goal 2XC	0.125	87.5	2.5	2.5	6.3
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	98.8	0	2.5	3.8
5	Prowl H_2O 3.8 C	1.0	96.3	2.5	5	15
6	Caparol FL 4.0	0.8	98.8	2.5	0	3.8
7	Outlook 6.0 EC	0.656	97.5	2.5	0	3.8
8	Lorox 50 DF	0.5	100	0	0	3.8
	Mean		96.1	4.8	10.4	14.8
	LSD (0.05)		NS	9.8	9.6	11.7

Table 14. Tolerance of *Lomatium grayi* to preemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand counts	Injury %			
		lb ai/acre	4/18	4/18	5/31	6/15	7/5
1	Untreated check	--	30.8	0	0	0	0
2	Prefar 4.0 EC	5.0	28.3	7.5	11.3	11.3	8.8
3	Kerb 50 WP	1.0	29.8	28.8	42.5	38.8	42.5
4	Treflan HFP	0.375	30	7.5	7.5	5	12.5
5	Prowl 3.8 SC	0.75	26.3	2.5	8.8	5	6.3
6	Balan 60 DF	1.2	35.3	6.3	0	0	0
7	Outlook 6.0 EC	0.656	30.5	11.3	6.3	5	6.3
8	Lorox 50 DF	1.0	29.8	10	11.3	6.3	8.8
	Mean		30.1	9.2	10.9	8.9	10.6
	LSD (0.05)		NS	12.7	19.5	20.4	24.7

Table 15. Tolerance of *Lomatium grayi* to postemergence herbicides screened at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Treatment	Rate	Plant stand %	Injury %		
		lb ai/acre	5/24	5/31	6/15	6/30
1	Untreated	--	100	0	0	0
2	Buctril 2.0 EC	0.125	98.8	22.5	37.5	30
3	Goal 2XC	0.125	92.5	10	7.5	5
4	Select 2.0 EC + Herbimax	0.094 + 1% v/v	96.3	5	0	0
5	Prowl H_2O 3.8 C	1.0	96.3	5	2.5	2.5
6	Caparol FL 4.0	0.8	90	10	7.5	7.5
7	Outlook 6.0 EC	0.656	95	2.5	2.5	3.8
8	Lorox 50 DF	0.5	98.8	8.85	6.3	6.3
	Mean		95.9	8.0	8.0	6.95
	LSD (0.05)		NS	5.3	7.2	15.1

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. Preemergence herbicide effects from 2006 were no longer visible on the *Lomatium* species. Where preemergence herbicides hurt or killed most of the sulfur buckwheat or penstemon plants, the negative effects were permanent. These observations suggest that some degree of phytotoxic damage may be acceptable in establishing native forb seed fields if effective weed control is achieved.

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2006 ONION VARIETY TRIALS

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Introduction

The objective of the onion variety trials was to evaluate yellow, white, and red onion varieties for bulb yield, quality, and single centers. Eight early season varieties (six yellow, two white) were planted in March and were harvested and graded at the end of August. Forty-three full-season varieties (33 yellow, 6 red, and 4 white) were planted in March, harvested and weighed in September 2006, and were graded and fully evaluated out of storage in January 2007. Each year, growers and seed industry representatives have the opportunity to examine the varieties at our annual Onion Variety Field Day and during onion grading in early January.

Methods

The onions were grown on an Owyhee silt loam previously planted to wheat. In the fall of 2005, the wheat stubble was shredded, and the field was irrigated and disked. Soil analysis indicated the need for 100 lb phosphate/acre, 100 lb sulfur/acre, 2 lb copper/acre and 1 lb/acre of boron, which were broadcast in the fall of 2005 after disking. The field was then moldboard-plowed, groundhogged, roller-harrowed, fumigated with Telone® C-17 at 20 gal/acre, and bedded.

A full-season trial and an early maturing trial were conducted adjacent to each other. Both trials were planted on March 23 in plots 4 double rows wide and 27 ft long. The early maturing trial had 8 varieties from 3 seed companies (Table 1) and the full-season trial had 43 varieties from 10 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 with a customized planter using 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 24. Onion emergence started on April 14. On May 15, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 17 through May 19, 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 onions were managed to try to avoid 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 28. On May 9, Goal® at 0.1 lb ai/acre, Buctril® at 0.3 lb ai/acre, and Select® at 0.25 lb ai/acre were applied. On May 17, Goal at 0.2 lb ai/acre and Buctril at 0.3 lb ai/acre were applied. On May 30, Goal at 0.2 lb ai/acre, Buctril at 0.3 lb ai/acre, and Select at 0.25 lb ai/acre were applied. After lay-by the field was hand weeded as necessary. Thrips were controlled with aerial applications of the following insecticides: June 12, Warrior®; June 18, Warrior plus Lannate®; July 1, Carzol®; July 17, Warrior plus Mustang®; July 24, Carzol; July 29, Warrior plus MSR; August 10, Warrior plus Lannate. Carzol was applied at 0.69 lb ai/acre, Warrior at 0.03 lb ai/acre, Lannate at 0.45 lb ai/acre, Mustang at 0.05 lb ai/acre, and MSR at 0.5 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 23.

The field was sidedressed with 100 lb of nitrogen/acre as urea and cultivated on May 25. On June 21, the field was sidedressed with 100 lb N/acre as urea. An onion root tissue analysis on July 14 showed the need for potassium. On July 21, potassium at 20 lb/acre was water run during a routine irrigation.

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 August 21 and the full-season trial on August 22 and September 7. 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) on August 22. Each plot was rated on a scale of 0 to 5, where 0 = no symptoms and 5 = over 80 percent foliage dried out due to symptoms.

After grading of the early maturing trial, 10 randomly chosen bulbs from each plot were shipped via UPS ground to Vidalia Labs International in Collins, Georgia. The bulb samples were analyzed for pyruvic acid content on September 6. Bulb pyruvic acid content is a measure of pungency with the unit being micro mols pyruvic acid per gram of fresh weight. Onion bulbs having a pyruvate concentration of 5.5 or less are considered sweet according to Vidalia Labs sweet onion certification specifications.

In early September, 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 double" had diameters less than 1.5 inches, "intermediate double" had diameters from 1.5 to 2.25 inches, and "blowout" had diameters greater than 2.25 inches. Single-centered onions were classed as a "bullet". Onions were considered functionally single centered for processing if they were a "bullet" or "small double."

Onions from the middle two 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. The onions in the full-season trial were lifted on September 8 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 13. The bags were put in storage on September 18. Before being placed into storage each bag was weighed. 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 3 and 4, 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. The red varieties were evaluated subjectively during grading for exterior thrips damage during storage. The bulbs from each red variety plot were rated on a scale from 0 (no damage) to 10 (most damage) for damage on the bulb surface, without removing the outer scales.

Varietal differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). Regression analyses of yield against IYSV ratings were conducted on both the data from 2005 (Shock et al. 2006) and the current year's data.

Results

Both environmental stress and pest stress limited onion performance at Ontario in 2006. The weather was cooler than normal, with fewer growing degree days than average until May 20. After May 20 the weather was warmer than average. Heat for the season exceeded norms, especially in July. A heat wave had maximum air temperatures equal to or greater than 100°F from July 21 to July 29. Thrips and IYSV were particularly damaging during the 2006 season.

Varieties are listed by company in alphabetical order. The LSD (0.05) values at the bottom of 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.

Since 2003, several experimental varieties were named. In 2004 Nunhems 'SX 7000ON' and 'SX 7002ON' were named 'Bandolero' and 'Montero', respectively. Global Genetics '6001' was named 'Maverick'. In 2005, Seminis 'XP5646' was named 'Orizaba', 'XP5813' was named 'Affirmed', and 'EX5843' was named 'Monarchos'. In 2006, D. Palmer 'DPS 1405' was named 'Generation X', 'DPS 1406' was named 'Evolution', and 'DPS 3052' was named 'Shiraz'. Nunhems 'NUN7004ON' was named 'Arcero', 'NUN7200ON' was named 'Grand Coulee', and 'NUN7008ON' was named 'Joaquin'. Varieties are all listed by name in the results. The experimental numbers are useful for comparing results from previous years.

Early Maturing Trial

The percentage of "bullet" single centers averaged 30.0 percent and ranged from 4.0 percent for 'Western Giant', to 66.6 percent for Montero (Table 1). The percentage of onions that were functionally single centered averaged 49.8 percent and ranged from 14.0 percent for Western Giant to 87.8 percent for Montero.

Total yield at harvest in September 2006 ranged from 496 cwt/acre for 'EX7106' to 727.5 cwt/acre for 'Exacta' (Table 1). Exacta, 'Ovation', and 'Spanish Medallion' were among the varieties with the highest total yield.

Marketable yield out of storage ranged from 466 cwt/acre for EX7106 to 691 cwt/acre for Exacta (Table 2). Colossal yield ranged from 9.7 cwt/acre for Montero to 166 cwt/acre for Exacta.

Full-season Trial

The percentage of "bullet" single centers averaged 43.4 percent and ranged from 3.3 percent for 'White Wing', to 89 percent for Generation X (Table 3). The percentage of onions that were functionally single centered averaged 66.6 percent and ranged from 13.3 percent for 'Snowflake' to 97.3 percent for Generation X. Generation X, 'Ruby Ring', 'Cometa', Grand Coulee, 'Ringleader', Arcero, and 'Koala' had higher than 90 percent functionally single-centered bulbs.

Total yield at harvest in September 2006 ranged from 377 cwt/acre for Shiraz to 834.8 cwt/acre for 'Tequila' (Table 3). Tequila, 'T-433', 'Ranchero', 'Harmony' and 'Charismatic' were among the varieties with the highest total yield.

Total yield out of storage ranged from 288.9 cwt/acre for Shiraz to 771 cwt/acre for OLYS05N5 (Table 4). Varieties OLYS05N5, Tequila, Joaquin, Charismatic, and Harmony were among the varieties with the highest total yield. Marketable yield ranged from 163.8 cwt/acre for Shiraz to 714 cwt/acre for Joaquin. Varieties Joaquin, EX5819, Harmony, and Charismatic were among the varieties with the highest marketable yield. Supercolossal onion yield ranged from 0 cwt/acre for many varieties to 28 cwt/acre for Tequila. Varieties Tequila, Joaquin, Evolution, Harmony, and 'Sweet Perfection' were among the varieties with the highest super-colossal yield. Colossal onion yield ranged from 0 cwt/acre for several varieties to 184 cwt/acre for Joaquin. Varieties Joaquin, Charismatic, Tequila, Evolution, and OLYS05N5 were among the varieties with the highest colossal yield.

Iris Yellow Spot Virus (IYSV)

Subjective ratings of IYSV symptom severity for the full-season varieties, on a scale from 0 to 5, ranged from 1.6 for Joaquin and OLYS05N5 to 4.1 for Generation X (Table 3). Average total onion yield by variety was closely related to the average IYSV symptom severity in 2005 and 2006 (Figs. 1 and 2). In general, varieties with a lower severity rating had higher total yield. Clearly, the relative onion variety tolerance to the effects of IYSV has become a major factor in onion productivity.

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.

Table 1. Onion multiple-center rating and pyruvate concentration for early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Seed company	Variety	Bulb color	Multiple center: Blowout	Multiple center: Intermediate double	Multiple center: Small double	Single center: Functional[a]	Single center: Bullet	Pyruvate concentration
			%					µmoles/g FW
Nunhems	Renegade	Y	60.7	17.3	12.7	22.0	9.3	6.3
	Montero	Y	8.0	4.2	21.2	87.8	66.6	7.3
Sakata	Ovation	Y	34.6	18.8	17.0	46.7	29.7	6.9
	Spanish Medallion	Y	25.3	16.0	23.3	58.7	35.3	7.0
	Western Giant	Y	61.3	24.7	10.0	14.0	4.0	7.6
Seminis	Exacta	Y	43.3	22.0	21.3	34.7	13.3	7.5
	Orizaba	W	13.3	20.0	30.7	66.7	36.0	6.6
	EX7106	W	18.7	13.3	22.0	68.0	46.0	6.4
LSD (0.05)			16.3	NS	11.1	14.3	10.6	NS

[a]Bullet + small double.

Table 2. 2006 performance data for early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Bulb color	Total yield	Marketable yield by grade: Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Bulb counts >4¼ in	Total rot	Non-marketable yield: No. 2s	Non-marketable yield: Small	Maturity on Aug. 21
		--- cwt/acre ---		----------- cwt/acre -----------				#/50 lb	%	-- cwt/acre --		%
Renegade	Y	602.1	516.3	3.1	72.7	417.0	23.4	33.1	0.6	71.3	11.14	67
Montero	Y	502.1	483.4	0.0	9.7	451.4	22.4	---	0.6	0.75	15.1	62
Spanish Medallion	Y	693.3	674.8	2.7	135.2	512.4	24.5	38.9	0.3	8.54	7.97	52
Ovation	Y	700.5	685.7	0.0	102.4	555.0	28.3	---	0.0	3.28	11.14	48
Western Giant	Y	596.5	548.8	1.6	51.0	470.7	25.5	31.5	0.3	36.88	9.2	65
Exacta	Y	727.5	691.0	8.1	165.6	497.1	20.2	29.4	0.8	21.39	9.41	63
Orizaba	W	591.9	563.1	0.0	31.5	489.2	42.4	---	1.2	10.59	11.07	34
EX7106	W	496.0	465.9	0.0	16.0	378.1	71.7	---	1.0	4.9	20.18	27
LSD (0.05)		140.0	146.9	NS	42.3	NS	19.8	NS	NS	14.9	NS	8.9

Table 3. Total yield at harvest, bulb multiple-center rating, and iris yellow spot virus rating for long season varieties, Malheur Experiment Station, Oregon State Univ., Ontario, OR, 2006.

Seed company	Variety	Bulb color	Multiple center: Blowout	Multiple center: Intermediate double	Multiple center: Small double	Single center: Functional[a]	Single center: Bullet	Iris yellow spot virus rating[b]
			%					0 - 5
A. Takii	Ruby Ring	R	0.7	2.7	28.7	96.7	68.0	3.7
	T-433	Y	42.4	27.2	22.4	30.4	8.0	2.5
	9003G	Y	16.0	34.0	30.0	50.0	20.0	2.9
Bejo	Calibra	Y	12.7	25.4	28.7	61.9	33.2	3.0
	Crocket	Y	34.7	28.7	28.0	36.7	8.7	3.4
	Snowflake	W	64.0	22.7	8.0	13.3	5.3	2.1
	Red Bull	R	23.3	21.3	27.3	55.3	28.0	4.0
	Sedona	Y	30.7	20.7	29.3	48.7	19.3	2.8
	Talon	Y	16.7	13.3	28.0	70.0	42.0	3.4
	White Wing	W	58.7	18.7	19.3	22.7	3.3	1.9
Crookham	Harmony	Y	10.7	14.7	14.7	74.7	60.0	2.6
	Sweet Perfection	Y	20.0	27.3	20.7	52.7	32.0	2.5
	OLYS05N5	Y	12.7	14.0	24.7	73.3	48.7	1.6
D. Palmer	Mesquite 06	Y	36.7	21.3	28.7	42.0	13.3	2.5
	Tequila	Y	24.0	21.3	22.0	54.7	32.7	2.0
	Generation X	Y	1.3	1.3	8.0	97.3	89.3	4.1
	Evolution	Y	3.3	9.3	17.3	87.3	70.0	2.1
	Shiraz	R	41.1	17.2	23.8	41.7	17.9	4
Global	Maverick	Y	21.3	18.0	28.0	60.7	32.7	2.7
	Ringleader	Y	2.7	5.3	13.3	92.0	78.7	2.6
	Varsity	Y	7.3	11.3	30.7	81.3	50.7	2.8
	6093	Y	6.0	8.0	19.3	86.0	66.7	3.5
Nunhems	Cometa	W	1.3	2.0	20.0	96.7	76.7	2.0
	Granero	Y	10.0	18.0	23.3	72.0	48.7	2.3
	Montero	Y	3.3	10.7	22.7	86.0	63.3	3.0
	Pandero	Y	22.0	18.0	24.0	60.0	36.0	2.5
	Ranchero	Y	14.0	12.0	28.0	74.0	46.0	2.7
	Sabroso	Y	2.7	10.0	29.3	87.3	58.0	3.2
	Salsa	R	40.0	15.3	22.0	44.7	22.7	3.8
	Vaquero	Y	6.0	16.0	17.3	78.0	60.7	2.9
	Arcero	Y	4.0	4.7	14.0	91.3	77.3	3.5
	Grand Coulee	Y	1.3	3.3	18.0	95.3	77.3	3.9
	Joaquin	Y	6.0	10.0	20.7	84.0	63.3	1.6
Rispens	Solid Gold	Y	26.0	22.0	31.3	52.0	20.7	3.8
	Silver Princess	W	49.3	14.0	17.3	36.7	19.3	2.8
	Red Castle	R	32.7	12.0	22.7	55.3	32.7	3.3
Sakata	XON-450Y	Y	32.7	17.3	26.0	50.0	24.0	2.3
Seminis	Affirmed	Y	12.0	16.7	26.7	71.3	44.7	1.8
	Charismatic	Y	23.3	21.3	30.7	55.3	24.7	1.9
	Mercury	R	24.7	22.7	33.3	52.7	19.3	3.3
	Monarchos	Y	1.3	10.7	29.3	88.0	58.7	2.2
	EX5819	Y	19.3	19.3	28.0	61.3	33.3	2.3
Zetaseeds	Koala	Y	3.4	6.0	14.1	90.6	76.4	3.5
	LSD (0.05)		9.5	9.2	11.4	12.3	12.8	0.42

[a]Bullet + small double

[b]Subjective symptom severity rating: 0 = no symptoms, 5 = over 80% leaf area dried out due to symptoms.

Table 4. Performance data for experimental and commercial onion varieties graded out of storage in January 2007, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade					Bulb counts >4¼ in	Non-marketable yield						Maturity		Bolters	Thrips damage[a]
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in		Total rot	Neck rot	Plate rot	Black mold	No. 2s	Small	Aug. 22	Sept. 7		
				--- cwt/acre ---					#/50 lb	----- % of total yield -----				-- cwt/acre --		%		#/plot	
A. Takii	Ruby Ring	R	338.7	284.7	0.0	0.0	52.5	232.2		4.6	1.4	2.9	0.4	0.8	35.8	70	93	0.0	1.2
	T-433	Y	709.7	550.1	1.8	120.7	408.8	18.8	28.3	10.9	7.5	3.4	0.0	74.3	7.3	22	42	0.0	
	9003G	Y	544.4	510.0	0.0	4.2	445.3	60.5		3.6	2.9	0.7	0.0	1.9	13.0	33	65	0.0	
Bejo	Calibra	Y	496.5	462.8	0.0	0.0	377.6	85.2		1.0	0.2	0.8	0.0	14.0	15.0	29	59	0.0	
	Crocket	Y	485.9	411.3	0.0	2.5	323.2	85.5		4.9	1.9	2.7	0.3	36.0	14.4	47	76	0.0	
	Snowflake	W	484.2	437.7	0.0	0.0	328.7	109.0		3.7	2.9	0.8	0.0	18.2	12.6	37	62	0.0	
	Red Bull	R	430.9	388.7	0.0	0.0	266.1	122.7		2.6	1.5	1.1	0.0	12.6	18.6	43	71	0.0	0.8
	Sedona	Y	558.3	481.2	0.0	3.9	433.0	44.3		7.3	5.5	1.8	0.0	26.9	9.3	29	66	0.0	
	Talon	Y	387.8	353.6	0.0	1.7	225.2	126.8		4.7	3.0	1.6	0.0	2.3	13.6	74	93	0.0	
	White Wing	W	508.1	361.9	0.0	8.0	281.9	72.1		10.2	7.5	2.7	0.0	78.8	14.9	62	84	0.0	
Crookham	Harmony	Y	731.9	671.3	14.6	141.6	493.5	21.6	35.0	7.6	4.3	3.1	0.2	1.0	6.3	24	48	0.0	
	Sweet Perfection	Y	691.3	572.9	13.9	145.0	395.1	18.9	34.1	10.0	5.7	3.3	1.0	42.9	7.7	36	51	0.0	
	OLYS05N5	Y	770.8	664.0	7.6	166.8	466.9	22.7	34.9	12.4	9.9	2.5	0.0	4.6	7.4	14	25	0.0	
D. Palmer	Mesquite 06	Y	707.2	622.5	10.9	139.5	445.6	26.5	34.0	4.3	1.9	2.1	0.2	43.4	11.1	20	43	0.2	
	Tequila	Y	740.5	645.3	27.6	170.7	423.3	23.7	29.8	6.2	3.1	2.9	0.2	42.5	6.5	27	45	0.0	
	Generation X	Y	488.4	426.4	0.0	3.3	371.3	51.8		9.5	6.8	2.3	0.4	6.8	7.6	46	73	0.0	
	Evolution	Y	694.4	639.2	16.2	169.6	437.9	15.5	33.8	5.9	4.2	1.7	0.0	10.1	5.0	19	38	0.0	
	Shiraz	R	288.9	163.8	0.0	2.6	52.7	108.4		2.0	0.7	1.3	0.0	86.9	32.5	47	76	0.0	0.8
Global Genetics	Maverick	Y	668.2	578.6	3.9	116.3	439.3	19.1	39.0	9.1	3.9	4.5	0.7	21.9	5.9	36	61	0.0	
	Ringleader	Y	583.1	543.4	1.5	64.6	454.7	22.7	34.9	5.4	3.6	1.8	0.0	2.3	7.1	34	65	0.0	
	Varsity	Y	509.7	485.6	0.0	10.6	426.8	48.3		2.0	1.1	0.9	0.0	6.5	7.4	56	79	0.0	
	6093	Y	583.0	532.1	0.0	20.5	472.8	38.8		5.7	2.9	2.8	0.0	8.7	9.68	28	63	0.0	

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Seed company	Variety	Bulb color	Total yield	Marketable yield by grade					Bulb counts	Non-marketable yield						Maturity		Bolters	Thrips damage[a]
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	>4¼ in	Total rot	Neck rot	Plate rot	Black mold	No. 2s	Small	Aug. 22	Sept. 7		
			--- cwt/acre ---						#/50 lb	----- % of total yield -----				-- cwt/acre --		%		#/plot	
Nunhems	Cometa	W	726.5	682.6	2.6	79.0	572.0	28.9	39.5	4.5	3.2	1.1	0.1	2.7	8.9	24	54	0.6	
	Granero	Y	670.7	632.3	0.0	49.3	554.5	28.5		4.2	2.3	1.9	0.0	5.9	4.2	27	60	0.2	
	Montero	Y	543.8	506.4	0.0	17.5	431.3	57.5		4.8	3.2	1.6	0.0	3.8	7.6	65	85	0.0	
	Pandero	Y	623.0	575.2	3.2	48.8	483.8	39.4	32.4	5.0	2.6	2.4	0.0	9.0	7.3	25	56	0.0	
	Ranchero	Y	677.2	631.0	1.8	110.6	489.4	29.2	28.3	4.7	4.1	0.5	0.0	8.1	6.6	32	59	0.0	
	Sabroso	Y	499.4	477.3	0.0	0.0	395.0	82.3		2.4	1.5	1.0	0.0	0.0	10.1	36	70	0.0	
	Salsa	R	383.7	326.3	0.0	0.0	237.6	88.7		2.5	1.2	1.3	0.0	32.5	14.9	52	78	0.0	1.8
	Vaquero	Y	643.8	595.4	2.0	52.3	509.3	31.8	25.2	5.8	4.6	1.1	0.1	3.8	7.2	31	64	0.0	
	Arcero	Y	620.3	588.6	0.0	39.9	514.7	34.0		3.1	2.8	0.4	0.0	1.7	9.2	38	67	0.0	
	Grand Coulee	Y	418.9	390.1	0.0	1.6	272.3	116.2		3.6	3.1	0.6	0.0	0.3	13.2	46	81	0.0	
	Joaquin	Y	738.0	713.5	16.2	184.2	496.7	16.5	35.7	1.9	1.2	0.7	0.0	5.9	4.9	14	32	0.0	
Rispens	Solid Gold	Y	316.1	245.6	0.0	0.0	106.4	139.2		3.2	2.0	1.2	0.0	35.4	24.7	45	72	0.0	
	Silver Princess	W	475.6	289.3	1.6	3.3	221.4	63.0	32.4	14.5	9.0	5.5	0.0	113.0	7.4	31	63	0.0	
	Red Castle	R	355.4	274.6	0.0	0.0	173.1	101.5		2.3	1.5	0.8	0.0	50.7	22.3	34	70	0.0	0.0
Sakata	XON-450Y	Y	696.2	624.4	12.6	142.7	439.7	29.3	31.7	4.3	2.8	1.5	0.0	30.9	9.0	24	54	0.0	
Seminis	Affirmed	Y	671.4	632.2	1.8	105.1	500.6	24.7	28.3	4.2	2.0	2.2	0.0	2.6	8.3	25	53	0.0	
	Charismatic	Y	736.4	669.6	10.4	177.6	450.7	31.0	35.2	5.8	4.4	1.4	0.0	17.0	9.3	18	49	0.0	
	Mercury	R	332.2	286.4	0.0	0.0	123.1	163.3		3.9	2.7	1.1	0.0	14.6	19.1	77	91	0.0	2.6
	Monarchos	Y	630.4	596.8	0.0	45.4	524.7	26.6		2.3	1.5	0.8	0.0	12.2	6.7	27	58	0.0	
	EX5819	Y	730.4	681.0	7.4	86.7	554.3	32.6	29.2	4.3	3.1	1.1	0.0	12.6	5.7	26	58	0.0	
Zetaseeds	Koala	Y	545.0	484.6	0.0	22.6	417.3	44.8		8.3	4.8	3.6	0.0	7.6	9.4	32	64	0.0	
	LSD (0.05)		81.1	82.3	7.2	36.0	79.9	21.4	NS	4.6	3.8	2.4	NS	18.6	6.7	10.7	7.5	0.2	0.6

[a]Thrips damage on the surface of red onions at the end of the storage January 3 and 4: 0 = least damage, 10 = most damage.

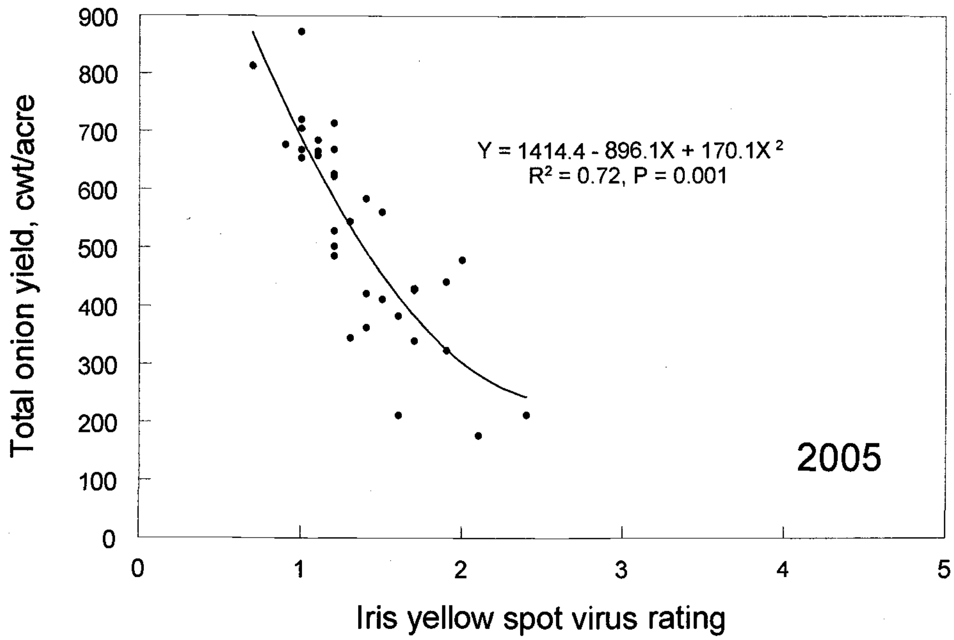

Figure 1. Average onion total yield by variety as a function of the average observed iris yellow spot virus symptoms in 2005. Virus ratings were based on subjective evaluations (0 = no symptoms, 5 = highest damage). Each data point is the average of the yield of five plots of each variety compared with the average observed symptoms. Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

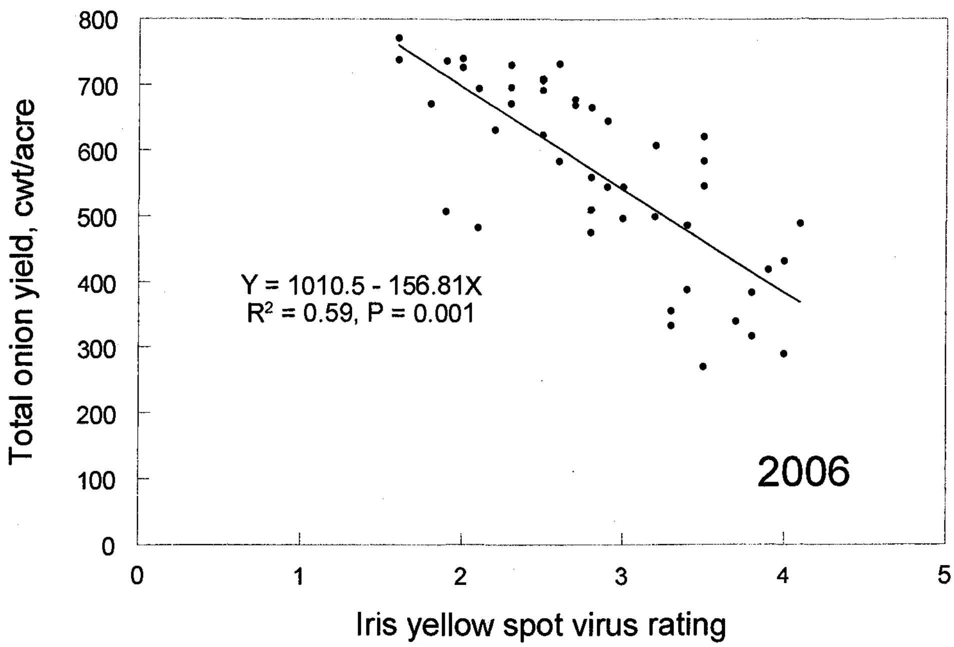

Figure 2. Average onion total yield by variety as a function of the average observed iris yellow spot virus symptoms in 2006. Virus ratings were based on subjective evaluations (0 = no symptoms, 5 = highest damage). Each data point is the average of the yield of five plots of each variety compared with the average observed symptoms. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

EVALUATION OF OVERWINTERING ONION FOR PRODUCTION IN THE TREASURE VALLEY, 2005-2006 TRIAL

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Introduction

The objective of the trial was to evaluate onion varieties for overwintering onion production in the Treasure Valley. Bulb yield, grade, single centeredness, and pungency were evaluated. Seven varieties were planted in August 2005, and were harvested and graded in June, 2006.

Procedures

The onions were grown on a field of Owyhee silt loam located northeast of the Malheur Experiment Station on Railroad Ave. between Highway 201 and Alameda Drive. Seed of the 7 varieties (Table 1) was planted in double rows spaced 3 inches apart at 9 seeds/ft of single row on August 31, 2005. Each double row was planted on beds spaced 20 inches apart with a customized planter using John Deere Flexi Planter units equipped with disc openers. All cultural practices were performed by the grower.

Onions from the middle two rows in each plot were lifted, topped by hand and bagged on June 29, 2006. The onion bags were transported to the Malheur Experiment Station and graded.

Before grading, all bulbs from each plot were counted to determine actual plant populations at harvest. 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 (< 2¼ inch), medium (2¼ to 3 inch), jumbo (3 to 4 inch), colossal (4 to 4¼ inch), and supercolossal (>4¼ inch). 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.

In June, 10 randomly chosen bulbs from each plot were shipped via UPS ground to Vidalia Labs International in Collins, Georgia. The bulb samples were analyzed for pyruvic acid content. Bulb pyruvic acid content is a measure of pungency with the unit being micro mols pyruvic acid per gram of fresh weight. Onion bulbs having a pyruvate concentration of 5.5 or less are considered sweet according to Vidalia Labs sweet onion certification specifications.

After harvest bulbs from each plot were rated for single centers. Twenty-five 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 interior diameter of the first single ring: "small double" with interior diameters less than 1½ inches, "intermediate double" with diameters of 1½-2¼ inches, and "blowout" with diameters more than 2¼ inches. Single-centered onions are classed as a "bullet". Onions are considered functionally single centered for processing if they are a "bullet" or "small double."

Table 1. Overwintering onion varieties planted on August 31, 2005.

Company	Variety
A. Takii	Hi Keeper
	T-420
	T-440
Bejo	Electric
	Olympic
	Stansa
Sakata	XON-533Y

Results

The fall of 2005 had fewer growing degree days than normal and onion growth was poor. The field had poor stand because the seedlings were uprooted by frost heaving. The variety trial had very poor stand due to Roundup® herbicide injury caused by an earlier emergence date for the variety trial compared to the rest of the field. The low plant stand resulted in too few plots being available for reliable data to be obtained.

ONION PRODUCTION FROM TRANSPLANTS

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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, 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 greenhouses during the winter.

In order to make early onion production from transplants cost effective, we hypothesized that transplants might be produced by growing them outdoors in late summer at a high density and transplanting them either in the fall or in March. This trial tested seven varieties grown from overwintering transplants. This trial also tested two long-season varieties grown from transplants started in the winter in a greenhouse. In addition, a small number of 'Vaquero' transplants were grown from unheated "low tunnel" cold frames and these transplants were planted along with the other varieties.

Materials and Methods

The transplants were grown from seed in a field of Greenleaf silt loam during the fall and winter of 2005-2006. Onion seed of seven overwintering varieties was planted in plots four double rows wide and 27 ft long on August 29, 2005. Seed was planted in double rows spaced 3 inches apart at 21 seeds/ft of single row. 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. The field was furrow irrigated as necessary. Emergence started on September 6.

Repeated insecticide and herbicide applications were needed to control thrips and weeds. Poast® at 0.19 lb ai/acre was applied in 40 gal/acre of water on September 6. On September 8, the onions were sprayed with Malathion® at 1 lb ai/acre. On September 13, the onions were sprayed with Prowl® at 1.5 lb ai/acre and Warrior® at 0.03 lb ai/acre. On September 22 and September 30, the onions were sprayed with a tank mix of Warrior at 0.03 lb ai/acre and Malathion at 1 lb ai/acre. On October 10, Buctril® at 0.12 lb ai/acre and Select® at 0.25 lb ai/acre were applied to control weeds. On October 18, 50 lb N/acre were applied as water run uran. Due to unusually wet weather during the fall of 2005, fall transplanting was not possible.

Onion seed of long day varieties Vaquero and 'Ranchero' (Nunhems, Parma, ID) was planted in flats with a vacuum seeder at 72 seeds/flat on January 17, 2006. The seed was sowed on a 1-inch layer of Sunshine® (Sun Gro Horticulture, Canada, LTD) 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. The onion seedlings were grown in a heated greenhouse (65°F day, 45°F night air temperatures) until transplanting.

On April 11 and 12 the field- and greenhouse-grown seedlings were transplanted to a field of Nyssa-Malheur silt loam, 3 weeks later than planned. The seedlings were manually dug and 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 variety were 20 ft long by four double rows wide arranged in a randomized complete block design with five replicates. A limited number of Vaquero transplants grown by Bob Simerly in an unheated low tunnel cold frame were transplanted on April 17 into one plot.

The field was drip irrigated using drip tapes buried at 4-inch depth between the double onion rows. Thereafter the trial was irrigated when the soil water tension at 8-inch depth reached 20 cb (1 cb = 1 kPa). Soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed below the onion row at 8-inch depth.

Weeds were controlled with an application of Prowl at 1 lb ai/acre on April 14, and Goal® at 0.2 lb ai/acre, Buctril at 0.3 lb ai/acre, and Select at 0.25 lb ai/acre on May 30. The field had 50 lb N/acre injected through the drip system as urea ammonium nitrate solution on April 17 and May 2, and 25 lb N/acre injected on June 2. The field was sprayed with Aza-Direct® at 0.025 lb ai/acre and Success® at 0.19 lb ai/acre on June 1 and June 9.

On July 19, August 3, and August 30, 6.5 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), 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.

Ten randomly chosen bulbs from every plot of the seven highest yielding varieties from the July 19 harvest were shipped on July 20 via UPS ground to Vidalia Labs International in Collins, Georgia. The bulb samples were analyzed for pyruvic acid content on August 3. Bulb pyruvic acid content is a measure of pungency with the unit being micro mols pyruvic acid per gram of fresh weight. Onion bulbs having a pyruvate concentration of 5.5 micromols or less are considered sweet according to Vidalia Labs sweet onion certification specifications.

Onion bulbs from all harvests were rated for single centers. Twenty-five consecutive 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 double" had diameters less than 1½ inch, "intermediate double" had diameters from 1½ to 2¼ inches, and "blowout" had diameters over 2¼ inches. Single-centered onions were classed as a "bullet". Onions were considered "functionally single centered" for processing if they were a "bullet" or "small double".

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

Results and Discussion

Field-grown onions for transplants grew poorly in the fall of 2005, possibly due to cool weather in October. It was our intention to transplant onions in October of 2005 as well as March of 2006, but poor onion plant growth and rainy weather in October of 2005 did not allow field operations or fall transplanting. The weather in the spring was initially cooler than average in March and April, but was warmer than average in May and June. March had 61 percent fewer and April had 14 percent fewer growing degree days (50 to 86°F) than the 19-year average.

July 19 harvest

The overwintering varieties, grown from overwintering transplants, matured early, with most varieties being close to full maturity on July 19. Varieties 'Electric', 'Stanza', and 'XON-533Y' were less mature, but had ceased leaf growth by July 19 and were harvested along with the other overwintering varieties. Of the overwintering varieties, Stanza, Electric, and XON-533Y had among the highest total yield and jumbo bulb yield (Table 1).

The long-season varieties, grown from greenhouse transplants, had substantially higher total, colossal, and jumbo onion yields than the overwintering varieties. The long-season varieties showed vigorous leaf and bulb growth through the last harvest on August 30.

Varieties 'Olympic', XON-533Y, and Ranchero had pyruvate concentration low enough (5.5 or less) to be considered "sweet" according to Vidalia Labs sweet onion certification specifications (Table 3). Vaquero and Ranchero had the highest percentage of 'bullet' single-centered bulbs and functionally single-centered bulbs.

August 3 and August 30 harvests

Colossal onion yield for Vaquero and Ranchero was about double on August 3 compared to July 19 (Table 1, Fig. 1). Colossal onion yield more than doubled between August 3 and August 30. Vaquero yielded 59 cwt/acre and Ranchero yielded 87 cwt/acre of supercolossal onions on August 30. Vaquero had a higher percentage of bullet single-centered bulbs than Ranchero on August 30. Both varieties had higher than 70 percent bullet single-centered bulbs on all three harvest dates.

The low tunnel cold frame transplants of Vaquero had substantially lower yield and size than the heated greenhouse transplants on all harvest dates, but had similar single centeredness (Tables 2 and 4). Statistical comparisons were not possible since this treatment was not replicated.

References

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.

Table 1. Performance data for experimental and commercial onion varieties produced from field grown and greenhouse grown transplants from three harvest dates, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Total yield	Marketable yield by grade					Bulb counts			Maturity	Bolters
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	>4¼ in	No. 2s	Small		
		cwt/acre						#/50 lb	- cwt/acre -		%	#/plot
July 19												
A. Takii	Hi Keeper	208.6	11.3	0.0	0.0	0.0	11.3	-	0.0	197.3	80.0	0.0
	T-420	208.0	9.2	0.0	0.0	0.0	9.2	-	0.0	198.8	86.0	0.0
	T-440	145.0	1.1	0.0	0.0	0.0	1.1	-	0.0	144.0	86.0	0.0
Bejo	Electric	523.0	306.8	0.0	0.0	54.8	252.0	-	1.1	216.3	9.0	0.0
	Olympic	192.3	6.4	0.0	0.0	0.0	6.4	-	0.0	185.9	66.0	0.0
	Stansa	642.9	426.6	0.0	0.0	36.1	390.4	-	0.3	216.3	22.0	0.0
Sakata	XON-533Y	453.9	298.5	0.0	0.0	72.3	226.2	-	3.8	155.4	7.5	0.0
Nunhems	Vaquero	617.7	611.8	0.0	73.1	473.1	65.6	-	0.0	5.9	0.0	0.0
	Ranchero	579.8	560.5	0.0	42.5	439.4	78.7	-	0.0	19.3	0.0	0.0
LSD (0.05)		116.7	140.4	-	32.6	91.1	108.0		NS	52.0	7.5	-
August 3												
Nunhems	Vaquero	754.6	751.1	0.0	122.1	597.9	31.0	-	7.4	3.5	10.0	0.0
	Ranchero	693.3	690.5	0.0	132.7	514.6	43.2	-	4.8	2.8	10.0	0.0
LSD (0.05)		NS	NS	-	NS	NS	NS		NS	NS	NS	
August 30												
Nunhems	Vaquero	960.3	945.2	59.3	381.4	474.2	30.4	28.7	0.0	15.1	50.0	13.5
	Ranchero	957.5	944.0	87.3	351.8	477.9	27.0	26.4	8.6	13.5	50.0	17.1
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Performance data for 'Vaquero' onions produced from transplants grown in a heated greenhouse and in an unheated low tunnel cold frame from three harvest dates, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Total yield	Marketable yield by grade					Bulb counts			Maturity	Bolters
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	>4¼ in	No. 2s	Small		
		---------- cwt/acre ----------						#/50 lb	- cwt/acre -		%	#/plot
					July 19							
Nunhems	Vaquero	617.7	611.8	0.0	73.1	473.1	65.6	-	0.0	5.9	0.0	0.0
	Vaquero[a]	376.4	333.7	0.0	0.0	191.0	142.7		0.0	42.7	0.0	0.0
					August 3							
Nunhems	Vaquero	754.6	751.1	0.0	122.1	597.9	31.0	-	7.4	3.5	10.0	0.0
	Vaquero[a]	412.3	398.2	0.0	0.0	335.3	62.9			14.1	10.0	0.0
					August 30							
Nunhems	Vaquero	960.3	945.2	59.3	381.4	474.2	30.4	28.7	0.0	15.1	50.0	13.5
	Vaquero[a]	573.8	523.9	0.0	0.0	449.1	74.8		0.0	49.9	50.0	0.0

[a]Transplants grown in a low tunnel cold frame, unreplicated data.

Table 3. Pyruvate concentrations and multiple center rating for selected onion varieties produced from field grown and greenhouse grown transplants from three harvest dates, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Multiple center				Functionally single centered[a]	Pyruvate concentration
		Blowout	Intermediate double	Small double	Bullet		
		---------- % ----------					µmoles/g FW
			July 19				
A. Takii	Hi Keeper	na[b]	na	na	na	na	
	T-420	na	na	na	na	na	6.2
	T-440	na	na	na	na	na	6.1
Bejo	Electric	83.2	12.8	4.0	0.0	4.0	
	Olympic	na	na	na	na	na	5.0
	Stansa	81.0	11.1	7.1	0.8	7.9	5.8
Sakata	XON-533Y	79.0	8.0	10.0	3.0	13.0	4.9
Nunhems	Vaquero	1.3	2.7	4.0	92.0	96.0	5.6
	Ranchero	0.0	1.6	13.6	84.8	98.4	5.4
LSD (0.05)		18.1	NS	NS	9.7	13.6	NS
			August 3				
Nunhems	Vaquero	1.3	8.0	10.7	80.0	91.0	
	Ranchero	0.8	7.2	15.2	76.8	92.0	
LSD (0.05)		NS	NS	NS	NS	NS	
			August 30				
Nunhems	Vaquero	0.0	4.0	1.3	94.7	96.0	
	Ranchero	0.0	7.0	5.0	88.0	93.0	
LSD (0.05)		NS	NS	NS	5.0	NS	

[a]Bullet + small double.
[b]Not available, because none of the bulbs had adequate size to evaluate for single centers.

Table 4. Multiple center rating for 'Vaquero' onions produced from transplants grown in a heated greenhouse and in an unheated low tunnel cold frame from three harvest dates, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Multiple center				Functionally
		Blowout	Intermediate double	Small double	Bullet	single centered[a]
		%				
		July 19				
Nunhems	Vaquero	1.3	2.7	4.0	92.0	96.0
	Vaquero[b]	0.0	0.0	0.0	100.0	100.0
		August 3				
Nunhems	Vaquero	1.3	8.0	10.7	80.0	91.0
	Vaquero[b]	0.0	8.0	8.0	84.0	92.0
		August 30				
Nunhems	Vaquero	0.0	4.0	1.3	94.7	96.0
	Vaquero[b]	0.0	0.0	16.0	84.0	100.0

[a]Bullet + small double.
[b]Transplants grown in a low tunnel cold frame, unreplicated data.

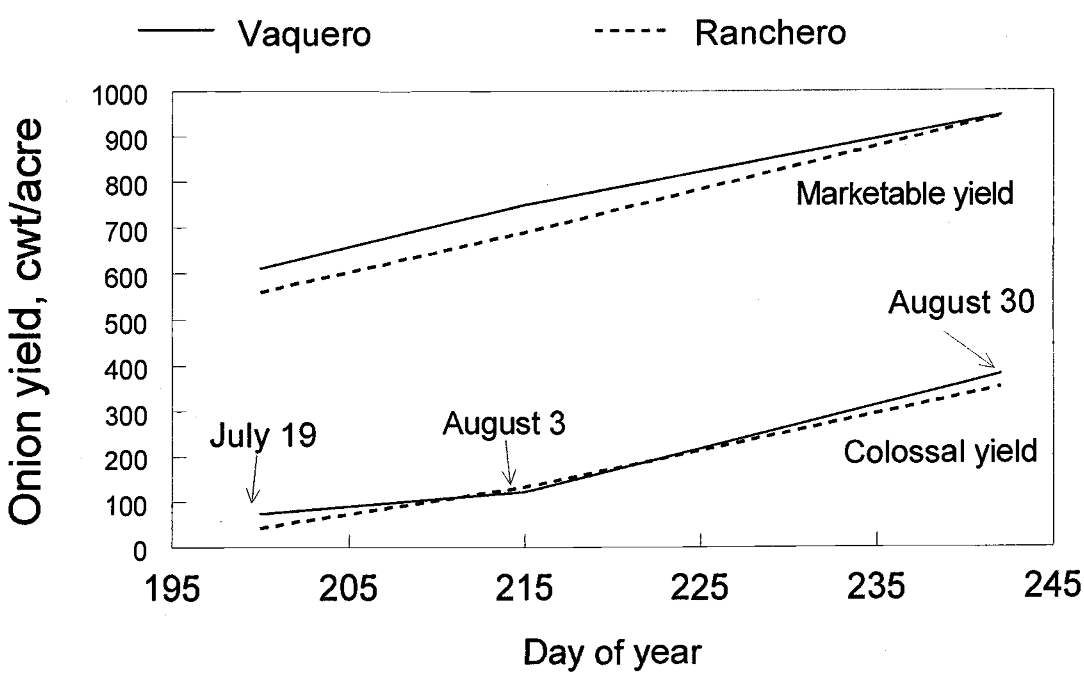

Figure 1. Onion yield at three harvests for two varieties grown from heated greenhouse transplants. Malheur Experiment Station, Oregon State University, Ontario, OR.

EVALUATION OF PRIMED ONION SEED

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Introduction

The objective of this trial was to evaluate the performance of onion variety 'Vaquero' in response to three types of seed pelleting: conventional pellet, primed and pelleted seed, and a modified pellet.

Methods

The onions were grown on a Owyhee silt loam previously planted to wheat. The experimental design was a randomized complete block with five replicates. The three treatments were a conventional pellet, a 118 pellet, and primed seed with a conventional pellet. Primed seed are seed treated to shorten the time from planting to seedling emergence. The 118 pellet is a new pellet formulation that produces a more uniform pellet. Onion seed ('Vaquero', Nunhems, Parma, ID) was planted in double rows spaced 3 inches apart at 9 seeds/ft of single row (427,680 seeds/acre) on March 23. 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. 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 24. On April 12, emerged seedlings in 10 ft of row in each plot were counted. From May 17 through May 19, 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 trial was conducted in the same field as the 2006 onion variety trial. All other procedures can be found in this report for the 2006 onion variety trial (Shock et al. 2007).

Results

On April 12, the conventional pelleted seed had just started emerging (0.4 percent of full stand of 427,680 seeds/acre) and the primed seed emergence was approximately 27 percent of full stand (Table 1). On April 12, there were statistically significant differences in stand count between the primed seed, the conventional pellet, and the 118 pellet. The primed seed had the highest stand count and the conventional pellet had the lowest stand count. The primed seed had a higher plant population than the 118 pellet and the conventional pellet.

There was no significant difference in onion single centeredness, yield, or grade between the seed treatments (Tables 2 and 3).

Soil moisture was probably not limiting for onion germination and emergence, because significant precipitation occurred before and after the seed was planted. Primed seed could be advantageous when soil moisture is marginal during germination and emergence, because primed seed can emerge before soil moisture becomes too low.

Under limited soil moisture, primed seed could result in higher onion stands and higher onion yield. In this trial, conditions were not limiting for onion emergence. In addition, the onions in all plots were thinned to the same stand, eliminating most yield differences that could have resulted from the seed treatments.

References

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

Table 1. Stand counts and plant population on April 12, 2006 for three onion seed treatments. Onion seed was planted on March 23 at 180 seeds/10 ft of double row (427,680 seeds/acre). Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Preliminary stand counts	Preliminary plant population
	plants/10 ft of double row	plants/acre
Regular pellet	0.8	1,980
Primed, pelleted	48.5	115,236
118 pellet	15.0	35,640
LSD (0.05)	14.2	33,674

Table 2. Onion multiple-center rating in response to three onion seed treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Multiple-center bulbs			Single-center bulbs	
	Blowout	Intermediate double	Small double	Functional	Bullet
	------------------------------ % ------------------------------				
Regular pellet	6.4	16.8	20.0	76.8	56.8
Primed	7.2	7.2	28.0	85.6	57.6
118 pellet	5.6	6.4	19.2	88.0	68.8
LSD (0.05)	NS	NS	NS	NS	NS

Table 3. Performance data for onions graded out of storage in January 2007 in response to three onion seed treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Total yield	Marketable yield by grade					Bulb counts >4¼ in	Total rot	Non-marketable yield		Maturity on Sept. 7
		Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in			No. 2s	Small	
	--- cwt/acre ---	---------- cwt/acre ----------					#/50 lb	%	-- cwt/acre --		%
Regular pellet	643.8	595.4	2.1	52.3	509.3	31.8	25.2	5.8	3.8	7.2	64.0
Primed, pelleted	606.6	568.4	0.0	47.3	479.4	41.8		4.4	2.5	11.4	67.0
118 pellet	664.5	621.0	3.9	66.5	516.4	34.2	26.7	4.5	1.8	9.5	67.0
LSD (0.05)	NS [a]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] Seed treatments did not affect final plant stands, since onions were hand-thinned.

INSECTICIDE EFFICACY TRIAL FOR THRIPS CONTROL IN DRY BULB ONIONS

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Introduction

Controlling thrips (onion and western flower) 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 (Fig. 1). The objective of this trial was to screen registered and nonregistered insecticides to find those that have potential for use in thrips insecticide control programs. **Many of these products are not registered for use in onions and growers should always read the insecticide label to ensure a product is registered.**

Materials and Methods

A 2 acre field, soil type Owyhee silt loam, was planted with the onion variety 'Vaquero' (Nunhems, Parma, ID) on March 24, 2006. The onions were planted as two double rows on a 44-inch bed. The double rows were spaced 2 inches apart at the seeding rate of 137,000 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. Planting conditions were less than ideal, with the onions planted under high soil moisture, leading to soil compaction and low water infiltration during the growing season. Water was applied by furrow irrigation.

Treatments were made using a CO_2-pressurized plot sprayer with four nozzles spaced 19 inches apart. It was set to apply 36.8 gal/acre, with water as the carrier. A silicone surfactant was added to all treatments except the dolomite dust, and Carzol®, Lorsban, acephate, and Thiodan® were buffered to pH 6.0. Treatments were applied on a weekly basis beginning on June 9. 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.

Results and Discussion

There were significant differences between treatments during all weeks except the July 25 and August 2 evaluations (Table 2). The season totals for each treatment are shown in Figure 2. The most effective products tested were acephate, Carzol, Thiodan, Success®, and AgriMek. Only Success is currently registered, although Carzol had a Section 18 (U.S. Environmental Protection Agency) emergency label in 2006. AgriMek is a new chemistry for onion thrips control and may fit into a good management program if it becomes registered. The grower standard consisted of Warrior® in combination with either Lannate, MSR®, or Diazinon®.

Table 1. Insecticide treatments evaluated in the onion thrips efficacy trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Rates
Delta Gold & Interlock	2.4 oz + 4.0 oz
Delta Gold & Preference	2.4 oz + 2.0 pt/100 gal
Carzol	12.0 oz
BotaniGard	2.0 qt
Success	10.0 oz
Success alternated weekly w/ BotaniGard	10.0 oz – 2.0 qt
Success & Vegetable Oil	10.0 oz + 40 oz/100gal
BotaniGard and Prev Am	2.0 qt + 12 oz/100 gal
Lorsban (initial application) Growers Standard	1.0 qt
Warrior & Penncap M (rotated weekly)	3.84 oz + 1.0 qt
Warrior & Lannate	3.84 oz + 3.0 pt
Acephate	1.33 lb
Grower Standard	
UTC	
Aloe Vera	1.0 oz
AgriMek	16.0 oz
Thiodan	1.0 qt
Dolomite	20.0 lb

Table 2 a-b. Weekly average thrips populations for various insecticide treatments by month, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	8 Jun	13 Jun	15 Jun	21 Jun	27 Jun
Delta Gold + Interface	25.9	29.8	30.1	35.6	72.8
Delta Gold + Preference	32.4	35.1	27.7	37.4	71.3
Carzol	29.8	16.0	18.6	16.0	42.9
BotaniGard	28.0	31.9	29.0	51.4	65.5
Success	30.1	25.9	20.5	24	46.3
Success alt BotaniGard	27.7	28.4	26.9	29.6	61.2
Success + Vegetable oil	23.7	18.9	19.0	20.6	47.7
Prev Am + BotaniGard	26.4	25.8	32.8	42.9	66.4
Lorsban + Standard	29.2	32.6	26.3	26.1	66.5
Acephate	14.6	17.6	13.1	7.7	21.2
Grower standard	27.4	27.2	23.3	34.1	49.2
Untreated check	26.5	38.9	29.6	40.1	59.3
Aloe Vera	35.9	32.9	31.4	37.1	41.6
AgriMek	21.0	19.1	23.9	20.1	43.1
Thiodan	29.1	32.8	22.1	17.6	16.4
Dolomite	30.8	31.4	28.4	27.6	41.8
LSD (0.05)	10.0	9.1	7.3	9.0	23.5

Table 2b.

Treatment	3 Jul	6 Jul	13 Jul	21 Jul	25 Jul	2 Aug	Season average
Delta Gold + Interface	31.4	23.5	26.1	26.2	15.3	11.9	29.8
Delta Gold + Preference	32.2	30.4	23.1	11.8	11.4	10.4	29.4
Carzol	16.9	11.6	13.7	11.5	12.9	9.3	18.1
BotaniGard	30.1	25.1	20.5	13.9	15.9	10.4	29.2
Success	17.7	11.7	14.5	10.0	12.7	11.0	20.4
Success alt BotaniGard	16.7	17.5	14.1	9.5	13.4	11.8	23.3
Success + Vegetable oil	19.9	11.0	15.0	8.6	13.6	11.1	19.0
Prev Am + BotaniGard	30.8	28.3	18.1	11.7	13.2	11.0	27.9
Lorsban + Standard	26.3	16.8	14.6	9.9	12.1	12.1	24.8
Acephate	18.6	9.1	16.2	10.2	13.5	12.9	14.1
Grower standard	26.3	19.1	22.4	14.0	12.1	12.4	24.3
Untreated check	21.3	25.6	21.3	12.3	13.9	13.3	27.4
Aloe Vera	27.5	26.3	16.8	12.3	13.4	11.0	26.0
AgriMek	20.8	15.2	15.1	9.9	13.8	11.3	19.4
Thiodan	16.7	11.7	11.0	9.6	11.4	12.7	17.4
Dolomite	21.4	26.9	18.1	10.4	11.8	11.0	23.6
LSD (0.05)	8.8	6.3	5.4	3.8	NS	NS	3.5

Several biological insecticides were tried to determine if they would be effective including BotaniGard (Bt), aloe vera extract, and dolomite clay. None of the products gave acceptable thrips control under field conditions.

Lorsban applied early, and then a grower standard applied for the rest of the season, were no better than the grower standard. Neither program was very effective.

The synthetic pyrethroid Delta Gold™ had no effect on thrips control. This ineffectiveness is probably not related to Delta Gold, but to all synthetic pyrethroid insecticides. **Based on this trial, plus other experiences, it is recommended that growers not use synthetic pyrethroids in their spray programs for a period of 1-3 years unless they have been performing well on their farm. Keeping the synthetic pyrethroids out of the spray program for a few years may allow the nonresistant thrips population to rebuild and give some measure of control in future years.**

Conclusions

Synthetic pyrethroid insecticides are ineffective. The soft insecticides BotaniGard®, aloe vera, and dolomite clay were not effective.

Several insecticides not yet registered for use on onions were effective, including Carzol, acephate, endosulfan, and AgriMek. Success was also effective.

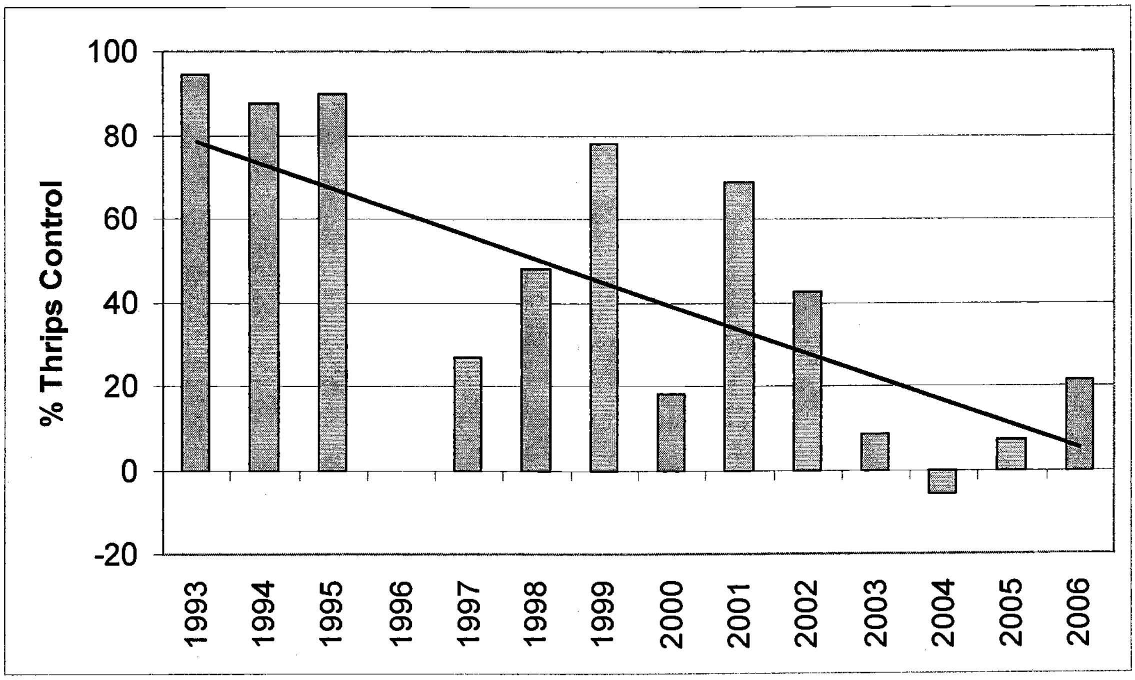

Figure 1. Percent thrips control in onions with a synthetic pyrethroid 7 days after treatment, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

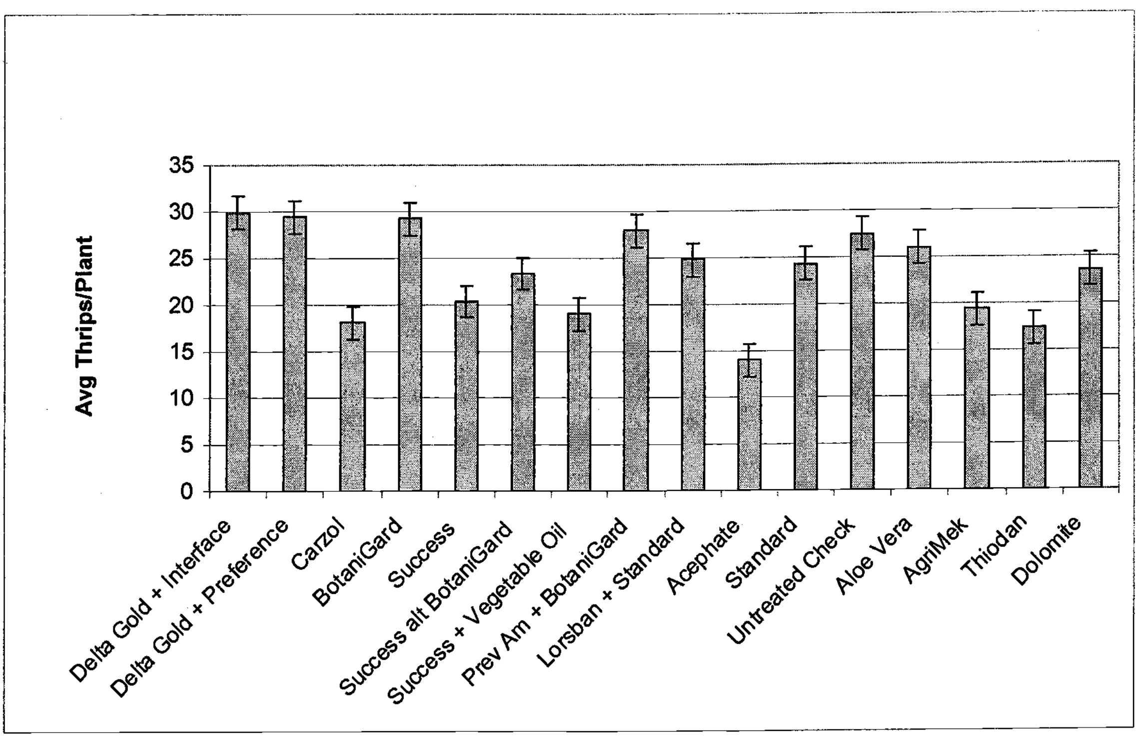

Figure 2. Season-long thrips populations with different insecticide treatments in onions, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

MANAGING CARZOL® FOR MAXIMUM EFFICACY AGAINST THRIPS

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Objective

Determine the most effective combinations of insecticides to use with Carzol® to provide season-long thrips control in onions and reduce the risk of resistance development.

Introduction

Oregon State University (OSU) trials in 2005 showed that Carzol (formetanate hydrochloride) was effective in controlling thrips and reducing iris yellow spot virus (IYSV) incidence. The U.S. Environmental Protection Agency (EPA) granted several states a Section 18 emergency registration for Carzol use on onions for the 2006 production year, but at a lower rate than was considered effective.

Materials and Methods

Two trials were established at the OSU Malheur Experiment Station using standard production practices, one to look at the effectiveness of Carzol applied at different rates and spray intervals, and the other trial tested the most effective insecticides to rotate with Carzol in a complete thrips control program. The Carzol spray interval trial consisted of Carzol rates of 8, 12, 16, and 20 oz/acre, with application intervals of 1, 2, 3, and 4 weeks. All Carzol, MSR®, Lannate®, and Penncap-M® applications were buffered to pH 6.0 and a silicon adjuvant added to all insecticide treatments. The Carzol rotation trial consisted of 16 treatments of Carzol rotated with other insecticides (Table 1).

Insecticide applications were made using a CO_2-pressurized backpack sprayer with water volume set at 38 gal/acre. Each treatment was replicated four times. Insecticide treatments were made on a weekly basis during June and July. Thrips counts were made weekly by visually counting the total number of thrips on 15 plants. Iris yellow spot virus severity was evaluated in August. Yield and grade information was completed in late September. The onion variety was 'Vaquero' (Nunhems, Parma, ID) and the seeding rate was 134,000 seeds/acre.

Table 1. Insecticide treatment rotated with Carzol to increase the effectiveness of a season-long program, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
A	Warrior+ MSR	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate
B	Skip	Skip	Skip	Carzol 20 oz	Skip	Skip	Carzol + Lannate	Skip
C	Warrior	Warrior+ MSR	Lannate	Success+ AzaDirect	Carzol 20 oz	MSR+ Diazinon	Skip	Skip
D	Success+ AzaDirect	Success+ AzaDirect	Carzol 12 oz	Skip	Skip	Carzol 12 oz	Skip	Skip
E	Warrior	Warrior	Carzol 12 oz	Warrior+ Lannate	Carzol 12 oz	Warrior+ Lannate	Skip	Skip
F	Warrior	MSR+ Penncap	Carzol 12 oz	MSR+ AzaDirect	Carzol 12 oz	MSR+ Penncap	Skip	Skip
G	Success+ Aza Direct	Skip	Carzol 12 oz	Success+ AzaDirect	Skip	Carzol 12 oz	Skip	Skip
H	Skip	Skip	Carzol 12 oz	Skip	Skip	Carzol 12 oz	Skip	Skip
I	Warrior+ Penncap-M	Warrior+ MSR	Warrior+ Lannate	Warrior+ Diazinon	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Diazinon	Warrior+ Lannate
J	Warrior	Skip	Carzol 12 oz	Success+ AzaDirect	Skip	Carzol 12 oz	Skip	Skip
K	Warrior	Skip	Lannate	Skip	Skip	Lannate	Skip	Skip
L	Warrior	Skip	Carzol 12 oz	MSR+ Diazinon	Skip	Carzol 12 oz	Skip	Skip
M	MSR+ AzaDirect	MSR+ AzaDirect	Carzol 12 oz	Skip	Skip	Carzol 12 oz	Skip	Skip
N	MSR+ AzaDirect	Warrior	Carzol 12 oz	Skip	Skip	Carzol 12 oz	Skip	Skip
O	Warrior	Warrior+ MSR	Warrior+ Lannate	Warrior+ Diazinon	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Diazinon	Warrior+ Lannate
P	UTC[a]	UTC	UTC	UTC	UTC	UTC	UTC	UTC

[a]UTC=Untreated check

Results

Carzol spray interval trial

Thrips control with Carzol was best at the 16-oz and 20-oz rates with a 7-day spray interval (Fig. 1). All of the Carzol rates were more effective when applied at weekly intervals rather than a longer interval. When the spray intervals and application rates (Fig. 2) were combined, there were no significant differences in thrips control due to Carzol application rates, but there were significant differences in thrips control due to spray intervals, with weekly applications significantly better than extended intervals (Fig. 3). There were no significant differences in total yield between any of the treatments; however, there were significant differences in colossal- and supercolossal-sized bulb (>4 inches) yield with different treatments (Fig. 4). The colossal and supercolossal yield was related to thrips populations with yields declining when thrips populations increased. Weekly application intervals gave significantly higher colossal and super-colossal bulb yield (Fig. 5) and significantly lower disease incidence (Fig. 6).

Carzol rotation trial

Weekly applications of only one insecticide are not a sustainable approach to thrips control, because resistance would quickly become a major issue. A number of insecticides were evaluated in a rotation sequence. Growers typically like to use a mix of at least two insecticides in an attempt to control thrips and to try to rotate insecticide classes. Sixteen rotation sequences (Table 1) were evaluated for thrips control, IYSV control, and effect on yield and quality. The five best rotations are listed in Table 2 and are labeled A-E.

Table 2. Five best insecticide treatments for a season-long program in onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
A	Warrior + MSR	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate	Warrior+ Lannate
B	Skip	Skip	Skip	Carzol 20 oz	Skip	Skip	Carzol Lannate	Skip
C	Warrior	Warrior+ MSR	Lannate	Success+ AzaDirect	Carzol 20 oz	MSR+ Diazinon	Skip	Skip
D	Success + Aza Direct	Success+ AzaDirect	Carzol 12 oz	Skip	Skip	Carzol 12 oz	Skip	Skip
E	Warrior	Warrior	Carzol 12 oz	Warrior+ Lannate	Carzol 12 oz	Warrior+ Lannate	Skip	Skip

These rotation sequences are shown graphically in Figure 7. Rotation A is similar to the Carzol treatments in the previous trial and is not a sustainable program. Rotations C and D offer a good mix of insecticide chemistries and should give growers a sound approach to minimizing insecticide resistance.

Conclusion

The highest rates of Carzol (16 or 20 oz) were most effective. Weekly applications were more effective than 2-, 3-, or 4-week application intervals.

Weekly applications of Carzol or a Lannate + Warrior mix increased the yield of large-sized bulbs. Success, Aza Direct, Carzol, and Lannate offer different kinds of insecticide chemistries that can help minimize thrips resistance to insecticides.

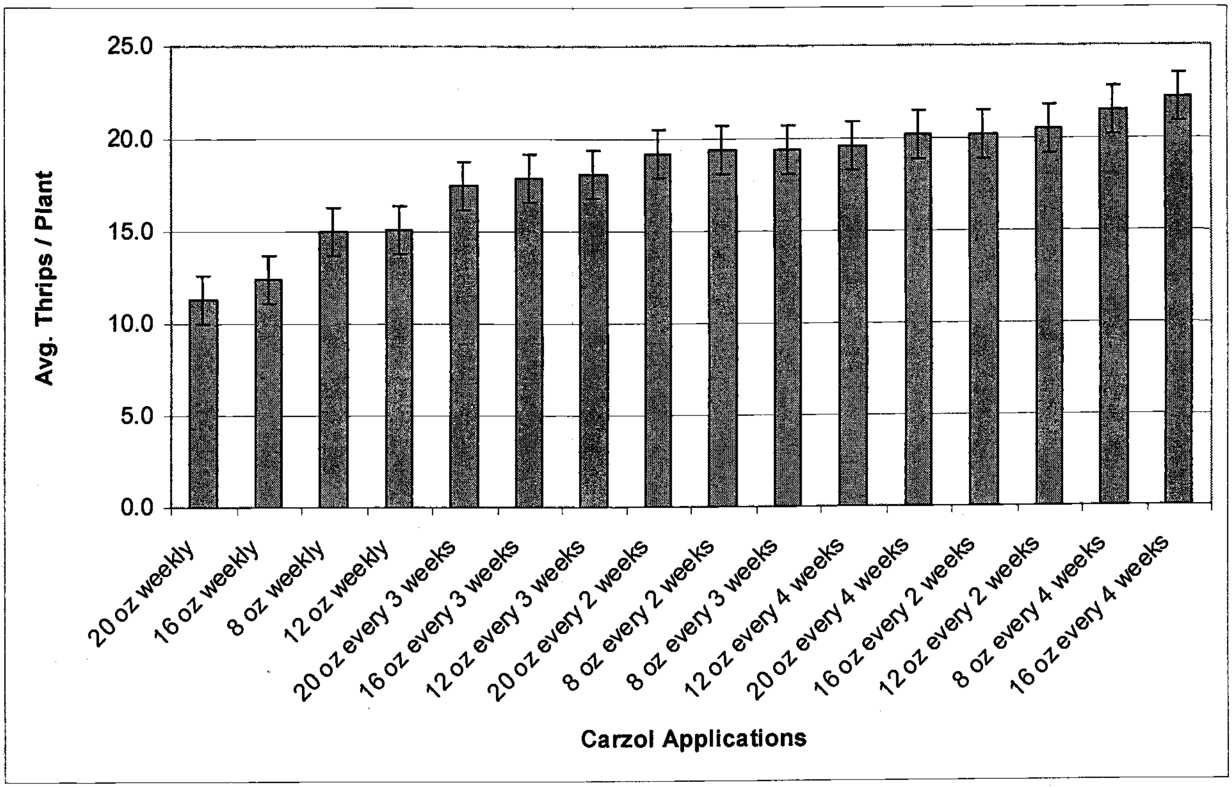

Figure 1. Average thrips season-long populations in onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

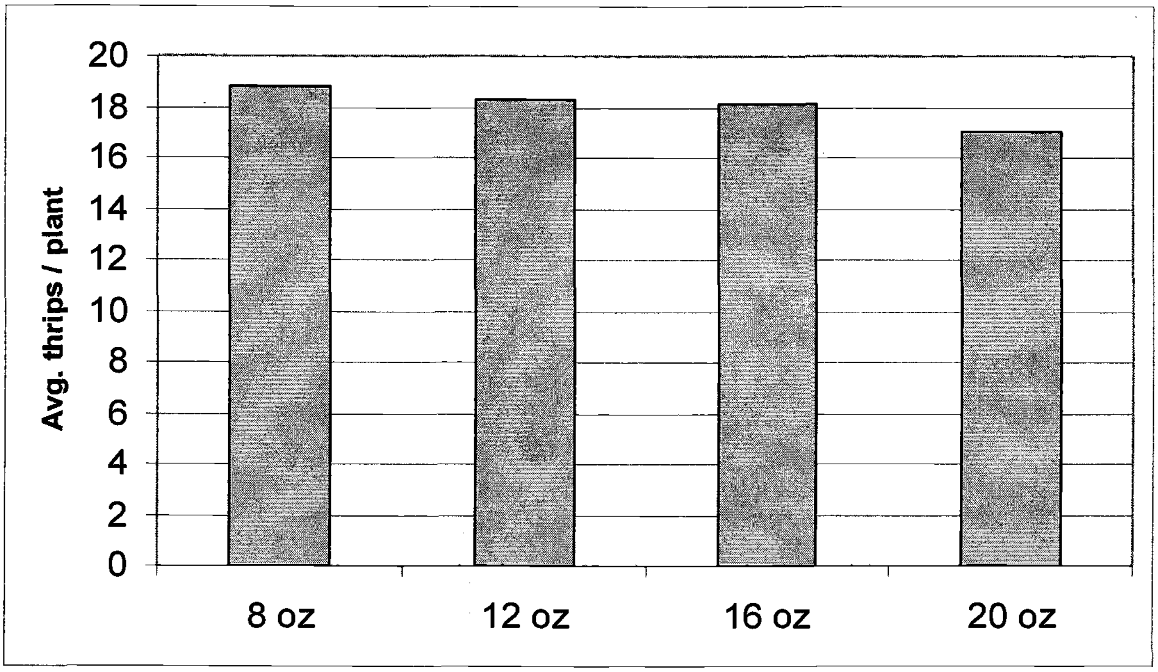

Figure 2. Effect of different Carzol rates on thrips populations in onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

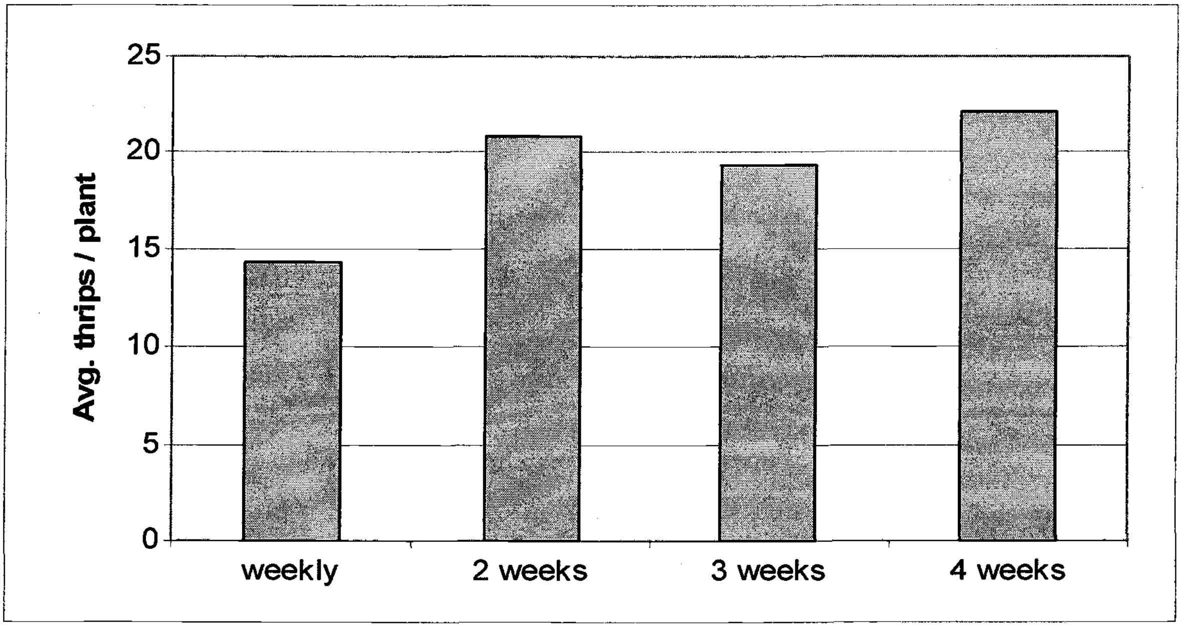

Figure 3. Thrips population vs. application interval. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

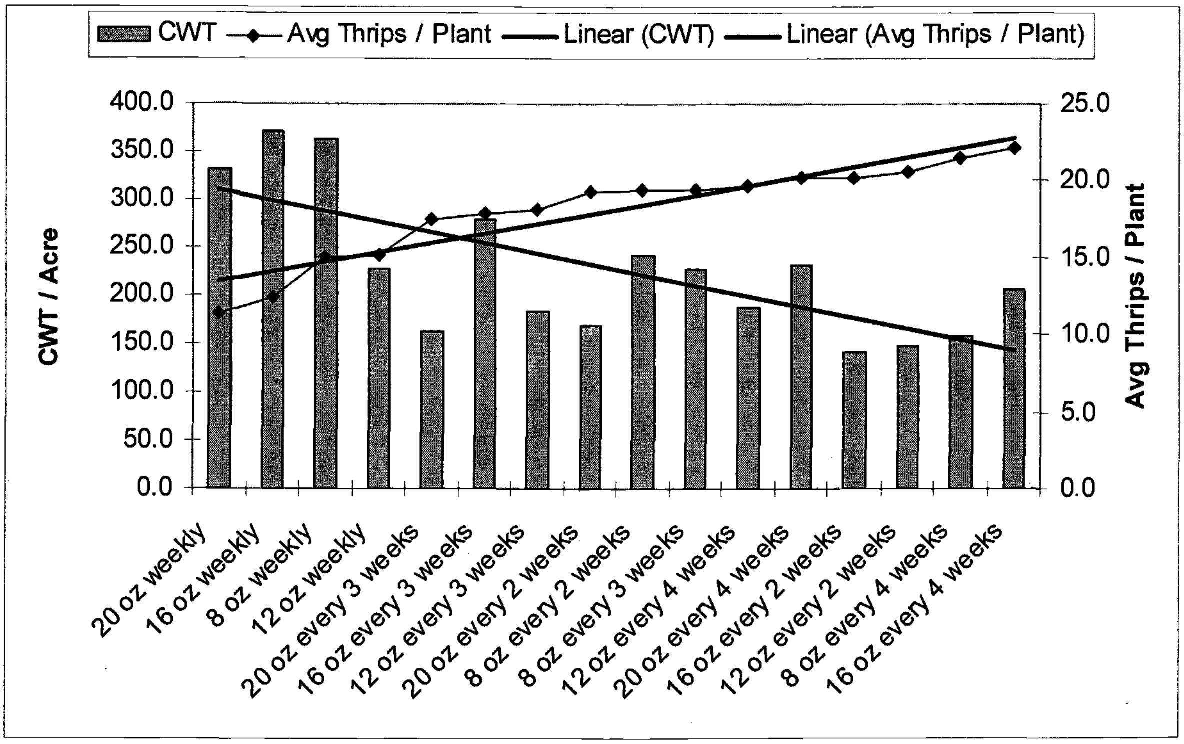

Figure 4. Colossal and supercolossal onions vs. average thrips population, Carzol residual trial. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

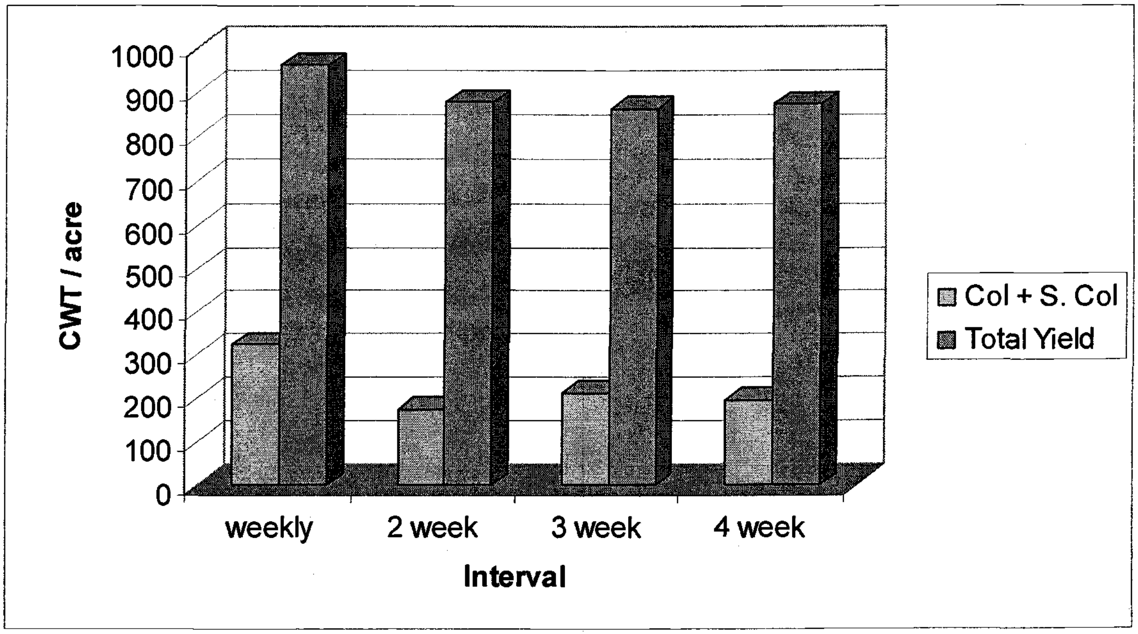

Figure 5. Application interval effects on onion yield. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

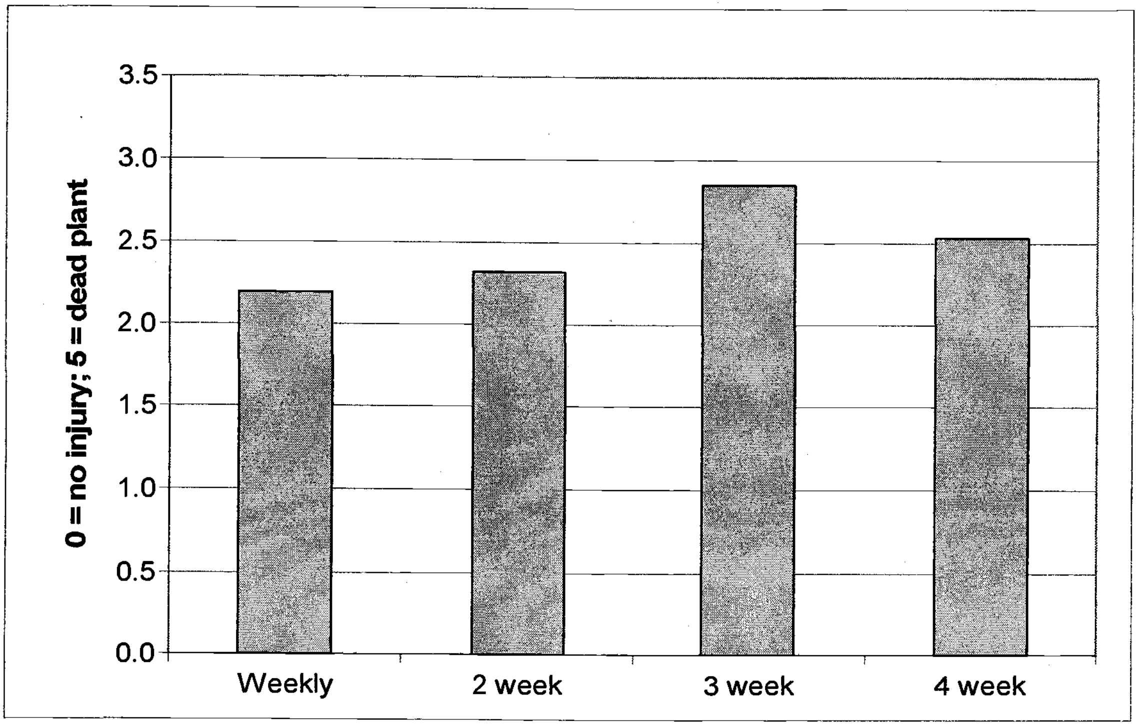

Figure 6. Iris yellow spot virus disease evaluation with different Carzol application intervals in onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

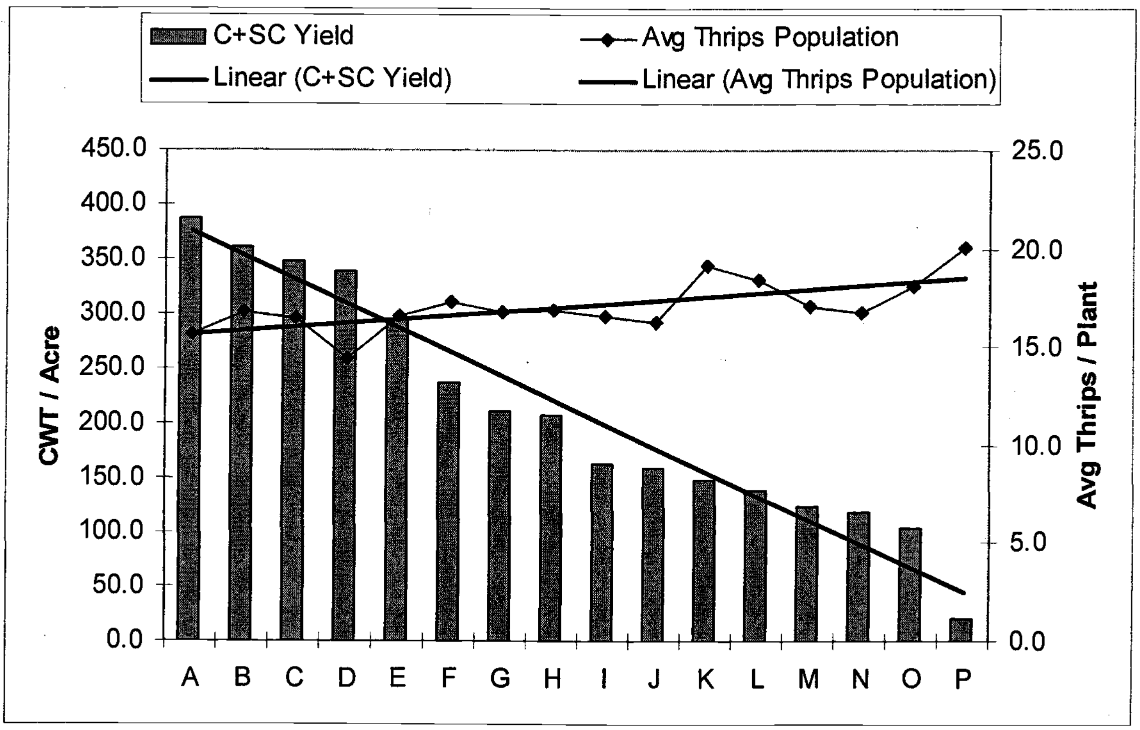

Figure 7. Colossal and supercolossal onion yield vs. average thrips population. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

EFFECTIVENESS OF REGENT® AS A SEED TREATMENT FOR EARLY SEASON THRIPS SUPPRESSION IN DRY BULB ONION

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Introduction

Seed treatments are commonly used for seedling protection from fungi such as those that cause damping off in onions. Some of the newer seed treatments used in other crops are designed to give control of insects, such as maggots or wireworm. One of these products is Regent® (fipronil). It appears to be effective on onion and seed corn maggot as well as wireworm. There have been suggestions that the product may also suppress early season thrips populations. This trial was designed to determine what level of thrips suppression might be expected.

Materials and Methods

A two-bed block was set aside to study the impact of Regent as a seed treatment. The onion variety 'Charismatic' (Seminis, Payette, ID) was treated with two rates of Regent, 0.5 and 1.0 oz/lb of seed. Regent insecticide was applied as a seed coating by Seminis, and planted on March 24 with two double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 137,000 seeds/acre. The soil type was an Owyhee silt loam and the crop was furrow irrigated.

The trial was a randomized complete block design with two rates of Regent plus an untreated check. No insecticide applications were made to the trial area other than Regent seed treatment. The thrips on 15 plants/plot were visually counted on a weekly basis.

Results and Discussion

Thrips populations for different treatments are shown in Table 1. Five weeks in June and early July showed significantly lower thrips populations in the Regent-treated plots as well as in the season average. All Regent-treated plots had lower thrips numbers until July 27, although not all weeks were statistically different. This information is shown graphically in Figure 1.

Jumbo, colossal plus supercolossal, and total yield were all higher with the seed treatments, but only total yield at the 1.0-oz rate (Table 2) was significantly different.

Conclusions

Regent, when used as a seed treatment, offers potential for early season thrips suppression. Because it is a different chemistry from any of the currently available insecticides, if registered, it will offer hope that growers will at last be able to mix insecticide chemistries enough to limit resistance development.

Table 1. Weekly thrips counts on onions grown from Regent-treated seed by month. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

June	1 Jun	6 Jun	14 Jun	20 Jun	29 Jun
Untreated	14.1	23.7	30.2	29.2	20.9
0.5 oz	3.6	8.9	17.5	15.5	17.4
1.0 oz	4.2	9.5	19.5	19.7	16.7
LSD (0.05)	5.9	11.5	8.3	NS	NS

July	3 Jul	11 Jul	17 Jul	21 Jul	24 Jul	27 Jul
Untreated	18.3	17.8	23.9	16.6	13.9	15.2
0.5 oz	9.9	10.4	19.6	13.7	12.5	16.1
1.0 oz	11.4	11.2	21.9	17.6	13.6	15.1
LSD (0.05)	3.8	3.1	NS	NS	NS	NS

August	3 Aug	7 Aug	Season average
Untreated	9.8	13.3	19.0
0.5 oz	8.2	10.7	12.6
1.0 oz	9.9	12.7	14.1
LSD (0.05)	NS	NS	2.6

Table 2. Effects on onion yield with Regent seed treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Medium	Jumbo	Colossal & super	Total yield
	------------------------------ cwt/acre ------------------------------			
Untreated	118.0	461.8	80.8	660.6
0.5 oz	84.1	562.9	110.9	757.8
1.0 oz	111.0	648.5	155.5	914.9
LSD (0.05)	NS	NS	NS	210.7

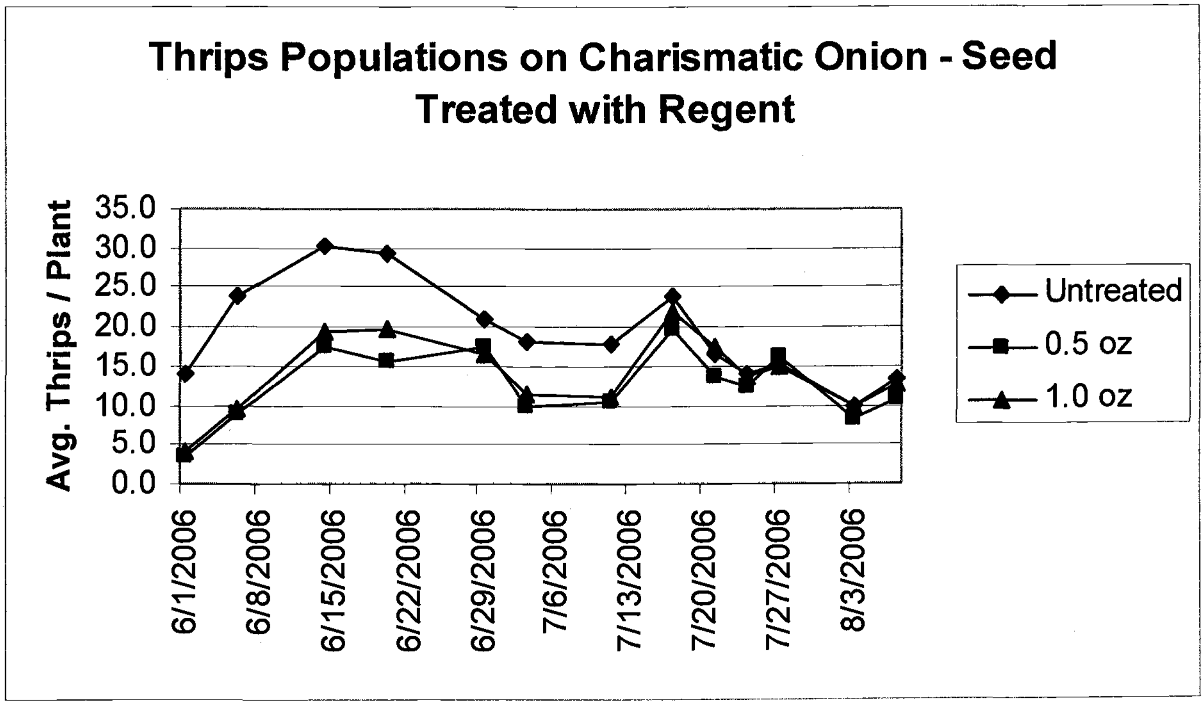

Figure 1. Thrips populations on 'Charismatic' onion seed treated with Regent. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

EFFECT OF NOZZLE TYPE, SPRAY PRESSURE, SPRAY VOLUME, AND TIME OF APPLICATION ON THRIPS CONTROL

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Introduction

Controlling thrips in onion is very difficult due to the thrips habit of completing much of its life cycle in the neck region of the onion, where it is difficult to place insecticide sprays. Also, new onion varieties have more foliage which makes spray coverage difficult. Couple these factors with thrips resistance to many of the registered insecticides and it is easy to see how difficult it is to get economic control. Any factor that increases control can give a grower a productive advantage. Spray manufacturers usually recommend either cone or double flat fan nozzles for insecticide applications and flat fan nozzles for herbicide applications. Both the cone and the double flat fan nozzle give better spay coverage than the flat fan.

Materials and Methods

A 2-acre field, soil type Owyhee silt loam, was planted with the onion variety 'Vaquero' (Nunhems, Parma, ID) on March 24, 2006. The onions were planted as two double rows on a 44-inch bed. The double rows were spaced 2 inches apart at the seeding rate of 137,000 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. Planting conditions were less than ideal, with the onions planted into wet soils, leading to soil compaction and low water infiltration during the growing season. Water was applied by furrow irrigation.

The trial area was divided into plots four rows (two beds) wide by 27 ft long. There were four replications of each treatment. Insecticide applications were made using a CO_2-pressurized plot sprayer on a weekly basis beginning on June 7 with Warrior® and MSR®. Warrior at 3.7 oz/acre and Lannate® at 3.0 pt/acre were applied on June 21 and evaluated 2 days later. The spray mixture was buffered to pH 6.0 and a silicone surfactant was added prior to application. Treatments included three nozzle types: twin flat spray tips, hollow cone spray tips, and flat fan tips; two spray pressures of 45 and 60 psi; two spray volumes of 30 and 60 gal/acre; and an early and mid-day application time for each, for a total of 24 treatments. Evaluations were made by counting the total number of thrips on 15 plants in each plot.

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

Results and Discussion

Only the June 21 application showed significant differences in thrips control. The early applications of Warrior and MSR were not effective in controlling thrips. Iris yellow spot virus symptoms showed in early July in this trial. The applications of Warrior and Lannate on June 21 and June 27 showed significant differences between treatments, but none of the July treatments showed differences, even when Carzol® was added. The June 23 evaluation showed clear differences in some of the treatments (Table 1). There was no difference in the time of day that the insecticide was applied, nor in the pressure used (45 vs. 60 psi). There were significant differences in spray volume and in nozzle type. The double flat fan nozzle gave the best control, followed by the cone nozzle. The flat fan gave the poorest control (Fig. 1).

The amount of water used in the spray mixture was also significantly different with the 60-gal rate being superior to the 30-gal rate (Fig. 2).

Table 1. Evaluations on June 23 of thrips control with different nozzle types, pressure, spray volume, and application time. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Average thrips/plant
Spray Pressure	
45 psi	46.5
60 psi	46.0
LSD (0.05)	NS
Application time	
Early morning	46.4
Early afternoon	46.4
LSD (0.05)	NS
Application amount	
30 gal/acre	50.4
60 gal/acre	42.4
LSD (0.05)	0.8
Nozzle type	
Flat fan	51.1
Double flat fan	42.5
Cone	45.7
LSD (0.05)	0.7

Conclusion

Time of day for insecticide applications for thrips control was not important in the trial. Time of day should be considered for other factors such as wind, inversions, temperature, and ease of application.

Pressure differences were not important. Neither the 45 psi nor the 60 psi made any difference in thrips control. The higher pressure produces smaller sized spray droplets that are more prone to drift away from the target area under some conditions, such as moderate winds or high temperatures.

Double flat fan nozzles gave the best thrips control, followed by cone nozzles. Flat fan nozzles gave the poorest control. Double flat fan nozzles have two orifices, each half the size of a regular flat fan orifice. This makes them more prone to plugging, so adequate screens should be used to prevent large particles from reaching the nozzle.

A positive response was seen with higher spray volume. Applying 60 gal of spray requires more time and effort, but growers should realize they may lose some control by reducing the volume.

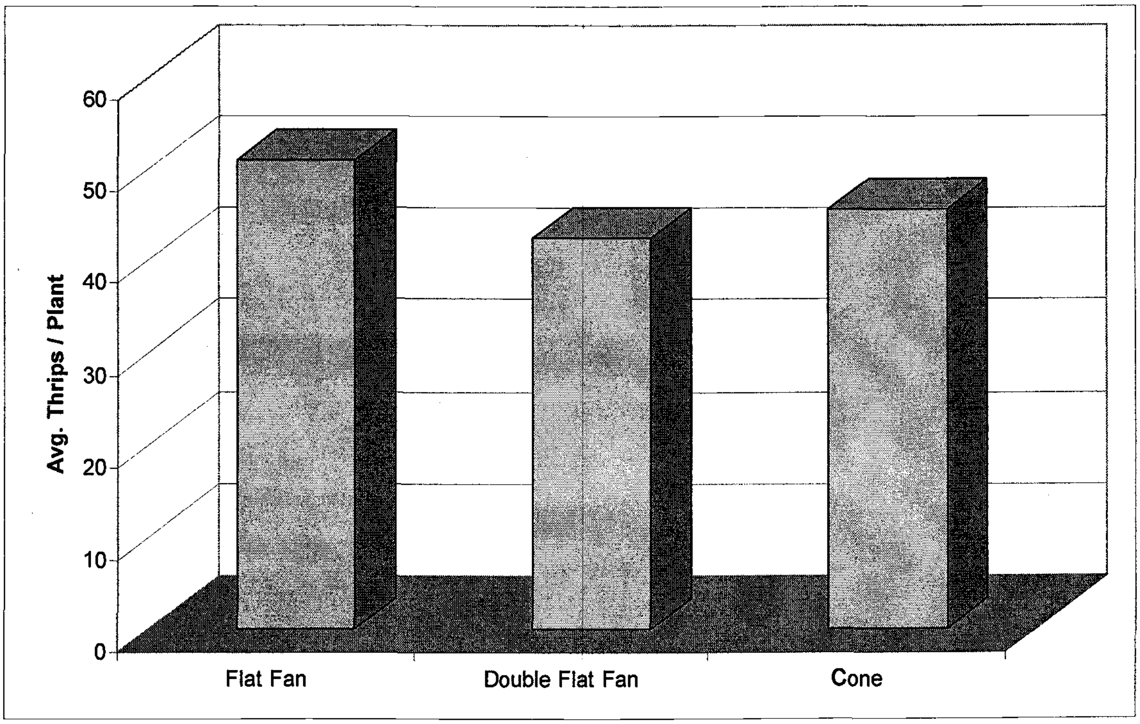

Figure 1. Comparison of nozzle design for thrips control. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

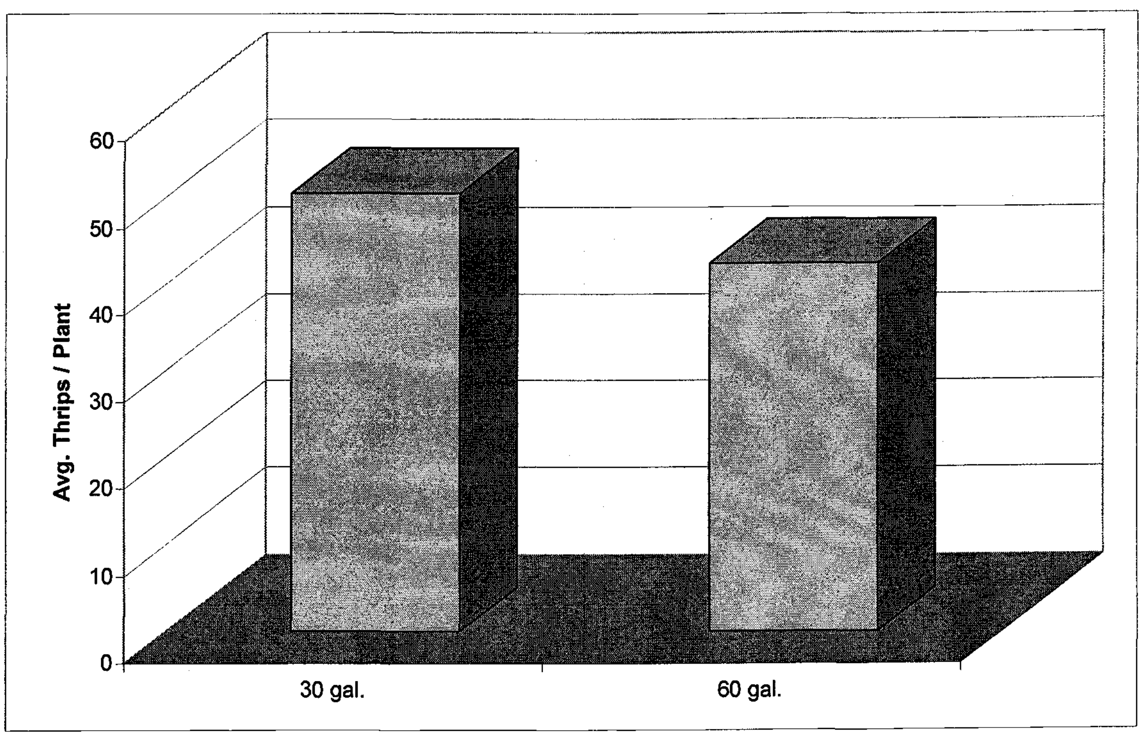

Figure 2. Comparison of spray volume on thrips control. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

A SURVEY OF THRIPS MOVEMENT INTO ONION FIELDS IN THE TREASURE VALLEY

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Introduction

Thrips are the vector for iris yellow spot virus in onion. Two of the challenges to integrated pest management of thrips are knowing when thrips are moving into the fields and where they are coming from. This survey was a first attempt to gather that information.

Materials and Methods

Yellow sticky cards were attached to wooden stakes at a height of 18 inches from the ground and placed on the edges of selected onion fields throughout the Treasure Valley. One card per field edge was placed, with the sticky side facing away from the onion field, on as many sides of the onion field as could be easily accessed. The sticky cards were replaced with fresh cards each week. The collected cards were examined and the thrips counted. In order to reduce time, a representative 35- by 70-mm rectangular area of the card was selected, from which counts were made.

Results and Discussion

Figure 1 shows the weekly movement of thrips into the onion fields. Thrips numbers increased dramatically after June 14 and diminished rapidly after July 13. This is consistent with thrips counts made in insecticide trials in Parma, Idaho and Ontario, Oregon where thrips populations peaked and declined during the same time period.

Thrips numbers moving into onion fields were evenly distributed for traps located on the north, south, and west edges of fields but were nearly double for the east edges (Fig. 2).

Surprisingly, fields with pasture as the neighboring crop had a higher influx of thrips than any other crop (Fig. 3). Onion fields adjacent to other onion fields had the fewest thrips moving into the onions. It should be noted that there was a large variation in the type of crop surrounding onion fields, so that there were very few repetitions of any particular crop. Making conclusions based on a few crops is tenuous where the crop factor is confounded with the location factor.

Oregon Slope and Nyssa, Oregon had the lowest populations of thrips while Vale, Oregon had the highest (Fig. 4).

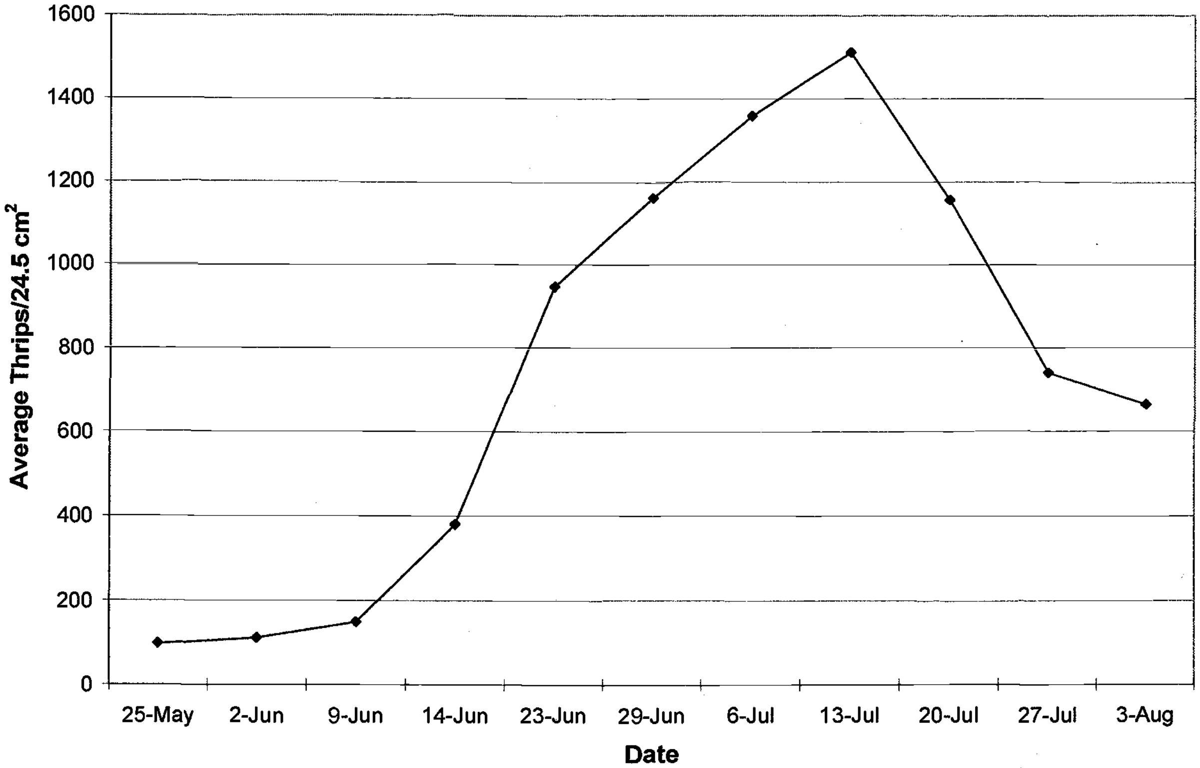

Figure 1. Average number of thrips per week per 24.5 cm^2 of sticky card. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

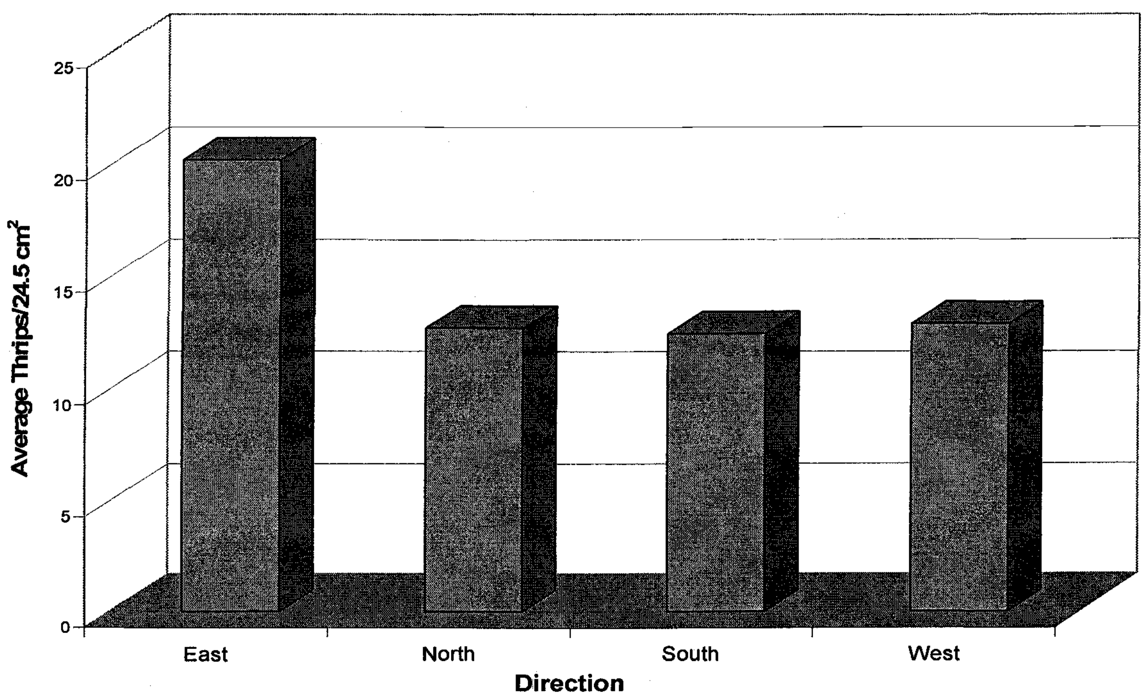

Figure 2. Average number of thrips by trap direction. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

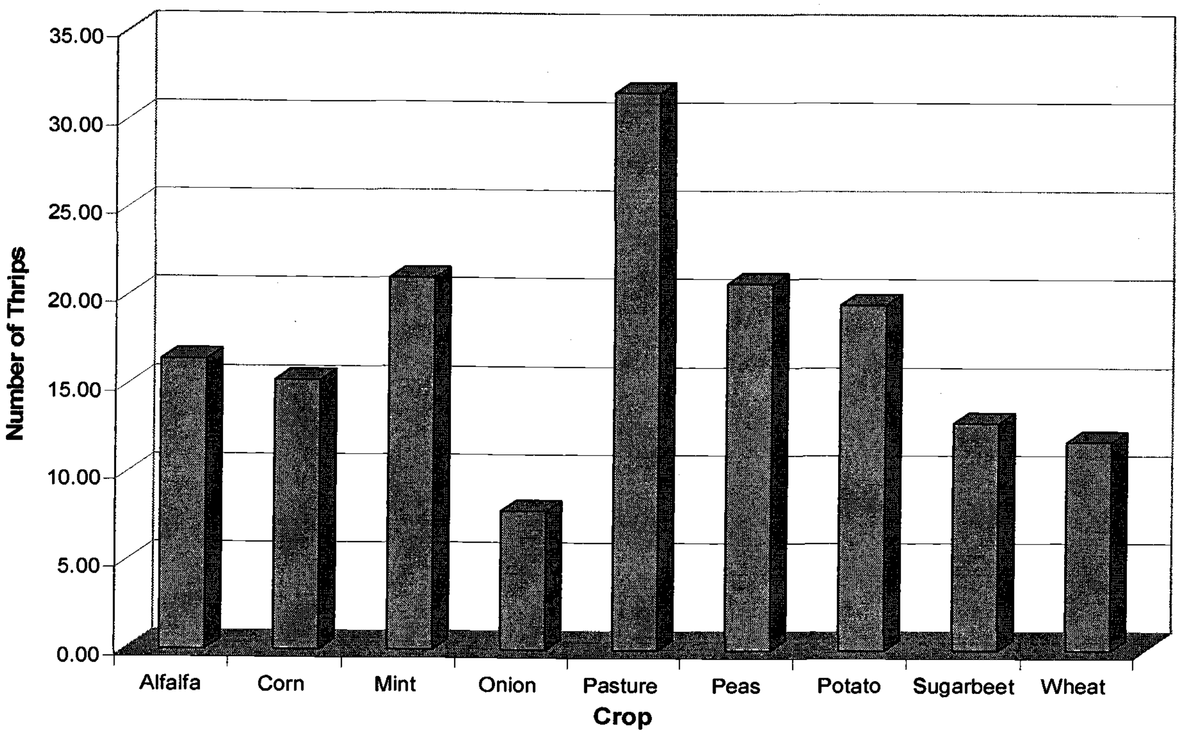

Figure 3. Average number of thrips by adjacent crop. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

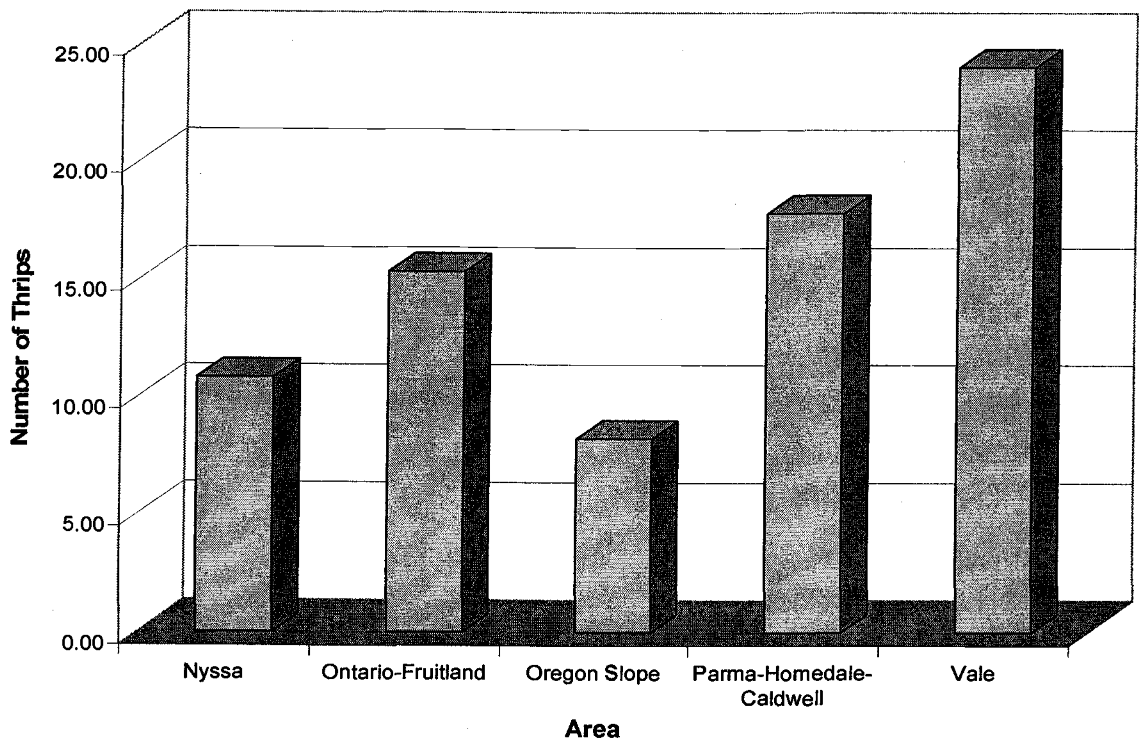

Figure 4. Average number of thrips by area. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

EVALUATION OF AUXIGRO® FOR DRIP-IRRIGATED ONION PRODUCTION

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Introduction

Auxigro® is manufactured by Emerald BioAgriculture Corp. (Lansing, MI) and marketed as a plant growth enhancer. Auxigro is a wettable powder and the active ingredients are gamma aminobutyric acid (29.2 percent) and L-Glutamic acid (29.2 percent). Auxigro contains 0.6 lb ai/lb of product. Auxigro has typically been applied as a foliar spray. The objective of this trial was to evaluate the effect of Auxigro on onion yield, grade, and single centeredness when applied through drip irrigation.

Methods

The trials were conducted at three sites in the Oregon side of the Treasure Valley: Vale, Oregon Slope, and Ontario. The Vale and Oregon Slope trials were on growers fields. The Ontario trial was at the Malheur Experiment Station. The treatments were an untreated check and an Auxigro treatment. Onions in all three trials were drip irrigated. The Auxigro was applied at 1 oz ai/acre/week starting in late June and ending in mid to late August for a total of 8 oz ai/acre.

Vale procedures

Onion (cv. 'Granero', Nunhems, Parma, ID) was planted in six double rows on 84-inch beds on April 12. Each bed had a drip tape buried between each pair of onion double rows (3 drip tapes per bed). The drip tape (T-tape, T-systems International, San Diego, CA) had emitters spaced 6 inches apart and a flow rate of 0.22 gal/min/100 ft. Each plot was three beds wide (21 ft wide) by 650 ft long. The experimental design was a randomized complete block with five replicates.

The Auxigro solution was injected into the drip tape during 3 hours after the first hour of an irrigation and approximately 8 hours before the end of the irrigation. The Auxigro solution was injected at 2.2 gal/hour using a model C-600 diaphragm injector pump (Blue White Industries, Huntington Beach, CA) wired to the irrigation controller. A new Auxigro solution was prepared for each weekly application by dissolving 2.7 oz of Auxigro (1 oz ai/acre) in 6 gal of water for a 3-hour injection. The first application was made on July 3 and the last on August 22 for a total of eight applications. After lifting on September 18, onions from four harvest areas down the length of each 650-ft plot were topped, bagged, and hauled to the Malheur Experiment Station on September 19. Each harvest area consisted of 20 ft of the middle bed in each three-bed plot. The harvest areas were located 65 and 165 ft from the top and from the bottom end of the field.

Oregon Slope procedures
Onion (cv. 'Vaquero', Nunhems, Parma, ID) was planted in two double rows, spaced 21 inches apart (center of double row to center of double row) on 42-inch beds on April 23. A drip tape (T-tape, T-systems International, San Diego, CA) was buried in each bed center between the two onion double rows. The drip tape had emitters spaced 8 inches apart and a flow rate of 0.17 gal/min/100 ft. Each plot was four beds wide (14 ft wide) by 1,250 ft long. The experimental design was a randomized complete block with five replicates.

The Auxigro solution was injected into the drip tape during 3 hours after the first hour of an irrigation and approximately 8 hours before the end of the irrigation. The Auxigro solution was injected at 2.2 gal/hour using a model C-600 diaphragm injector pump (Blue White Industries, Huntington Beach, CA) wired to the irrigation controller. A new Auxigro solution was prepared for each weekly application by dissolving 3.4 oz of Auxigro (1 oz ai/acre) in 6 gal of water for a 3-hour injection. The first application was made on July 3 and the last on August 22 for a total of eight applications. After lifting on September 25, onions from four harvest areas down the length of each 1,250-ft plot were topped, bagged, and hauled to the Malheur Experiment Station on September 27. Each harvest area consisted of 20 ft of the middle two beds in the four-bed plot. The harvest areas were located 65 ft and 165 ft from the top and bottom end of the field.

Ontario procedures
The onions were grown on a Owyhee silt loam previously planted to wheat. In the fall of 2005, the wheat stubble was shredded, and the field was irrigated and disked. Soil analysis on September 13, 2005 indicated the need for 100 lb phosphate/acre, 100 lb sulfur/acre, 2 lb copper/acre and 1 lb/acre of boron, which were broadcast in the fall of 2005 after disking. The field was then moldboard-plowed, groundhogged, roller-harrowed, and bedded.

Onion (cv. 'Vaquero', Nunhems, Parma, ID) was planted in two double rows spaced 22 inches apart (center of double row to center of double row) on 44-inch beds on March 28, 2006. The single rows within the double row were spaced 3 inches apart. Onion was planted at 150,000 seeds/acre. Drip tape (T-tape, T-systems International, San Diego, CA) was laid at 4-inch depth between the two double onion rows at the same time as planting. The distance between the tape and the 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. Immediately after planting 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.

The plots were four beds wide (14.7 ft wide) by 175 ft long. The experimental design was a randomized complete block with six replicates.

The Auxigro was injected into the drip tape during 1 hour after the first hour of an irrigation and approximately 6 hours before the end of the irrigation. A new Auxigro solution was prepared for each weekly application by dissolving 0.62 oz of Auxigro (1 oz ai/acre) in 4 gal of water for a 1-hour injection. The Auxigro solution was injected at 4 gal/hour using a model A-30 2.5 proportional chemical injector (Dosmatic, Carrolton, TX). The first application was made on June 29 and the last on August 15 for a total of eight applications.

The field had 50 lb of N/acre as urea applied through the drip tape on June 8 and on June 22. An onion root tissue analysis on July 14 showed the need for potassium. On July 21, potassium at 20 lb/acre was applied through the drip tape.

The onions were managed to avoid yield reductions from weeds, pests, and diseases. Weeds were controlled with an application of Prowl® at 1 lb ai/acre on April 28. On May 9, Goal® at 0.1 lb ai/acre, Buctril® at 0.3 lb ai/acre, and Select® at 0.25 lb ai/acre were applied. On May 17, Goal at 0.2 lb ai/acre and Buctril at 0.3 lb ai/acre were applied. On May 30, Goal at 0.2 lb ai/acre, Buctril at 0.3 lb ai/acre, and Select at 0.25 lb ai/acre were applied. After lay-by the field was hand weeded as necessary. Thrips were controlled with aerial applications of the following insecticides: June 12, Warrior®; June 18, Warrior plus Lannate®; July 1, Carzol®; July 17, Warrior plus Mustang®; July 24, Carzol; July 29, Warrior plus MSR®; August 10, Warrior plus Lannate. Carzol was applied at 0.69 lb ai/acre, Warrior at 0.03 lb ai/acre, Lannate at 0.45 lb ai/acre, Mustang at 0.05 lb ai/acre, and MSR at 0.5 lb ai/acre.

The trial was irrigated when the soil water tension at 8-inch depth reached 20 cb (1 cb = 1 kPa). Soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) installed in mid-June below the onion row centered at 8-inch depth (Shock et al. 2005). The sensors were automatically read hourly with an Irrometer monitor (Irrometer Co.). The last irrigation was on August 31.

After lifting on September 8, onions from four harvest areas in each 175-ft-long plot were topped, bagged, and hauled to storage. Each harvest area consisted of 20 ft of the middle two beds in the four-bed plot. The first harvest area was located 20 ft from the top of each plot and then the others were spaced 20 ft apart down the length of the plot.

All sites

On September 29 the onions from the three sites 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.

After grading, 25 bulbs ranging in diameter from 3.5 to 4.25 inches from each subplot were rated for single centers. 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 double" had diameters less than 1.5 inches, "intermediate double" had diameters from 1.5 to 2.25 inches, and "blowout" had diameters greater than 2.25 inches. Single-centered onions were classed as a "bullet". Onions were considered functionally single centered for processing if they were a "bullet" or "small double".

The yield for each plot was calculated as the sum of the yields of the four harvest areas. The gross income was calculated using the F.O.B. onion prices for Malheur County on November 9, 2006 ($/50 lb: medium 5.00, jumbo 8.50, colossal 11.00, and super colossal 17.00) minus the packing cost of $3.00/50 lb. The gross income for the Auxigro treatment had the Auxigro cost subtracted. The cost of the Auxigro treatment was calculated assuming $79.00/lb of Auxigro (Simplot Soilbuilders) and an application cost of $2.33/acre (transportation, mixing, and loading, assuming a 40-acre field). Treatment differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05).

Results

The 2006 season was not favorable for onion production in the Treasure Valley. Cool and wet weather in March and April delayed planting at some locations and reduced early season plant growth at most locations. The Vale and Oregon Slope onions were planted later than normal. The Ontario onions suffered from a heavy infestation of iris yellow spot virus (IYSV).

Comparing the three sites, the Vale site had the highest marketable and colossal onion yields (Table 1). Comparing the three sites, the Ontario site had the highest percentages of bullet single centered and functionally single centered bulbs, possibly due to the irrigation criterion used, but also had the lowest yield possibly due to a heavy infestation of IYSV.

The Auxigro treatment at the Vale site had significantly higher yield of colossal bulbs than the untreated check (Table 1). There was no significant difference in colossal bulb yield between treatments at the other two sites. For the other bulb size categories measured, there was no significant difference in yield or grade between the Auxigro treatment and the untreated check in any of the sites (Tables 1 and 2).

The increased colossal bulb yield with the Auxigro treatment at the Vale site resulted in an increase in gross income of $962/acre using prevailing prices.

There are no research reports on Auxigro that we could find published in refereed scientific journals. The existing literature on Auxigro research can be found in extension reports available on the internet. A study done in Colorado with Auxigro foliar applied to onions showed no significant yield increase (Swift and Cooley 2002).

Despite only one site out of three showing a benefit from Auxigro use, the results of this study suggest that, in some situations, drip-applied Auxigro could be beneficial to onion production in the Treasure Valley. The difficult growing conditions experienced in 2006 could have influenced the onion response to Auxigro in these trials. Further research is warranted before definitive recommendations can be made.

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.

Swift, C., and W.A. Cooley. 2002. Onion response to Auxigro applications at two locations in the Uncompahgre Valley in 2002. http://www.coopext.colostate.edu/TRA/PLANTS/2002auxigro.html

Table 1. Yield and grade for untreated onions and onions treated with Auxigro. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Location Treatment	Total yield	Marketable yield by grade Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Bulb counts >4¼ in	Non-marketable yield Total rot	No. 2s	Small	Gross income
	cwt/acre						#/50 lb	% of total	-- cwt/acre --		$/acre
Vale											
Check	928.5	903.1	17.7	146.9	654.9	83.7	25.2	0.4	2.0	19.5	10,383
Auxigro	969.7	946.6	21.9	190.2	684.5	49.9	27.6	0.3	1.1	18.7	11,345
Average	949.1	924.9	19.8	168.6	669.7	66.8	26.4	0.4	1.6	19.1	10,864
Oregon Slope											
Check	919.3	883.0	2.9	59.7	707.3	113.0	20.2	0.5	2.7	29.2	9,269
Auxigro	869.2	839.4	3.3	41.5	705.4	89.2	28.0	0.6	2.1	22.6	8,830
Average	894.3	861.2	3.1	50.6	706.4	101.1	24.1	0.5	2.4	25.9	9,050
Ontario											
Check	699.1	676.8	0.0	21.6	578.9	76.3	0.0	0.3	2.7	17.6	7,018
Auxigro	665.2	640.6	0.4	10.6	548.9	80.8	5.0	0.6	3.7	17.1	6,500
Average	682.1	658.7	0.2	16.1	563.9	78.5	2.5	0.4	3.2	17.4	6,759
3-site average											
Check	839.6	811.9	6.4	72.6	642.8	90.1	14.2	0.4	2.5	21.8	8,773
Auxigro	824.1	798.4	8.0	76.4	640.2	73.8	19.3	0.5	2.4	19.3	8,742
Average	831.9	805.2	7.2	74.5	641.5	82.0	16.8	0.5	2.5	20.6	8,758
LSD (0.05) values											
Treatment	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site	55.8	54.7	NS	20.9	65.7	NS	6.4	NS	NS	NS	614
Trt X site	NS	NS	NS	29.6	NS	NS	NS	NS	NS	NS	793

Table 2. Single-center rating for untreated onions and onions treated with Auxigro. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Location	Multiple center			Single center	
Treatment	Blowout	Intermediate double	Small double	Functional[a]	Bullet
	%				
Vale					
Check	3.4	16.6	28.2	80.0	51.8
Auxigro	5.5	16.7	24.6	77.8	53.2
Average	4.4	16.7	26.4	78.9	52.5
Oregon Slope					
Check	0.6	5.5	19.3	93.9	74.6
Auxigro	1.6	6.4	18.4	92.0	73.7
Average	1.1	5.9	18.8	93.0	74.1
Ontario					
Check	0.3	1.5	8.9	98.2	89.3
Auxigro	0.8	1.5	7.5	97.7	90.1
Average	0.6	1.5	8.2	97.9	89.7
3-site average					
Check	1.4	7.5	18.2	91.1	73.0
Auxigro	2.5	7.8	16.3	89.7	73.4
Average	2.0	7.6	17.2	90.4	73.2
LSD (0.05) values					
Treatment	NS	NS	NS	NS	NS
Site	NS	2.4	6.4	4.5	3.8
Trt X site	NS	NS	NS	NS	NS

[a]Bullet + small double.

EVALUATION OF INTRACEPT® FOR ONION PRODUCTION

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Introduction

The objective of this trial was to evaluate the effect of Intracept® on onion yield and grade. Intracept is manufactured by Northwest Agricultural Products (Pasco, WA) and is marketed as a foliar-applied micronutrient fertilizer and plant growth enhancer.

Methods

The trials were conducted on both a drip-irrigated and furrow-irrigated field at the Malheur Experiment Station. The experimental designs were randomized complete blocks with seven replicates. The two treatments were an untreated check and Intracept applied at 16 oz/acre on June 2. Intracept was applied as a foliar spray in 13 gal of water per acre using 8004 nozzles spaced 20 inches apart at a pressure of 40 PSI. Each plot was four double onion rows 25 ft long.

Furrow-irrigated field
The field was irrigated when the soil water tension at 8-inch depth reached 25 cb (1 cb = 1 kPa). The field was sidedressed with 100 lb of N/acre as urea on May 25 and on June 21. The last irrigation was on August 23. An onion root tissue analysis on July 14 from onions in the untreated check plots showed the need for potassium (Table 1). On July 21, potassium was water run at 20 lb/acre during a normal irrigation.

Drip-irrigated field
Drip tape (T-tape, T-systems International, San Diego, CA) was laid at 4-inch depth between the two double onion rows at the same time as planting. The distance between the tape and the 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 field was irrigated when the soil water tension at 8-inch depth reached 20 cb (1 cb = 1 kPa). The last irrigation was on August 31. The field had 50 lb of N/acre as urea applied through the drip tape on June 8 and June 22. An onion root tissue analysis on July 14 from onions in the untreated check plots showed the need for potassium (Table 1). On July 21, potassium at 20 lb/acre was injected through the drip tape.

Both fields
The onions in both fields were grown on Owyhee silt loam previously planted to wheat. In the fall of 2005, the wheat stubble was shredded and the fields were irrigated and disked. Soil analyses on September 13, 2005 (Table 2) for both fields indicated the

need for 100 lb phosphate/acre, 100 lb sulfur/acre, 2 lb copper/acre, and 1 lb/acre of boron, which were broadcast in the fall of 2005 after disking. The fields were then moldboard-plowed, groundhogged, roller-harrowed, and bedded.

Onion (cv. 'Vaquero', Nunhems, Parma, ID) was planted in two double rows, spaced 22 inches apart (center of double row to center of double row) on 44-inch beds on March 23 in the furrow-irrigated field and on March 28 in the drip-irrigated field. The two rows in the double row were spaced 3 inches apart. Onion was planted at 150,000 seeds/acre. For preventive control of onion maggot, after planting 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.

The onions were managed to avoid yield reductions from weeds, pests, and diseases. Weeds were controlled with an application of Prowl® at 1 lb ai/acre on April 28. On May 9, Goal® at 0.1 lb ai/acre, Buctril® at 0.3 lb ai/acre, and Select® at 0.25 lb ai/acre were applied. On May 17, Goal at 0.2 lb ai/acre and Buctril at 0.3 lb ai/acre were applied. On May 30, Goal at 0.2 lb ai/acre, Buctril at 0.3 lb ai/acre, and Select at 0.25 lb ai/acre were applied. After lay-by the field was hand weeded as necessary. Thrips were controlled with aerial applications of the following insecticides: June 12, Warrior®; June 18, Warrior plus Lannate®; July 1, Carzol®; July 17, Warrior plus Mustang®; July 24, Carzol; July 29, Warrior plus MSR®; August 10, Warrior plus Lannate. Carzol was applied at 0.69 lb ai/acre, Warrior at 0.03 lb ai/acre, Lannate at 0.45 lb ai/acre, Mustang at 0.05 lb ai/acre, and MSR at 0.5 lb ai/acre.

Soil water tension was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) installed in mid-June below the onion row at 8-inch depth. The sensors were automatically read hourly with an Irrometer monitor (Irrometer Co.).

After lifting on September 8, onions from the central 20 ft of the middle two rows in each plot were topped, bagged, and hauled to a barn on September 15.

On September 29 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.

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

Results

There was no significant difference in onion yield and grade between the Intracept-treated onions and the untreated onions in either of the two fields or when the data from the two fields were combined (Table 3). The furrow-irrigated field has a long-term history of high yields in previous years and had significantly higher total, marketable, and jumbo onion yields than the drip-irrigated field in 2006. This result was expected based on field history.

Intracept contains copper, iron, manganese, zinc, sulfur, and unknown polysaccharides and organic acids (Table 4). The amounts of these nutrients that were actually applied in one application of 16 oz of product per acre are listed in Table 4. Based on the onion root tissue analyses (Table 1) for the 2006 drip- and furrow-irrigated fields at the Malheur Experiment Station, the nutrients in the Intracept were not in short supply.

Table 1. Analysis of onion root tissue samples. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Field	NO_3	P	K	S	Ca	Mg	Zn	Cu	Mn	Fe	B
	ppm	----------	----------	%	----------	----------		----------	ppm	----------	
June 21											
Furrow	6,193[a]	0.88	3.3	0.81	0.73	0.44	168	220	17	4,864	26
Drip	3,787[a]	0.97	4.02	1.63	0.66	0.43	101	274	15	3,321	25
Sufficiency range[b]	11,800	0.32-0.7	2.7-6	0.24-0.85	0.4-1.2	0.3-0.6	25-50	35-100	6-20	60-250	19-60
July 14											
Furrow	7,083[c]	1.39	2.53	0.87	0.61	0.32	41	139	13	1,930	73
Drip	4,430[c]	1	2.34	1.36	0.69	0.36	72	209	13	1,958	67
Sufficiency range	8,125	0.32-0.7	2.7-6	0.24-0.85	0.4-1.2	0.3-0.6	25-50	35-100	6-20	60-250	19-60

[a]These results were followed by corrective fertilizer.
[b]Western Labs, Parma, ID.
[c]Late season N was not applied.

Table 2. Analysis of soil sample taken on September 13, 2005. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Field	pH	O.M.	NO_3	P	K	Sulfate	Ca	Mg	Na	Zn	Cu	Mn	Fe	B
		%	----------	----------	----------	----------	----------	ppm	----------	----------	----------	----------	----------	----------
Furrow	7.4	1.52	5	24	353	13	1,982	549	114	2.1	0.6	12	11	0.5
Drip	7.5	1.87	12	36	546	24	2,530	539	151	3.3	0.5	18	8	0.5

Table 3. Yield and grade for onions treated with Intracept® compared to an untreated check. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Treatment	Total yield	Marketable yield by grade					Non-marketable yield		
		Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Total rot	No. 2s	Small
	cwt/acre						% of total yield	cwt/acre	
Drip-irrigated field									
Check	658.6	632.4	0.0	50.5	542.6	39.3	0.8	2.8	17.8
Intracept	654.9	634.3	2.8	38.4	556.7	36.5	0.5	0.9	16.8
Average	656.8	633.4	1.4	44.4	549.6	37.9	0.7	1.9	17.3
Furrow-irrigated field									
Check	756.6	739.5	0.0	33.4	666.3	39.9	0.1	1.6	14.6
Intracept	745.2	725.7	0.0	35.8	650.0	39.9	0.3	4.1	13.0
Average	750.9	732.6	0.0	34.6	658.1	39.9	0.2	2.9	13.9
Average									
Check	707.6	686.0	0.0	41.9	604.5	39.6	0.5	2.2	16.2
Intracept	700.0	680.0	1.4	37.1	603.3	38.2	0.4	2.5	14.9
Average	703.8	683.0	0.7	39.5	603.9	38.9	0.5	2.4	15.6
LSD (0.05)									
Treatment	NS	NS	NS	NS	NS	NS	NS	NS	NS
Field	33.8	37.3	NS	NS	51.3	NS	NS	NS	NS
Trt X field	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Intracept® nutrient content and the actual amounts of nutrients applied via Intracept. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Cu	Fe	Mn	Zn	S	Polysaccharides	Organic acids
	% by weight						
Product analysis[a]	0.10	0.10	0.33	0.40	1.00	0.82	1.00
	lbs/acre						
Amounts applied[b]	0.00121	0.00121	0.004	0.005	0.0121	0.0099	0.0121

[a]Guaranteed analysis in product label. Product density is 9.75 lbs/gal.
[b]Amounts of each nutrient actually applied based on an application of 16 oz/acre of product.

PERFORMANCE OF HYBRID POPLAR CLONES ON AN ALKALINE SOIL THROUGH 2006

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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 saw logs 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. This 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, Oregon demonstrated that clone OP-367 (hybrid of *Populus deltoides* x *P. 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 (*Triticum aestivum*) in 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 Mg, 40 lb K, 1 lb B, and 1 lb 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 five 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 Malheur 1, 2, and 3 corresponding to three 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. Starting around mid-July 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 boron and sulfur fertilization (Table 1). On July 28, sulfur at 10 lb/acre as ammonium sulfate and boron 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, 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 boron (Table 1). On July 19, boron 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 USA, 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, 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 run for each clone separately. 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 is 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.

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 or crooked tops) ranged from 0 defects for clone 57-276 to 1.75 for clone 49-177 (Table 1).

2005 Measurements

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.

2006 Measurements

By November of 2006, Malheur 3, 59-289, DN-34, 184-401, and Malheur 2 were significantly taller than OP-367 (Table 2). By November of 2006, clone Malheur 3 had significantly larger DBH than OP-367. By November of 2006, clones Malheur 3 and 59-289 had significantly greater wood volume than OP-367. Clone Malheur 3 had significantly greater wood volume increment than OP-367 in 2006. Clones Malheur 2, Malheur 3, 184-401, 52-225, 52-280, 59-289, 309-74, NM-6, and DN-34 were among the clones with the highest wood volume increment in 2006.

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.

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

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

	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, Oregon, 2006.

#	Clone	Cross	November 2006 measurements			2006 growth increment			2004 measurements		
			Height	DBH	Wood volume	Height	DBH	Wood volume	Leaf chlorophyll content	Leaf chlorosis symptoms	Trunk defects
			feet	inch	inch³/tree	feet	inch	inch³/tree	0 - 100	0 - 5[a]	0 - 2[b]
1	15-29	P. trichocarpa X P. deltoides	25.5	4.4	1552.4	1.8	0.67	499.2	35.7	1.5	1
2	50-184	P. trichocarpa X P. deltoides	13.6	2.4	235.4	0.2	0.22	41.3	31.1	2.5	1
3	50-197	P. trichocarpa X P. deltoides	25.5	4.3	1615.5	3.0	0.84	721.9	30.3	3	0.3
4	52-225	P. trichocarpa X P. deltoides	22.3	3.1	822.8	1.9	0.47	309.5	26.6	3	0.5
5	55-260	P. trichocarpa X P. deltoides	22.3	3.8	1123.1	3.4	0.87	515.2	25.8	2.8	0.8
6	56-273	P. trichocarpa X P. deltoides	23.4	3.5	980.6	1.3	0.58	312.6	40.8	1	1
7	57-276	P. trichocarpa X P. deltoides	19.6	3.3	704.8	1.4	0.63	271.6	36.3	1.8	0
8	58-280	P. trichocarpa X P. deltoides	24.1	4.2	1356.6	4.4	0.98	682.7	44.4	0.8	0.8
9	59-289	P. trichocarpa X P. deltoides	29.0	4.5	1927.9	2.7	0.83	739.9	42	0.5	0.8
10	184-401	P. trichocarpa X P. deltoides	27.2	4.1	1539.4	5.1	0.89	774.6	34	0.5	1
11	184-411	P. trichocarpa X P. deltoides	24.0	3.1	804.9	4.3	0.91	462.9	32.4	1.5	0.5
12	195-529	P. trichocarpa X P. deltoides	20.2	3.3	756.6	1.6	0.58	285.9	32.2	1.5	0.8
13	309-74	P. trichocarpa X P. nigra	24.7	3.6	1226.0	2.3	0.74	538.1	26.3	2.8	0.8
14	311-93	P. trichocarpa X P. nigra	22.1	3.0	677.8	4.4	0.85	388.7	30.2	3.3	1.3
15	NM-6	P. trichocarpa X P. maximowiczii	24.9	3.5	1032.9	4.6	0.79	532.3	43.5	1.5	1.3
16	DTAC-7	P. trichocarpa X P. deltoides	17.0	2.4	388.2	1.4	0.29	142.1	34	2	0.8
17	OP-367	P. deltoides X P. nigra	22.1	3.9	1060.9	2.7	0.76	458.1	40.6	0	0.3
18	PC1	P. deltoides X P. nigra	25.3	3.6	1210.2	1.9	0.55	416.4	45.8	0	0.3
19	PC2	P. trichocarpa X P. deltoides	20.5	2.8	566.7	0.4	0.28	123.8	45.3	0.3	0.5
20	49-177	P. trichocarpa X P. deltoides	22.6	3.0	817.0	3.0	0.62	380.4	33.5	1.5	1.8
21	Malheur 1	P. deltoides, Malheur County, OR	24.0	3.2	924.3	3.6	0.72	445.9	49.3	0	0.5
22	Malheur 2	P. deltoides, Malheur County, OR	27.0	3.8	1307.4	4.2	1.04	711.2	46.7	0	0.5
23	Malheur 3	P. deltoides, Malheur County, OR	29.4	4.9	2277.7	3.3	0.92	920.8	42.2	0	0.3
24	DN-34	P. deltoides X P. nigra	27.3	3.6	1278.4	4.0	1.00	714.7	43.8	0.5	0.3
LSD (0.05)			4.9	1.0	781.5	2.3	NS	399.5	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 straight stems and single tops, 1 = less than half of trees have either split or crooked stems, 2 = more than half of the trees have either split or crooked stems.

MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION, 2006 TRIAL

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Summary

Hybrid poplar (cultivar OP-367) was planted for saw log production in April 1997 at the Malheur Experiment Station. Five irrigation treatments were established in 2000 and were continued through 2006. Irrigation treatments consisted of three water application rates using microsprinklers and two water application rates using drip tape. Irrigation scheduling was by soil water tension at 8-inch depth with a threshold for initiating irrigations of 50 kPa in 2000 through 2002 and 25 kPa in 2003 through 2006. Increasing the water application rate increased the annual growth in stem volume for the microsprinkler-irrigated treatments. There was no significant difference between the microsprinkler treatment irrigated at the highest rate and the drip-irrigated treatments in terms of height, DBH, or stem volume growth in 2000 and 2001. In 2002 and 2003, drip irrigation with two tapes per tree row resulted in greater tree growth than microsprinkler irrigation. In 2004, the microsprinkler and the drip-irrigated treatments irrigated at the highest rate had among the greatest stem volume growth. In 2005 and 2006, drip irrigation with two tapes per tree row resulted in the greatest stem volume growth.

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 kPa, but 38 irrigations were required for 3-year-old trees, and more were anticipated for larger trees. Based on simplicity of operations, we decided to use an irrigation criterion of 50 kPa for the wettest treatments starting in 1998. In 2000 we noticed that the rate of increase in annual tree growth started to decline in the wettest treatment. One of the causes probably was the use of an irrigation criterion of 50 kPa. Starting in 2003 the irrigation criterion was changed to 25 kPa for the wettest treatment. 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 and 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. 2002a) and groundcover research (Shock et al. 2002b) 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 one of five treatments arranged in a randomized complete block design and replicated four times. 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.
The five irrigation treatments consisted of three water application rates for the microsprinkler-irrigated plots and two water application rates for the drip-irrigated plots. 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 treatment 1, reached 50 kPa. 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 kPa. In 2003, the irrigation criterion was increased from 50 kPa to 25 kPa. 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 treatment 1 microsprinkler-irrigated trees and for the 2 drip tape configurations 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 had been 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/ac 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 S) 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, the 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 many 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 S, 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 S 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 kPa 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 kPa. 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 kPa. 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 feet 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, Fe at 1 lb/acre was broadcast aerially. Leaf analyses on July 26 showed the need for N and P in trees in the drip plots. 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.

Results and Discussion

The increase in irrigation intensity in 2006 for the microsprinkler-irrigated plots resulted in an increase in the total amount of water applied compared to previous years. For the microsprinkler-irrigated treatment receiving 2 inches of water/irrigation and for the 2 drip tubing treatments the total amount of water applied was higher than estimated evapotraspiration (ET_c) (49.3 inches) for the season (Table 2). In 2006, the two drip tube treatments had the highest stem volume growth increment followed by the one drip tube treatment and the microsprinkler treatment irrigated with 2 inches of water per irrigation (Table 3). The highest 2000-2006 stem volume growth increment was achieved with the two drip tubing treatment. In the fall of 2006 (tenth year), the highest wood volume per acre was for the 2 drip tubing treatment, with the 2-inch microsprinkler treatment and the 1 drip tubing treatment having among the highest wood volume of the other treatments. In the fall of 2006, the 2 drip tubing and 2-inch microsprinkler treatments 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). There were similar linear relationships, with similar slopes, between total water applied and stem volume growth from 2000 to 2006 for the drip and microsprinkler systems (Fig. 1). The greater stem volume growth for the drip system reflected the higher water use efficiency of the drip system.

The soil water tension at 8-inch depth was maintained below the criterion of 25 kPa, except for brief periods during the season for microsprinkler irrigation with 2 inches of water applied and for drip irrigation (Fig. 2). The soil water tension at 8-inch depth was increased, as expected, with the reductions in the water application rate in the sprinkler treatments (Fig. 2, Table 4).

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 5, 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 soil water tension for irrigation scheduling from 25 to 50 kPa in 2000 might be 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 the change to a wetter irrigation threshold from 50 to 25 kPa.

Starting in 2004, and through 2006, the trees in the microsprinkler-irrigated plots started exhibiting leaf chlorosis around the middle of July, whereas the trees in the drip-irrigated plots did not exhibit leaf chlorosis. Foliar analysis has not revealed a clear cause-and-effect relationship.

The soil Na concentration increased over the years through the fall of 2005 and decreased in the spring of 2006, but remained above the recommended maximum level in the microsprinkler and drip plots (Table 6). The increase in Na concentration over the years could be due to the high Na in the well water used for irrigation (200 ppm). The recommended maximum Na level in irrigation water is 69 ppm.

In 2005, leaf analyses showed that the microsprinkler trees had excesses of S, Ca, Mg, and B. In 2005, leaf analyses showed that the drip trees had excesses of S, Ca, Mg, Fe, and B. In 2006, the leaf analyses showed that the microsprinkler trees had excesses of N, P, K, S, Ca, Mg, Zn, Mn, Cu, and Fe. In 2006, leaf analyses showed that the drip trees had excesses of S, Ca, Mg, Mn, Cu, Fe, and B. Both Na and B in excess in the soil or irrigation water can cause leaf chlorosis. The normal leaf B concentrations in the microsprinkler trees and the excessive leaf B concentrations in the drip trees in 2006 suggest that the leaf chlorosis in the microsprinkler poplar is not related to B.

The CAI decreased for both the drip and microsprinkler trees compared to 2005 (Fig. 3). The MAI continued to increase over time. 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 intersected in 2006 for the microsprinkler trees, but not for the drip trees. The lower CAI for the microsprinkler trees could be related to undetermined nutritional problems discussed above.

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Table 1. Nutrients applied through the drip- and microsprinkler-irrigation systems in 2006. Malheur Experiment Station, Oregon State University, Ontario, OR.

Date	Nutrient	Quantity
Sprinkler		lb/acre
June 26	Fe	1.3
July 5	Fe	1.3
July 12	Fe	1.3
August 10	Fe	1.3
July 31	N	20
July 31	P	10
August 28	N	30
Drip		
June 28	Fe	2.9
July 5	Fe	2.9
July 12	Fe	2.9
July 31	N	20
July 31	P	10
August 16	N	30
August 22	P	10

Table 2. Irrigation rates, amounts, and water use efficiency for hybrid poplar submitted to five irrigation regimes in 2006, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Irrigation threshold	Water application	Irrigation system	Total number of irrigations	Total water applied[a]	Water use efficiency
	kPa[b]	inch			acre-inch/ acre	ft^3 of wood/acre-inch of water
1	25	2	Microsprinkler	42	89.1	3.4
2	coincide with trt #1	1.54	Microsprinkler	42	45.0	5.1
3	coincide with trt #1	0.77	Microsprinkler	42	30.9	7.6
4	25	1	Drip, 2 tapes	38	74.3	8.4
5	25	0.5	Drip, 1 tape	40	55.7	8.5
LSD (0.05)				1	29.4	NS

[a]Includes 2.18 inches of precipitation from mid-April through September.
[b]Soil water tension at 8-inch depth.

Table 3. Height, diameter at breast height (DBH), and stem volume in early November 2006, and 2006 growth in height, DBH, and stem volume for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	November 2006 measurements			2006 growth increment			2000-2006 growth increment
	Height	DBH	Stem volume	Height	DBH	Stem volume	Stem volume
	ft	inch	ft³/acre	ft	inch	ft³/acre	ft³/acre
1	64.3	10.0	2,819	1.3	0.48	303.2	2,588
2	54.4	8.9	1,878	1.5	0.53	229.9	1,678
3	45.3	6.6	849	4.1	0.74	235.0	772
4	78.4	11.1	4,330	1.6	0.77	629.8	4,157
5	61.3	9.5	2,489	3.1	0.69	453.7	2,304
LSD (0.05)	NS	1.4	1,209	NS	NS	319.5[a]	1,241

[a]Significant at a 0.10 level of probability.

Table 4. Average soil water tension and volumetric soil water content for hybrid poplar submitted to five irrigation treatments in 2006, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Average soil water tension		
	1st ft	2nd ft	3rd ft
	kPa		
1	26.8	25.2	24.7
2	55.4	36.1	31.2
3	62.5	46.2	43.9
4	26.5	24	26.4
5	23.7	19.5	22.3
LSD (0.05)	21.6	NS	NS

[a]Significant at P = 0.10.

Table 5. Annual stem volume growth, seasonal average soil water tension at 8-inch depth, and growing degree days for the drip and microsprinkler treatments receiving the most water, Malheur Experiment Station, Oregon State University, Ontario, OR.

Year	Annual stem volume growth		Seasonal average soil water tension at 8-inch depth		Water applied plus precipitation		ET_c	April - Oct. Growing degree days (50 - 86°F)
	Drip	Microsprinkler	Drip	Microsprinkler	Drip	Microsprinkler		
	---- ft³/acre ----		---- kPa ----		---------- inches ----------			
1997		1.3		21.4		27.2		3,049
1998		78.5		20.0		45.0	37.1	2,968
1999		177.7		22.2		51.0	45.5	2,846
2000	387.9	401.5	24.2	37.9	35.2	42.1	47.1	3,067
2001	479.9	354.7	26.4	33.9	35.8	34.3	44.7	3,118
2002	440.1	256.8	31.3	35.8	30.6	38.1	44.4	3,023
2003	737.9	450.7	21.8	26.9	54.8	47.1	45.9	3,354
2004	679.4	512.3	20.2	22.2	56.3	51.7	44.1	3,106
2005	719.3	306.4	24.0	25.9	56.1	51.5	45.3	2,829
2006	629.8	303.2	26.5	26.8	74.3	89.1	49.3	3,022

Table 6. Soil pH, soluble salts, Na, and B for poplar microsprinkler and drip plots over time. Malheur Experiment Station, Oregon State University, Ontario, OR.

Year	pH	Soluble salts	Na (ppm)	B (ppm)
		Sprinkler		
April 1999	8.2	0.8	159	0.5
March 2001	8.3	0.84	132	0.9
March 2003	8.4	0.66	132	0.8
April 2005	8	0.57	265	2.7
October 2005	8.4	0.29	200	4
April 2006	8.2	0.24	139	1.7
		Drip		
October 2005	8.2	1.63	606	15.8
April 2006	8.5	0.26	291	2.3
Sufficiency range		<1.5	<225	0.7-1.5

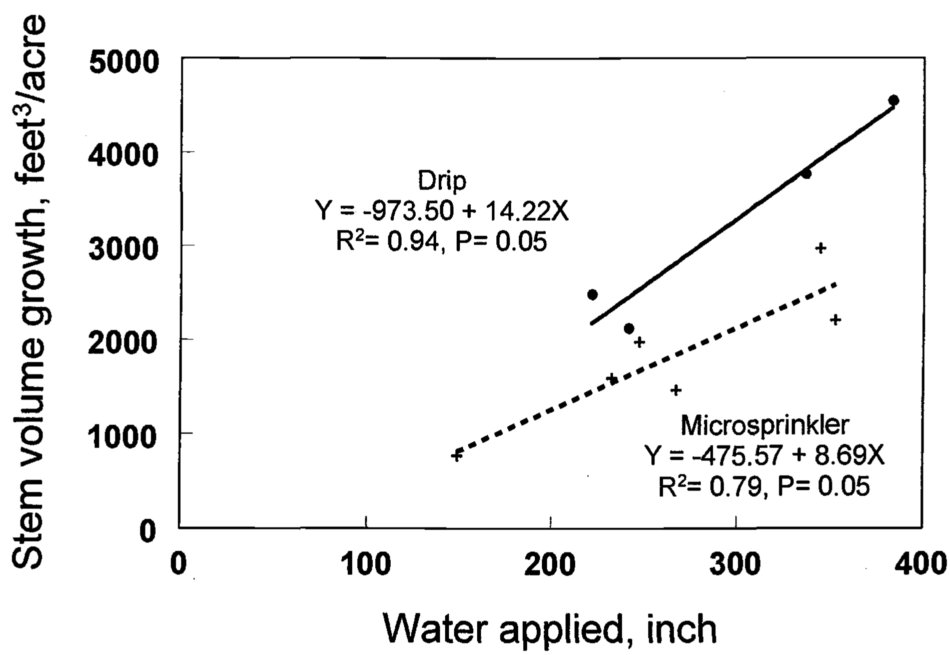


Figure 1. Response of stem volume growth to water applied from March 2000 through November 2006 for the drip and microsprinkler systems. Malheur Experiment Station, Oregon State University, Ontario, OR.

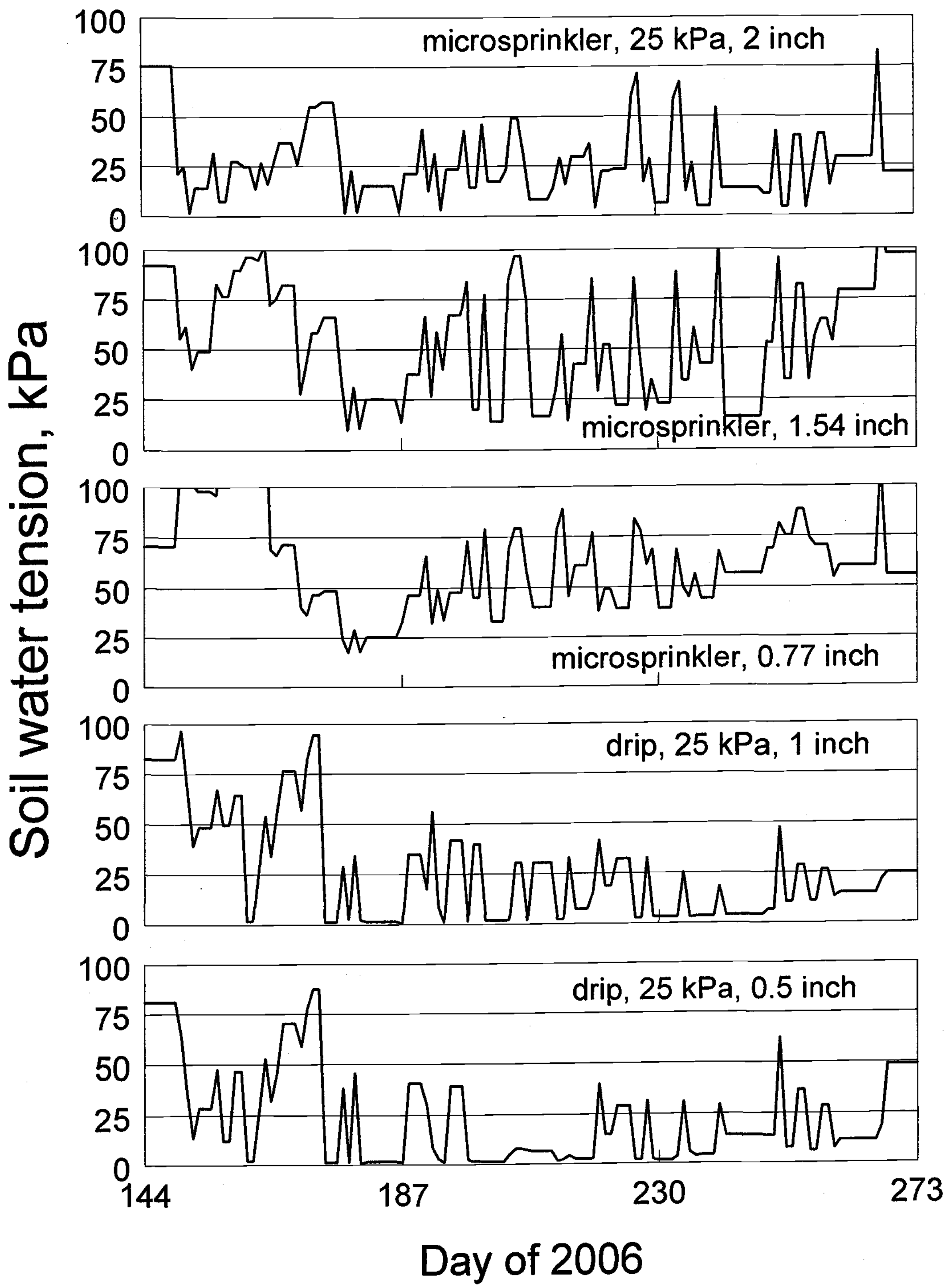
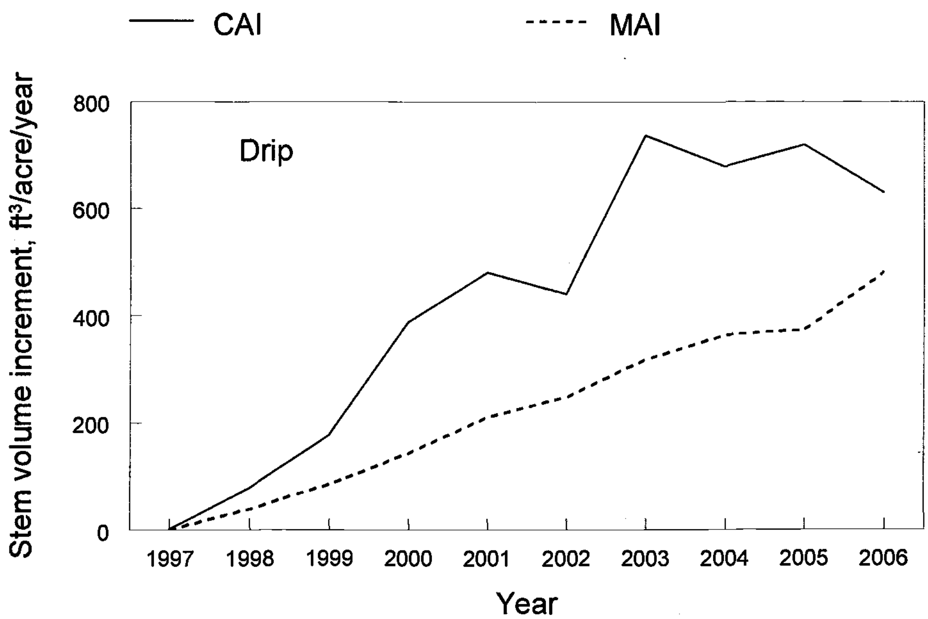


Figure 2. Soil water tension at 8-inch depth in a poplar stand submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR.



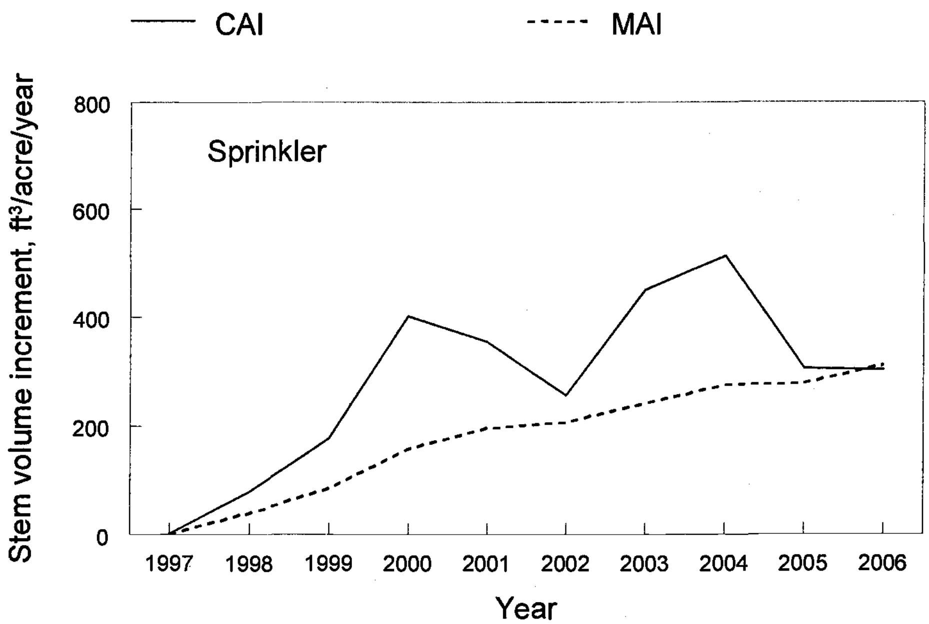


Figure 3. Current annual increment (CAI, annual stem volume growth) and mean annual increment (MAI, mean annual stem volume growth) starting at planting in 1997 through the tenth year for hybrid poplar irrigated with two drip tapes per tree row and with microsprinklers. Data are from plots receiving the highest irrigation rates, Malheur Experiment Station, Oregon State University, Ontario, OR.

EFFECT OF PRUNING SEVERITY ON THE ANNUAL GROWTH OF HYBRID POPLAR THROUGH 2006

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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 might have an effect on tree growth. More 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 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 22.2 percent of the total stem that was pruned (least intensive treatment) to 47.3 percent (most intensive treatment). Treatments were complete in 2004. Stem volume growth in 2006 and over the previous six 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 alternatives. 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 7 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. 2002a).

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 and 0.8 percent organic matter. The field had been planted to wheat for the 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. 2002a) and groundcover research (Shock et al. 2002b) 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 "Mircro-irrigation Alternatives for Hybrid Poplar Production, 2006 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 two rows in each irrigation plot were assigned to pruning treatment 2 (Table 1). The remaining two 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. The pruning treatments were replicated eight times. There was no significant difference between treatments in average DBH, height, or wood volume in the spring of 2000 (Table 3). The trees in treatments 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 2005 were calculated as the difference in the respective parameter between October 2004 and October 2005. Growth increments for the seven seasons (2000-2006) were calculated as the difference in the respective parameter between October 1999 and October 2006.

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 were no differences in the percentage of the tree stem that was pruned. There was no significant difference between treatments in wood volume growth over the years (Table 2). In the fall of 2006, there was no significant difference between treatments in DBH, height, or wood volume (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 highest pruning intensity achieved in this study was 47 percent in 2000.

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Shock, C.C., E.B.G. Feibert, M. Seddigh, and L.D. Saunders. 2002b. Initial growth of irrigated hybrid poplar decreased by ground covers. Western Journal of Applied Forestry 17:61-65.

Table 1. Poplar pruning treatments and actual percentage of total height pruned (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.

Treatment	Pruning height[a] (ft from ground)						Actual percentage of total tree height that was pruned trunk in March						
	1999	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004	2005	2006
1	6	6	9	12	15	18	22.2	22.9	26.1	28.1	30.5	27.7	25.6
2	6	9	12	15	18	18	33.7	29.3	32.0	35.3	29.9	29.9	25.2
3	6	12	15	18	18	18	47.3	39.4	35.2	33.5	30.0	27.5	25.5
LSD (0.05)							2.8	1.9	4.6	2.5	NS	NS	NS

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

Table 2. Wood volume increment for three pruning intensity treatments in hybrid poplar, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Growth increment 2000	2001	2002	2003	2004	2005	2006	1999-2006
	ft³/acre							
1	369.3	379.0	397.4	552.4	571.3	413.7	523.6	3,207
2	360.1	414.5	356.4	542.4	570.3	541.1	478.8	3,264
3	318.9	423.5	328.1	547.8	529.7	473.8	479.6	3,101
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Hybrid poplar tree measurements before and 2 years after the end of pruning treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Nov 99			Nov 06		
Treatment	DBH	Height	Volume	DBH	Height	Volume
	inch	feet	ft³/acre	inch	feet	ft³/acre
1	4.3	30.5	1.1	10.5	70.6	3449.2
2	3.8	29.6	0.9	10.1	72.2	3460.2
3	3.6	29.1	0.8	9.7	70.5	3273.8
average	3.9	29.7	0.9	10.1	71.1	3394.4
LSD (0.05)	NS	NS	NS	NS	NS	NS

POTATO VARIETY TRIALS 2006

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Introduction

New potato varieties were evaluated for their productivity and suitability for processing. Potatoes are grown under contract in Malheur County 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 needs to 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 2006 included the Western Regional Late Harvest Trial with 21 entries, the Oregon Statewide Trial with 24 entries, the Oregon Preliminary Yield Trial with 140 entries, and a Specialty Trial of 25 colored-flesh potato varieties. Through these trials and active cooperation with other scientists in Idaho, Oregon, and Washington, promising new lines are bred, evaluated, and the best of them may eventually 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

10 years. A soil test taken on September 12, 2005 showed 24 lb N/acre in the top foot of soil, and 14 ppm P_2O_5, 362 ppm K_2O, 11 ppm SO_4, 2,072 ppm Ca, 473 ppm Mg, 2.5 ppm Zn, 6 ppm Fe, 4 ppm Mn, 0.4 ppm Cu, 0.5 ppm B, organic matter 0.92 percent, and pH 7.8. Fertilizer was applied in the fall to supply 200 lb P_2O_5/acre, 200 lb S/acre, 4 lb Mg/acre, 2 lb Cu/acre, and 1 lb B/acre. The soil was fumigated in the fall with Telone II® at 25 gal/acre. On April 12 the field was sprayed with Roundup® at 4 pt/acre, and on April 26 the field was bedded on 36-inch row spacing.

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 Trial where Ranger Russet was used as the marker.

The Western Regional Late Harvest Trial was planted on April 27, 2006. The Statewide Trial, the Specialty Trial, and the Oregon Preliminary Yield Trial were planted on April 28. The Oregon Preliminary Yield Trial and the Specialty Trial plots were 20 seed pieces long with 2 replicates, and the Statewide and Western Regional Late Harvest Trials each had plots 30 seed pieces long with 4 replicates.

After planting, hills were reformed 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 10 and were incorporated with the Lilliston. Matrix® herbicide was applied on May 19 and incorporated with 0.375 inch sprinkler irrigation on May 25.

Irrigation was applied 21 times (Fig. 1), from June 7 to September 13, with scheduling based on 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 potential at seed piece depth every 8 hours (Fig. 1). Irrigations were managed to prevent the soil at the seed piece depth from drying beyond 50 kPa water tension until late in the growing season. 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® plus 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 were 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 (J.R. Simplot Co.) at 4 lb/acre plus liquid sulfur at 6 lb S/acre was applied to remedy a nutrient deficiency and to prevent 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 and 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 means separation at the 95 percent confidence level.

Results and Discussion

Potato planting at the Malheur Experiment Station in 2006 was delayed by about 1 week by wet spring weather, with 3.57 inch rain in March and 1.76 inch rain in April. No rain was measured in July, and only 0.08 inch in August. In the 145 days between planting and vine destruction there were 81 days with high temperatures of 86°F or above, and 12 days of 100°F or above, with the maximum of 106°F on July 23. No disease, insect, or mite problems were observed in the field.

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
Among the highest total yields in the Western Regional Late Harvest Trial were produced by 'MWTX2609-4Ru', with 874 cwt/acre, 'MWTX2609-2Ru', with 845 cwt/acre, and 'CO95172-3Ru' with 803 cwt/acre (Table 1). Those three clones also produced among the highest marketable yield, however, their average fry color as measured by light reflectance was too dark for processing into frozen potato products. The clones MWTX2609-4Ru, and MWTX2609-2Ru also produced 2.5 percent sugar ends in this trial, so they may be unsuitable for processing. The clones 'AO96164-1' and 'AOA95155-7' produced 661 cwt/acre marketable yield, with light fry color, zero percent sugar ends, and high specific gravity. Russet Burbank and 'AO96141-3' produced significantly more U.S. No. 2 tubers than other clones in this trial.

Oregon Statewide Trial
In the Oregon Statewide Trial, the six clones marked with an asterisk were retained by the variety selection committee (Table 2). The clone 'AO96160-3' will graduate from the variety selection program to be released as a named variety. The clone 'AO96141-3' will advance to the Western Regional Trial, and the clones 'AO96305-3' and 'AO96365-2' will advance to the Tri-State Trial. The clones 'AO98282-5', and, 'AO00057-2' will be maintained in the Statewide Trial in 2007.

At this location in 2006, 'AO98104-1', 'AO00024-7', 'AO96364-2', and, AO98282-5 produced among the highest total yields. Russet Burbank and Shepody, two check varieties in this trial, produced significantly more U.S. No. 2 tubers, and significantly more culls than the other entries. The clones 'AO98104-1' and 'AO01012-4' produced significantly more small tubers under 4 oz than other clones in this trial. The clones AO96141-3, 'AO00076-4', 'AO99192-2', Ranger Russet, and AO98282-5 had specific gravity, a measure of tuber solids, among the highest in this trial. The clones AO96160-3, AO96141-3, 'AO96164-1', and AO98282-5 had among the lightest fry color for processing. Russet Burbank produced 25 percent sugar ends, significantly more than any other entry in this trial.

Oregon Preliminary Yield Trial
In the Preliminary Yield Trial, 140 numbered clones were compared to Russet Burbank, Ranger Russet, Shepody, and 'Russet Norkotah' (Table 3). The clones 'AO98281-2',

'OR03050-1', 'AO02045-2', and 'AO02126-3' produced among the highest total yield in this trial but were discarded due to undesirable characteristics.

The Oregon potato variety selection committee kept 12 clones, based on their performance at Hermiston, Klamath Falls, Powell Butte, and Ontario, to advance to the Statewide Trial for 2007. The clones that were advanced were: 'AO98259-5', 'AO98286-4', 'AO01057-5', 'AO02019-2', 'AO02019-3', 'AO02019-8', 'AO02027-6', 'AO02103-1', 'AO02182-1', 'AO02183-2', 'AO02196-5', and 'OR03029-2'. These clones yielded well across the four locations (Hermiston, Klamath Falls, and Powell Butte data are not shown in this report), had a low incidence of undesirable characteristics, had high percent U.S. No. 1 grade tubers, and had high specific gravity, light fry color, and resistance to developing sugar ends in response to stress.

Specialty Potato Trial

This was the second year for a colored-flesh potato variety trial at Malheur Experiment Station. Potato tubers with red to yellow carotinoid or red, blue, and purple anthocyanin pigments are of interest because of the antioxidant properties of those pigments in human nutrition. The performance of the colored clones evaluated at this location is shown in Table 4.The clones 'PA96RR1-193', 'POR00PG4-1', 'POR02PG26-5', and 'POR02PG37-2' will advance to the Regional Specialty Trial, while the clones 'POR01PG45-5', 'OR00068-11', 'POR02PG5-1', 'POR03PG12-2', 'POR03PG23-1' and 'POR03PG80-2' will be retained in the Statewide Specialty Trial for 2007.

The clones 'POR02PG2-4' with 1,029 cwt/acre, 'POR02PG26-6' with 941 cwt/acre, and POR02PG5-1with 932 cwt/acre had the highest yields of the 25 clones, far higher than the check varieties 'Yukon Gold' with 467 cwt/acre and 'All Blue' with 532 cwt/acre. Pigmentation of these specialty potatoes is highly variable. The clone POR02PG2-4 produced tubers that were reddish-purple with a red interior flesh. The clone POR02PG26-6 produced round tubers with a yellow skin with pink eyes and creamy yellow flesh. The clone POR02PG5-1 produced yellow tubers with pink eyes with a light yellow flesh. The clones POR02PG2-4, and POR02PG26-6 had a good size distribution for fresh market, but also had tubers that adhered to the stolons, and were sprouting at harvest. The clone POR02PG5-1 produced 299 cwt/acre of oversized tubers, over 10 oz, which are considered cull tubers in the usual markets for specialty potatoes.

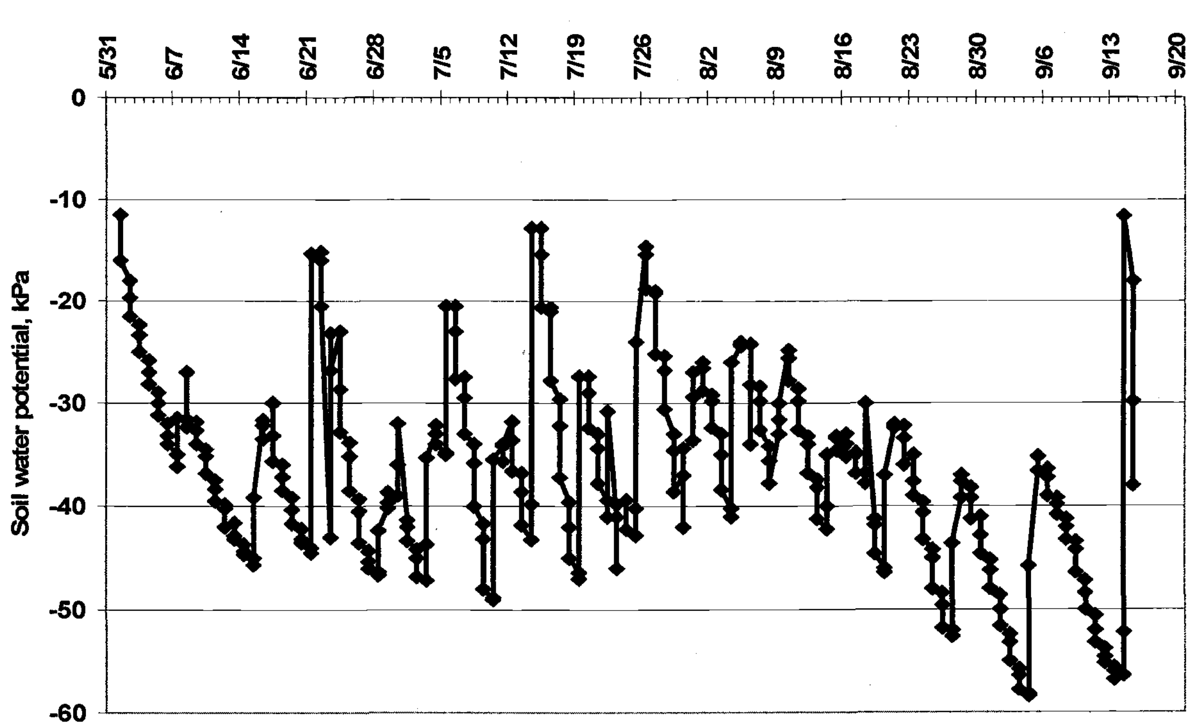

Figure 1. Soil water potential in the sprinkler-irrigated potato variety trials at Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

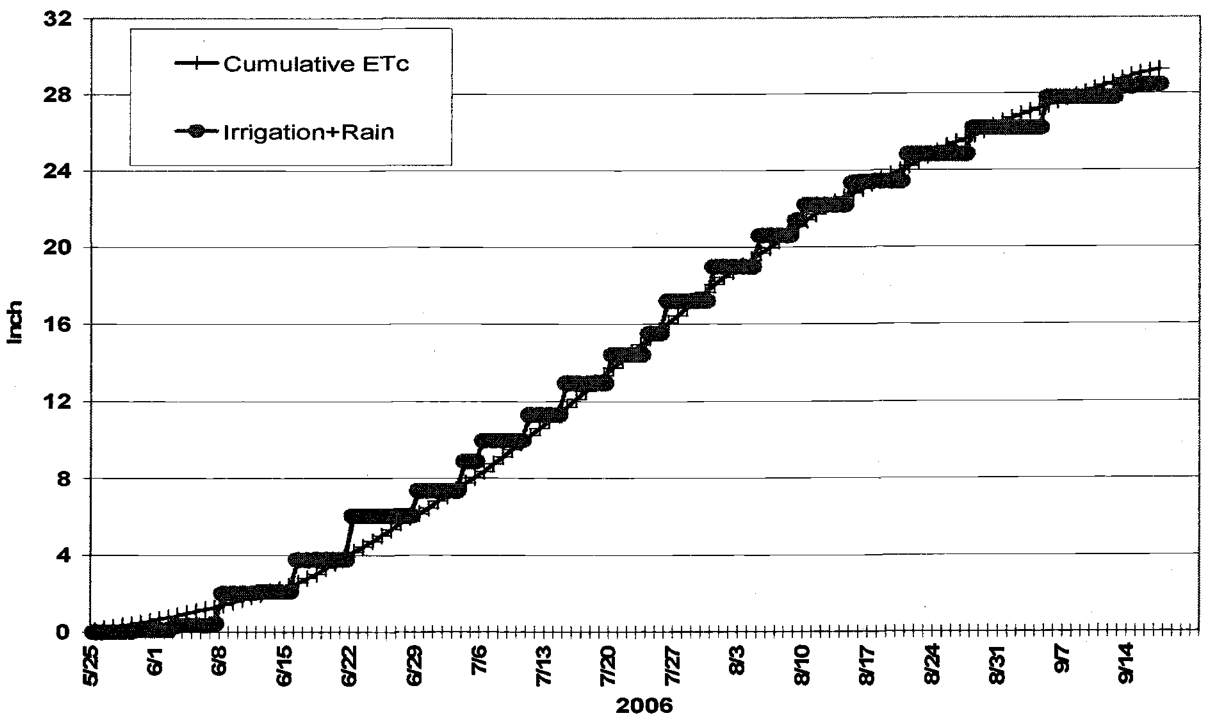

Figure 2. Crop evapotranspiration (ET_C) and sprinkler irrigation applied (plus rain) to potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Table 1. Western Regional Late Harvest Trial potato yield, grade, and processing quality. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

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 6-2 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	cwt/acre	cwt/acre	cwt/acre	cwt/acre	cwt/acre	cwt/acre	cwt/acre	ratio	g cm^{-3}	%	%
Ranger Russet	607	67	402	183	178	41	135	537	30	41	2.02	1.0935	45	0.0
Russet Burbank	648	32	207	44	115	49	260	466	58	123	1.82	1.0704	36	15.0
Russet Norkotah	390	86	338	122	167	49	15	353	28	10	1.90	1.0700	33	5.0
A95074-6	644	80	513	108	272	133	52	566	79	0	1.71	1.0882	45	0.0
A95109-1	571	90	516	304	193	19	42	558	11	2	1.79	1.0830	41	0.0
A95409-1	706	92	648	401	217	31	34	682	16	7	1.93	1.0920	41	0.0
A96104-2	594	81	485	174	244	67	57	543	42	9	1.82	1.0789	43	0.0
AC96052-1RU	596	83	496	93	302	102	22	518	78	0	1.74	1.0827	44	0.0
AO96141-3	665	47	301	57	175	70	302	603	51	11	1.94	1.0925	51	0.0
AO96160-3	627	88	553	117	313	123	21	574	53	1	1.69	1.0940	53	0.0
AO96164-1	698	89	619	218	321	81	42	661	34	4	1.80	1.0941	51	0.0
AOA95154-1	636	84	532	68	332	133	34	566	70	0	1.58	1.0933	47	0.0
AOA95155-7	716	88	627	108	389	131	34	661	51	4	1.68	1.0866	48	0.0
AOTX95265-2ARu	637	76	486	239	207	41	114	600	31	6	1.85	1.0712	35	12.5
AOTX95265-4Ru	654	75	484	231	203	50	133	617	30	7	2.00	1.0710	34	5.0
CO94035-15RU	618	80	496	140	300	57	79	575	40	4	1.58	1.0805	43	0.0
CO95172-3RU	803	80	646	137	407	103	102	748	54	1	1.66	1.0863	35	0.0
CO97137-1W	469	77	362	58	211	94	44	406	62	2	2.16	1.0843	33	7.5
MWTX2609-2Ru	845	78	670	353	274	43	135	805	26	14	1.79	1.0848	34	2.5
MWTX2609-4Ru	874	81	706	340	301	64	122	828	37	9	1.87	1.0856	32	2.5
TXA549-1Ru	589	87	514	253	219	42	50	564	23	2	1.61	1.0821	40	2.5
Mean	647	78	505	178	254	72	87	592	43	12	1.81	1.0840	41	2.5
LSD (0.05)	98	12	109	76	69	27	68	92	17	30	0.21	0.0065	3	6.1

Table 2. Oregon Statewide Trial potato yield, grade, and processing quality. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Total yield	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	565	43	244	44	144	55	235	478	40	47	2.24	1.0706	36	25
Ranger Russet	594	78	463	183	238	42	107	570	22	2	1.94	1.0990	47	0
Shepody	620	48	270	73	151	47	322	592	18	11	1.55	1.0829	42	3
Norkotah	439	88	384	160	171	53	39	422	16	0	1.90	1.0748	35	0
AO96160-3[a]	534	87	469	44	274	151	22	491	43	0	1.72	1.0951	54	0
AO96164-1	574	89	510	131	307	72	26	535	39	1	1.86	1.0936	52	0
AO96141-3[a]	611	65	398	60	237	101	152	550	61	0	1.99	1.1032	52	0
AO96305-3[a]	504	76	383	145	196	42	99	482	21	2	2.16	1.0849	51	0
AO96365-2[a]	664	77	513	103	308	103	98	611	53	0	1.58	1.0878	43	0
AO98282-5[a]	650	81	522	103	305	114	81	604	46	1	1.93	1.0979	52	0
AO98086-1	450	93	419	219	170	30	20	438	12	0	1.80	1.0838	50	0
AO98104-1	746	72	539	86	278	174	113	652	95	0	1.67	1.0838	40	0
AO98129-4	482	71	347	200	126	21	119	465	12	6	1.72	1.0864	46	0
AO98170-4	425	74	315	90	171	54	72	387	37	1	2.02	1.0896	50	0
AO99178-2	603	86	514	119	298	96	45	559	43	0	1.67	1.0888	48	0
AO99179-1	544	83	454	248	176	30	76	530	15	0	2.09	1.0815	47	0
AO99179-4	588	79	463	377	76	11	113	576	11	2	1.97	1.0770	41	3
AO99192-2	598	76	454	42	281	131	81	535	64	0	1.90	1.0994	51	0
AO00018-3	506	88	447	157	233	58	30	478	28	0	1.80	1.0951	48	0
AO00024-7	666	91	603	329	249	25	49	652	14	0	1.74	1.0817	45	0
AO00057-2[a]	460	76	350	125	167	58	86	435	25	0	2.03	1.0888	51	0
AO00076-4	544	87	476	95	267	115	16	491	52	0	1.63	1.1023	47	0
AO00088-11	491	89	437	189	212	36	30	467	25	0	1.78	1.0919	48	0
AO01012-4	470	80	378	26	226	126	12	389	81	1	1.88	1.0949	51	0
Mean	555	78	431	139	219	73	85	516	36	3	1.86	1.0889	47	1
LSD (0.05)	114	9	88	69	64	36	89	123	20	17	0.14	0.0069	3	6

[a]Retained for further testing.

Table 3. Oregon Preliminary Yield Trial potato yield, grade, and processing quality. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Total yield	U.S. No. 1					U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
		Percent No. 1	Total	>12 oz	6-12 oz	4-6 oz								
	cwt/acre	%	----------cwt/acre----------								ratio	g cm^{-3}	%	%
R. Burbank	631	49	311	49	193	68	221	531	49	51	2.14	1.07879	35.0	30.0
Ranger R.	610	79	484	125	270	89	101	585	20	5	1.94	1.09958	45.0	0.0
Shepody	457	57	260	35	163	62	143	403	37	17	1.58	1.08959	42.6	0.0
Norkotah	466	89	420	142	226	52	20	439	26	0	1.95	1.09137	32.4	20.0
AO98259-5 [a]	223	79	171	25	105	41	30	202	21	0	1.69	1.09305	47.1	0.0
AO98286-4 [a]	529	86	460	46	289	125	14	474	54	0	1.63	1.08245	37.1	0.0
AO01057-5 [a]	497	92	457	53	297	107	10	467	30	0	1.72	1.08525	43.9	0.0
AO02019-2 [a]	477	92	437	168	239	31	21	459	18	0	2.55	1.08272	48.3	0.0
AO02019-3 [a]	344	94	325	156	156	12	5	330	14	0	2.23	1.08554	41.6	0.0
AO02019-8 [a]	655	80	518	200	246	72	93	611	43	0	2.42	1.08272	49.9	0.0
AO02027-6 [a]	633	95	599	222	303	75	12	612	21	0	1.95	1.0861	45.6	0.0
AO02103-1 [a]	456	92	418	103	257	58	23	440	15	0	1.68	1.08235	48.3	0.0
AO02182-1 [a]	514	82	420	88	242	90	33	454	60	0	2.03	1.08096	42.6	0.0
AO02183-2 [a]	653	90	586	270	287	29	38	623	30	0	1.89	1.09365	55.3	0.0
AO02196-5 [a]	714	92	658	271	318	69	27	684	29	0	1.79	1.09817	50.2	0.0
OR03029-2 [a]	391	22	87	0	17	70	2	90	301	0	1.56	1.10348	50.9	0.0
Mean	511.6	81.8	417.4	135.4	212.8	69.2	51.4	468.8	40.3	2.5	1.82	1.08852	44.4	1.5
LSD (0.05)	93.4	9.4	99.9	89.7	69.8	32.1	40.7	92.6	21.0	13.0	0.18	0.00817	3.9	6.8

[a]Retained for further testing.

Table 4. Specialty Potato Trial yield and grade of colored-flesh clones. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Total yield	B-10 oz	4-10 oz	4-6 oz	6-10 oz	Under 4 oz	Over 10 oz	U.S. No. 2	Cull	Twos plus culls	Rotten tubers
	cwt/acre										
All Blue	532	457	242	151	91	215	33	42	0	42	0
Yukon Gold	467	224	197	41	155	28	225	3	0	3	1
PA96RR1-193[a]	598	583	413	248	164	171	11	2	0	2	2
PA97B36-3	640	464	411	123	288	53	169	3	2	5	0
POR00PG4-1[a]	407	299	231	72	159	69	89	19	0	19	0
POR01PG45-5[a]	684	597	439	174	266	158	76	9	0	9	1
OR00068-11[a]	747	653	439	217	221	214	65	29	0	29	1
OR00068-29	343	323	111	85	26	213	15	4	0	4	0
POR02PG2-4	1029	963	487	275	212	476	50	14	0	14	4
POR02PG4-2	220	210	20	17	2	190	5	6	0	6	0
POR02PG5-1[a]	932	480	363	140	223	118	299	39	0	39	1
POR02PG26-4	549	479	384	162	222	95	57	4	6	10	3
POR02PG26-5[a]	720	619	498	208	291	121	62	37	0	37	2
POR02PG26-6	941	811	447	267	180	364	34	95	0	95	2
POR02PG26-11	786	626	464	216	248	162	115	23	0	23	4
POR02PG37-2[a]	527	496	323	173	150	173	26	4	0	4	1
POR03PG12-2[a]	474	409	319	166	153	90	39	27	0	27	0
POR03PG23-1[a]	467	383	183	134	50	199	2	76	0	76	7
POR03PG25-2	494	456	146	117	29	310	10	25	0	25	3
POR03PG38-1	583	471	392	137	255	79	109	2	0	2	0
POR03PG43-1	699	614	363	218	146	250	27	58	0	58	0
POR03PG46-1	571	224	199	39	160	25	327	18	0	18	1
POR03PG74-3	625	271	250	49	201	21	278	50	0	50	17
POR03PG74-4	643	502	434	141	292	68	137	1	0	1	0
POR03PG80-2[a]	519	353	327	76	251	26	159	6	0	6	2
Mean	608	479	323	146	177	155	97	24	0	24	2
LSD (0.05)	99	97	67	57	47	59	88	47	ns	48	7

[a]Retained for further testing.

IRRIGATION SYSTEMS AND BED CONFIGURATION INFLUENCE POTATO PERFORMANCE

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Introduction

Methods of irrigation used in potato production must ensure adequate and uniform application of water with minimum losses, such as deep percolation and runoff. Maintenance of a proper balance between soil water and soil air in the root zone for ideal root and tuber growth can be achieved by careful management of irrigation scheduling with properly designed furrow-, sprinkler-, and drip-irrigation systems.

Surveys of growers in the Treasure Valley of southeastern Oregon and southeastern Idaho indicated that 'Russet Burbank' tends to produce better quality tubers under sprinkler irrigation than with furrow irrigation (Shock et al. 1989, Trout et al. 1994). Shock conducted two replicated plot trials and two field demonstrations in growers' fields and Trout et al. (1994) carried out irrigation plot studies over 3 years on two sites to determine if the differences observed between sprinkler and furrow irrigation were an inherent result of the irrigation method. With precise irrigation scheduling, irrigation method did not affect yields, but sprinkler irrigation produced tubers with slightly better grade and much lower incidence of sugar ends.

Although potato is still most often irrigated using sprinkler irrigation, drip systems are used in potato production in a few areas where water is in short supply. Sammis (1980) compared sprinkler, surface drip, subsurface drip, and furrow irrigation for the production of potato and lettuce in New Mexico. The subsurface drip system with an irrigation criterion, meaning the point at which the next irrigation must be applied, corresponding to a soil water tension (SWT) of 20 kPa was the most productive among the irrigation systems assessed.

Shock et al. (2002) investigated the performance of 'Umatilla Russet' under drip irrigation in silt loam. The factors considered in the study were tape placement (one tape per row or one tape per two rows) and four SWT levels for automatically starting irrigation (15, 30, 45, and 60 kPa). Tape placement and irrigation criterion interacted to influence total yield, total marketable potatoes, and U.S. No. 2 yield. Results from this study indicated that potato should be irrigated at 30 kPa SWT, given the silt loam soil and 2.5 mm water applied at each irrigation. Eldredge et al. (1996) and Shock et al. (2002) determined that the ideal potato SWT irrigation criterion for furrow and sprinkler irrigation was 50-60 kPa on silt loam in the Treasure Valley.
Over the last 4-5 years, drip-irrigated potato trials carried out at the Malheur Experiment Station (MES) have shown reasonable tuber yields and grade (Shock et al. 2002, 2004,

2005; Akin et al. 2003). Although potato production normally uses hilled planting, our drip-irrigated trials have used flat beds. The flat beds have been used by preference, since we have studied the relative lateral placement of potato rows and drip tapes (Shock et al. 2002, 2004, 2005) along with other variables. If growers were to adopt drip irrigation, it would be more convenient if they could use drip irrigation in normal hilled beds.

Consequently, in 2004 hilled beds for sprinkler- and drip-irrigated potatoes were compared with flat beds with drip-irrigated potatoes (Shock et al. 2005). Potatoes planted in flat beds with one drip tape above the rows were more productive and of better quality than drip-irrigated potatoes grown in conventional beds. These results led us to propose that part of the benefits in potato quality observed with drip irrigation at Ontario over the past years might be associated with flat bed configuration and not with drip irrigation alone, per se.

Midmore et al. (1986) showed that mulch increased tuber yield by 20 percent during the summer in Peru. In the same country, Manrique and Meyer (1984) studied the impact of mulch on potato production during winter and summer seasons and found no effect on yields during the winter, but observed yield increases of 58 percent and improvements in soil moisture retention in the summer with surface mulch. Mahmood et al. (2002) reported that the use of mulch in Pakistan decreased daily maximum soil temperature at 6-inch depth, resulting in faster emergence, earlier canopy development, and higher tuber yields.

Since tuber yield and grade are affected by soil water status and heat stress, the main goal of this research was to investigate whether irrigation systems, irrigation criteria, bed configuration, and use of straw mulch can generate differences in soil temperature regime around the developing tubers, and quantify the influence of such management practice factors on the performance of six potato cultivars grown during the crop season of 2005 at Ontario, Oregon.

Materials and Methods

Six irrigation and bed configuration treatments were chosen to try to use irrigation system, bed design, irrigation criteria, and straw mulch to reduce soil temperature, as described below:

T_1 – Sprinkler irrigation, potato seeds planted in ordinary beds (rows bedded into 36-inch hills), with irrigation starting whenever the SWT was equal to 60 kPa;
T_2 – Drip irrigation, potato seeds planted in flat beds, with irrigation criterion based on a SWT of 30 kPa, with the expectation that the total irrigation amounts would correspond to about 70 percent of crop evapotranspiration (ET_c);
T_3 – Drip irrigation, potato seeds planted in flat beds, with daily irrigation matching ET_c;
T_4 – Furrow irrigation, seeds planted in ordinary beds, with irrigation starting when SWT reached a threshold of 60 kPa;
T_5 – Sprinkler irrigation, seeds planted flat in 36-inch rows, irrigation criterion of 60 kPa, and with irrigation amounts to match ET_c;

T_6 – Sprinkler irrigation, seeds planted flat in 36-inch rows, with irrigation starting at a SWT of 60 kPa, soil receiving 2,000 lb/acre of straw mulch at tuber initiation (on June 6), and irrigation amounts to match ET_c.

Procedures in 2005

All 6 treatments were replicated 7 times and the experimental design was split plot in a randomized complete block design, with a total of 42 plots and 252 subplots for 6 varieties.

The soil preparation for this trial differed from our usual practices. The soil was too wet to work or fumigate in the fall of 2004. Vapam® was applied at 75 gal/acre via sprinklers on March 3, 2005 and the field was spring bedded in April prior to planting. The summer weather pattern in 2005 was similar to 2004 and also similar to the 10- and 60-year averages.

Six potato cultivars ('Russet Burbank', 'Ranger Russet', 'Umatilla Russet', 'GemStar Russet', 'A92294-6', and 'A93157-6LS') were planted on April 19, 2005 in 42 12-ft-wide strips, each 90 ft long at MES, Oregon State University, in Ontario, Oregon. The planted harvest area of each cultivar was 30 seed pieces long.

Potato seed pieces (45 g) were treated with Tops-MZ® plus Gaucho® dust 1-2 weeks before planting, and then planted using a 2-row cup planter with 9-inch seed spacing in 36-inch rows. Planting depth was adjusted to plant the seed in each flat bed plot deeper than the seed was planted in each hilled treatment plot. After planting, hills were formed over the rows with a Lilliston rolling cultivator for the hilled treatment and a bed harrow for the flat bed treatments. Prowl® at 1 lb/acre plus Dual® at 2 lb/acre herbicide was applied as a tank mix for weed control on May 2 and was incorporated by 1.7 inch of rain over the following 10 days.

The soil temperature was measured continuously throughout the growing season in every plot at 4-inch depth below the surface in the plant row among the developing tubers using Hobo soil thermometers and dataloggers. Twelve of the plots had two additional temperature sensors at 4- and 8-inch depth on NASA SensorWeb Pods (NASA Jet Propulsion Lab, Pasadena, CA). Four pods were located in each of the sprinkler-, drip-, and furrow-irrigated potato plots.

The SWT was measured by granular matrix sensors (GMS, Watermark soil moisture sensors model 200SS, Irrometer, Co., Riverside, CA) at six locations in every plot at 8-inch depth below the surface in the plant row. Sensor data were read automatically using CR10 and 21X dataloggers and multiplexers (Campbell Scientific, Logan, UT). The GMS had been previously calibrated to SWT using tensiometers fitted with pressure transducers (Shock et al. 1998).

Irrigation episodes were scheduled to avoid SWT in the root zone exceeding the threshold of 30 kPa under the drip system for treatments 2 and 3, and of 60 kPa under furrow- and sprinkler-irrigation systems for treatments 1, 4, 5, and 6. Crop evapotranspiration (ET_c) was estimated by an automated AgriMet (U.S. Bureau of Reclamation, Boise, ID) station located about 0.25 miles from the trial on the Malheur Experiment Station.

Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold® and Bravo® at 1.5 pt/acre on June 13. On June 18, Endura® plus Dithane® was applied; on June 28, Dithane fungicide plus liquid sulfur with 6 lb phosphate (P_2O_5)/acre was applied on June 28. Bravo was applied again on July 20 and September 6. Dithane plus Tanos® was applied July 28. To prevent two-spotted spider mite and powdery mildew infestation, 6 lb sulfur (S)/acre was applied on August 20.

Petiole tests were taken from Russet Burbank plants every 2 weeks starting on June 13 for the sprinkler-, furrow-, and drip-irrigated potatoes. Potatoes in each irrigation system received nutrients in accordance with the petiole analyses. A total of 100 lb nitrogen (N)/acre, 40 lb P_2O_5/acre, 20 lb potash (K_2O)/acre, 30 lb sulfate (SO_4)/acre, 3.5 lb magnesium (Mg)/acre, 0.55 lb zinc (Zn)/acre, 0.8 lb manganese (Mn)/acre, 0.05 lb copper (Cu)/acre, 0.1 lb iron (Fe), and 0.02 lb boron (B)/acre was applied via drip irrigation system. The furrow-irrigated potatoes received 100 lb N/acre, 30 lb P_2O_5/acre, 10 lb SO_4/acre, 10 lb Mg/acre, 0.25 lb Zn/acre, 0.5 lb Mn/acre, and the sprinkler-irrigated potatoes received 100 lb N/acre, 50 lb P_2O_5/acre, 20 lb K_2O/acre, 4.5 lb SO_4/acre, 5 lb Mg/acre, 0.3 lb Zn/acre, 0.55 lb Mn/acre, 0.05 lb Cu/acre, 0.1 lb Fe/acre, and 0.02 lb B/acre.

Procedures in 2006

All 6 treatments were replicated 5 times and the experimental design was split plot in a randomized complete block design, with a total of 30 plots and 180 subplots for 6 varieties. More temperature sensors were used in 2006.

Procedures both years

Four potato cultivars ('Russet Burbank', 'Ranger Russet', 'Umatilla Russet', and 'A93157-6LS') were planted both years.

Vines were flailed in late September and tubers were harvested on October from each replicate, and graded by the U.S. No. 1 and No. 2 for processing standards, sorted by weight, and weighed in each size category. Specific gravity and length-to-width ratio were measured using a sample of 10 tubers. Stem and bud ends fry color was measured from a sample of 20 tubers frying in 375°F soybean oil for 3.5 minutes from each cultivar of every irrigation plot. Fry colors were read 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. Visual evaluations included observations of desirable traits, such as a high yield of large, smooth, uniformly shaped and sized, oblong to long, attractively russeted tubers, with shallow eyes evenly distributed over the tuber length.

Data were analyzed with the General Linear Models analysis of variance procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT) using the Fisher's Protected LSD means separation t-test at the 95 percent confidence level.

Results and Discussion

Irrigation systems and hilled rows made clear differences in potato performance among the cultivars studied. The drip-irrigation systems were the most conducive to the production of U.S. No. 1 tubers and the furrow-irrigation system was the least conducive (Table 1). Furrow irrigation was the least productive system tested. There was a tendency for flat beds to be advantageous compared to hilled rows. Not all of the statistical comparisons have been made.

None of the varieties tested expressed hollow heart, brown center, internal brownspot, or vascular discoloration in any of the irrigation treatments. The absence of these internal defects is commonplace for potato grown at MES.

The experimental line A93157-6LS was highly productive in every management system and averaged 76 percent U.S. No. 1 tubers. A93157-6LS produced U.S. No. 1 tubers under drip irrigation, regardless of the irrigation criteria adopted (data not shown).

Under drip irrigation, total yields were higher with drip irrigation and full ET_c than with drip irrigation using SWT; however, irrigation by SWT resulted in a greater proportion of U.S. No. 1 tubers and a less production of U.S. No. 2 tubers. Therefore, the application of full ET_c for drip-irrigation systems may not be needed to maximize potato productivity or optimize crop water use. Firm conclusions will have to wait for the evaluations of how much water was actually applied to each treatment.

As to mulching, there was a tendency for the straw mulch treatment to be advantageous compared to non-strawed potatoes, but the differences were not statistically significant. Nevertheless, further statistical analyses, taking into consideration soil temperature and moisture, need to be made to allow for more consistent inferences on the beneficial effect of mulching for potato production at Ontario. One result is clear: tubers from Umatilla Russet and A93157-6LS sprinkler-irrigated mulched rows planted flat were smoother than tubers from conventional sprinkler-irrigated hilled rows without mulch.

Thinking outside of conventional wisdom at the beginning of this project, we asked a series of questions:

a. Would it be possible to use sprinkler irrigation in such a way to reduce the heat load to developing tubers compared with conventional furrow irrigation? The answer to this question is apparently yes. But sprinkler irrigation does not seem to be as important as the shape of the hills.

b. Could potato be planted flat rather than bedded in "hills", so that the average tuber would be deeper from the surface? A flat bed might heat slower than a corrugated bedded hill soil surface. Would the deeper planting and flatter surface lead to cooler peak soil temperature around the developing tubers? Flatter beds appeared to result in cooler tubers and better quality tubers. The conventionally hilled soil tended to get hotter regardless of the irrigation system, but the soil in the conventionally hilled furrow irrigation system was hottest.

c. Could mechanically applied straw mulch moderate peak soil temperatures at tuber depth? Probably yes, but the effect is small and less than cooling contribution of the shape of the bed alone. Straw was of only modest benefit in reducing soil temperature. A heavier straw application would probably have been required to significantly lower maximum temperatures and heat load.

d. Would sprinkler irrigation, flat planting, and straw mulch interact to cool the temperature environment around developing tubers? If so, would the cooler soil temperatures be beneficial to the tubers? Yes. The cooler beds were beneficial to tuber quality. But the main effect seems to have been the bed shape. Sprinkler-irrigated potatoes had cooler soil temperatures when planted in flat beds.

e. So what about potato quality? Potato yields and tuber quality from the flat beds (treatments with cooler soil temperatures) tended to be improved compared to the conventionally hilled beds, over all potato varieties tested. But soil temperature is not all that is going on, since potatoes irrigated modestly by drip using a soil water tension (SWT) criterion were excellent (Table 1).

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Table 1. Potato tuber yield and quality in response to six irrigation and bed configuration treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2005 and 2006.

Treatments	Total yield	Total marketable	Yield by grade category									Specific gravity	Fry color		
			U.S. No. 1	Total No. 1	>12 oz	6-12 oz	4-6 oz	U.S. No. 2	<4 oz	Cull	Rot		Stem end	Bud end	Average
	--------cwt/acre------		%	----------------------------cwt/acre----------------------------								g cm^{-3}	---% light reflectance---		
Russet Burbank	621	34	50	109	53	212	239	450	71	74	25	1.0806	33	43	38
Ranger Russet	553	62	50	159	130	339	136	475	50	25	3	1.0969	44	45	45
Umatilla Russet	519	62	52	160	108	319	121	440	55	18	5	1.0930	47	47	47
A93157-6LS	603	76	60	220	175	455	89	545	45	10	3	1.0945	46	45	46
Means overall	574	58	53	162	116	331	146	478	56	32	9	1.0913	43	45	44
LSD (0.05)	25.1	3.0	6.2	14.9	16.7	24.1	16.1	26.7	5.7	7.7	6.7	0.0022	1.0	0.7	0.7
Sprinkler, hilled	580	56	49	160	109	318	163	481	58	27	14	1.0907	42	45	44
Drip, flat bed, SWT	562	66	69	180	124	373	96	468	59	27	7	1.0922	44	46	45
Drip, flat bed, ET	596	59	60	173	124	356	124	481	63	49	5	1.0917	44	45	44
Furrow, hilled	526	52	49	141	73	264	174	437	50	28	11	1.0913	40	44	42
Sprinkler, flat bed	581	57	45	156	127	328	163	490	54	31	6	1.0913	43	45	44
Sprinkler, flat, straw	597	60	46	161	143	351	157	508	48	29	12	1.0905	43	46	44
Means overall	574	58	53	162	116	331	146	478	56	32	9	1.0913	43	45	44
LSD (0.05)	32.9	3.6	7.0	15.0	19.3	27.3	24.3	34.3	8.4	12.6	NS	NS	1.4	1.2	1.2
2005 Sprinkler, Hilled	651	49	46	152	121	319	233	551	78	7	14	1.0866	44	45	45
2005 Drip, Flat bed, SWT	618	71	62	201	176	439	119	558	59	1	1	1.0880	43	43	43
2005 Drip, Flat bed, ET	662	67	57	209	178	444	147	591	62	9	1	1.0900	44	43	44
2005 Furrow, Hilled	567	47	44	129	94	267	228	495	57	5	9	1.0920	42	44	43
2005 Sprinkler, Flat bed	654	52	49	163	132	344	229	572	73	8	1	1.0887	44	44	44
2005 Sprinkler, Flat, Straw	670	55	46	158	159	363	233	596	65	8	1	1.0882	44	45	45
Means 2005	637	57	51	169	143	363	198	560	65	6	5	1.0889	44	44	44
2006 Sprinkler, hilled	510	64	51	169	97	317	94	411	39	46	14	1.0948	40	46	43
2006 Drip, flat bed, SWT	506	61	77	159	71	307	72	379	60	53	14	1.0963	45	49	47
2006 Drip, flat bed, ET	531	51	63	136	69	268	102	371	64	88	9	1.0934	43	47	45
2006 Furrow, hilled	486	56	54	154	52	260	120	379	43	52	12	1.0905	38	44	41
2006 Sprinkler, flat bed	509	62	42	149	122	312	97	409	36	55	10	1.0938	41	46	44
2006 Sprinkler, flat, straw	524	66	46	165	126	338	82	419	32	50	22	1.0927	41	47	44
Means 2006	511	60	56	155	89	300	94	395	46	57	14	1.0936	42	46	44
LSD (0.05) Year	30.8	2.9	5.2	NS	25.3	NS	18.8	40.0	6.1	4.6	NS	0.0037	NS	0.5	NS
LSD (0.05) Year x tmt	NS	5.0	NS	21.3	27.3	38.6	34.4	NS	11.9	17.8	11.1	0.0040	2.0	1.7	1.7
LSD (0.05) Year x cltvr	NS	4.2	NS	NS	23.5	34.0	22.8	NS	8.1	10.9	9.4	0.0031	1.4	NS	1.0
LSD (0.05) Tmt x cltvr	NS	7.3	15.2	36.4	NS	59.0	39.5	NS	NS	18.9	16.4	0.0054	NS	NS	NS

SOYBEAN PERFORMANCE IN ONTARIO IN 2006

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Introduction

Soybean is a potentially valuable new crop for the Pacific Northwest. Soybean could 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 could 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 and lodging, reduced plant height, 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 to avoid contamination of 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. Its objective was to provide a more uniform distribution of the plants over the soil surface. The new planting configuration had 3 plant rows on a 30-inch bed. The more uniform plant distribution resulted in higher yields, perhaps due to improved access to light, nutrients, and water for individual plants.

This report summarizes work done in 2006 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 2006 trial was conducted on a Owyhee silt loam (pH of 7.6 and 0.9 percent organic matter) previously planted to wheat. Twenty-one lb N, 100 lb P, 100 lb S, 2 lb Cu, and 1 lb of B were broadcast in the fall of 2005. In the fall of 2005, after fertilization, the field was disked twice, moldboard plowed, groundhogged twice, and bedded to 30-inch rows. On May 26, 2006, 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. The 39 selections were evaluated in 10-ft by 25-ft plots arranged in a randomized complete block design with four replicates. The seed was planted on May 24 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). *Rhizobium japonicum* soil implant inoculant was applied in the seed furrow at planting. Emergence started on May 30.

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). 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 (M.K. Hansen Co., East Wenatchee, WA).

For lygus bug, stinkbug, and spider mite control, the field was sprayed with Carzol® at 0.69 lb ai/acre on July 24 and on July 29, and with dimethoate at 0.5 lb ai/acre and Comite® at 1.6 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 7 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

Consistent with previous years, 2006 soybean production at Ontario included inoculation with *Rhizobium* strains specific to soybeans, control of pests (especially lygus bug and spider mite), modest fertilization, and consistent irrigation. Lack of inoculation or lack of pest control compromises the crop. Heavy fertilization, especially with N, has resulted in severe lodging in growers fields and poor recovery of beans.

Yields in 2006 ranged from 64.4 bu/acre for 'M92-085" to 81.9 bu/acre for 'Lambert' (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. On average, yields in 2005 and 2006 were higher than in the previous 3 years (Table 2), possibly as a result of the modified planting configuration. The planting configuration used previously had seeds planted in single rows on 22-inch beds. In 2005 and 2006 there were 3 rows on a 30-inch bed (Fig. 1).

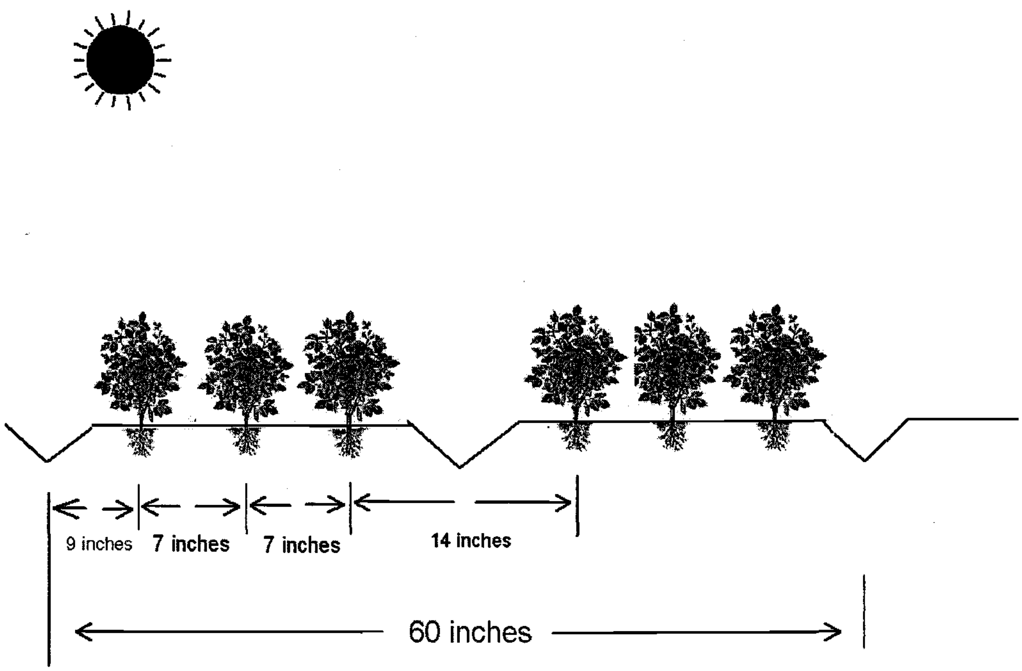

Figure 1. Soybean planting configuration used in 2005 and 2006, Malheur Experiment Station, Oregon State University, Ontario, OR.

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 *Rhizobium japonicum* inoculation, proper May planting dates, appropriate irrigation, and timely control of lygus and spider mites.

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Table 1. Performance of soybean cultivars ranked by yield in 2006, 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
Lambert		99	106	7.8	90	2,344	81.9
Gnome 85		93	100	8.8	95	2,278	75.3
107	M92-085	93	100	4.3	95	2,274	74.2
M4	M92-330	93	100	6.3	95	2,345	72.6
103	M92-085	93	100	5.5	95	2,287	72.4
OR-6		93	100	8.5	85	2,300	72.2
M3	M92-330	93	100	7.3	100	2,285	72.2
312	M92-220	93	100	4.0	80	2,480	71.8
Evans		93	100	8.5	100	2,431	71.0
Korada		93	100	5.5	95	2,315	70.6
M1	M92-330	93	100	5.5	95	2,216	70.6
106	M92-085	93	100	4.5	90	2,259	70.4
101	M92-085	93	100	5.3	95	2,172	70.2
511	M92-237	105	112	3.8	90	2,573	70.2
M2	M92-330	93	100	5.3	100	2,295	70.0
M12	M92-330	93	100	6.5	90	2,208	70.0
307	M92-220	93	100	3.0	80	2,495	70.0
OR-8		105	112	8.7	75	2,142	69.6
M16	M92-330	93	100	5.3	95	2,310	69.6
M92-220		93	100	6.0	85	2,463	68.8
M15	M92-330	93	100	6.3	95	2,201	68.4
313	M92-220	93	100	4.3	85	2,523	68.4
M9	M92-330	93	100	2.5	85	2,455	68.2
608	M92-314	93	100	5.5	95	2,399	68.0
311	M92-220	93	100	3.3	80	2,510	67.4
303	M92-220	93	100	4.8	85	2,421	67.0
Sibley		105	112	8.5	85	2,273	66.8
M13	M92-330	93	100	6.5	100	2,328	66.6
104	M92-085	93	100	6.3	95	2,154	66.6
305	M92-220	93	100	5.3	85	2,490	66.6
514	M92-237	93	100	7.0	90	2,316	66.6
601	M92-314	93	100	3.8	80	2,475	66.4
309	M92-220	93	100	3.3	80	2,499	66.2
905	OR-6	93	100	8.8	85	2,318	66.2
909	OR-6	93	100	8.5	85	2,196	66.2
M92-225		93	100	6.8	100	2,418	66.0
108	M92-085	93	100	3.5	95	2,355	65.8
308	M92-220	105	112	3.3	80	2,622	65.2
M92-085		93	100	5.3	95	2,324	64.4
LSD (0.05)				1.7		181	6.1

Table 2. Performance of soybean varieties over the last few years, Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Yield			Average 2002-2006			
	2005	2006	Average	Days to maturity	Lodging	Height	Seed count
	bu/acre				0-10	cm	seeds/lb
107	76.6	74.2	75.4	82	3.5	86	2,187
M12	70.4	70.0	70.2	82	4.3	86	2,125
M9	73.9	68.2	71.1	80	5	87	2,217
106	72.0	70.4	71.2	81	3.6	83	2,117
103	73.7	72.4	73.1	82	3.7	91	2,140
M15	73.9	68.4	71.2	82	3.6	92	2,204
Lambert	73.3	81.9	77.6	93	8.1	86	2,343
M1	73.0	70.6	71.8	82	3.8	85	2,239
104	70.9	66.6	68.8	80	4.1	93	2,228
M3	69.6	72.2	70.9	84	3.6	93	2,254
108	70.5	65.8	68.2	79	3.2	86	2,180
M4	73.0	72.6	72.8	84	3.1	84	2,236
M92-085	71.9	64.4	68.2	81	3.7	88	2,155
312	68.4	71.8	70.1	87	2.3	91	2,428
101	74.4	70.2	72.3	82	4.1	91	2,094
M16	69.1	69.6	69.4	81	2.8	93	2,183
M13	67.9	66.6	67.3	80	3.5	92	2,251
Korada	67.8	70.6	69.2	87	4.4	86	2,384
601	65.6	66.4	66.0	84	2.7	91	2,379
303	67.7	67.0	67.4	84	3.8	94	2,469
M2	62.0	70.0	66.0	85	4.3	84	2,144
511	65.0	70.2	67.6	86	3.2	89	2,519
307	64.3	70.0	67.2	85	2.9	90	2,497
608	70.2	68.0	69.1	80	3.8	87	2,161
305	64.2	66.6	65.4	85	2.7	84	2,450
309	67.5	66.2	66.9	84	3.1	91	2,501
514	68.6	66.6	67.6	80	2.5	90	2,284
M92-220	63.4	68.8	66.1	86	4.4	97	2,515
313	62.5	68.4	65.5	86	4.5	91	2,460
311	68.1	67.4	67.8	85	2.1	87	2,404
308	64.6	65.2	64.9	85	1.8	88	2,503
Gnome 85	65.4	75.3	70.4	89	8	86	2,220
M92-225	68.0	66.0	67.0	78	3.7	90	2,292
909	70.8	66.2	68.5	79	7.4	87	2,301
905	71.1	66.2	68.7	79	7.5	86	2,378
OR-6	65.1	72.2	68.7	84	7.9	85	2,328
Evans	69.3	71.0	70.2	88	8.8	88	2,232
Sibley	56.2	66.8	61.5	88	9	87	2,111
OR-8	57.8	69.6	63.7	88	8.8	85	2,102
Average	68.4	69.2	68.8				
LSD (0.05)	8.0	6.1					

SUGAR BEET VARIETY TRIALS 2006

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Introduction

The sugar beet industry in southern Idaho and eastern Oregon, in cooperation with Oregon State University, tests commercial and experimental 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 2006 trials.

Methods

Sugar beet varieties were entered by ACH Seeds, Betaseed, Hilleshog/Syngenta, Holly Hybrids, and Seedex in 2006. Twenty-seven varieties were tested in the Commercial Trial, and 32 varieties (including the four commercial check varieties) were tested in the Experimental Trial. Seed was organized by Amalgamated Sugar Company, Paul, Idaho.

The 2006 sugar beet trials were grown on Owyhee silt loam with winter wheat as the previous crop. A soil test taken on September 26, 2005, showed 39 lb available N/acre in the top 2 ft of soil. The top foot of soil had pH 7.6, 0.81 percent organic matter, 24 ppm P, 379 ppm K, 10 ppm SO_4, 480 ppm Mg, 128 ppm Na, 0.6 ppm Zn, 9 ppm Fe, 8 ppm Mn, 0.4 ppm Cu, and 0.4 ppm B. The grain stubble was chopped and the field was irrigated and disked, then 100 lb P_2O_5/acre, 100 lb S/acre, 13 lb Zn/acre, 2 lb Cu/acre, and 3 lb B/acre fertilizer were applied based on the soil sample analysis.

The field was deep ripped in the fall, plowed, groundhogged, and bedded on 22-inch rows with Telone C17® at 15 gal/acre. On April 13, 2006, the tops were dragged off the beds with a bed harrow and on April 14, Nortron® was applied at 6 pt/acre and incorporated using the bed harrow.

Both the Commercial Trial and the Experimental Trial were planted on April 18. Seed for the 32 varieties tested in the Commercial Trial, and 27 varieties (including the 4 commercial check varieties) tested in the Experimental 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 4-ft alley separating each tier of plots. The seeding rate was 12 viable seed/ft of row. Each entry was replicated eight times in a randomized complete block design.

On April 21, Counter® insecticide was applied in a band over the row at 7.4 lb/acre to protect the emerging seedlings. The first irrigation was applied on April 24 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 Watermark soil moisture sensors Model 200SS (Irrometer Co. Inc., Riverside, CA) connected to an AM400 Hansen datalogger (M.K. Hansen Co., Wenatchee, WA) to maintain the soil water tension wetter than 50 centibar at 10-inch depth in the beet row.

Beets had emerged by May 4 and had four leaves by May 11. Alleys were hoed on May 15. On May 16 and 17, seedlings were thinned by hand to one plant per 7 inches, and the field was hand weeded during thinning. On May 22, urea was sidedressed to supply 180 lb N/acre.

The field was sidedressed with Temik 15G® at 10 lb/acre on May 27 to control sugar beet root maggot, and recorrugated. The field was irrigated for 24 hours on May 30 to move the insecticide with the wetting front into the sugar beet seedlings' root zone, and irrigated again on June 7. The field was cultivated and recorrugated the final time on June 15. The field was hand weeded on June 12, July 5, July 26, and August 15.

Gem® fungicide at 7 oz/acre plus Super-Six® sulfur at 1 gal/acre were applied by aerial applicator on June 14 for control of powdery mildew. On July 1, Topsin-M® at 20 oz/acre plus Dithane® fungicide at 2 lb/acre were applied by aerial applicator. The first petiole test, taken on July 3, showed nitrate slightly high at 11,852 ppm, when the sufficiency level was 9,426 ppm; all of the other nutrients were sufficient. Sulfur at 6 lb/acre plus Headline® at 12 oz/acre were sprayed by airplane on July 18 to control powdery mildew.

A second petiole test taken on July 17 showed nitrate slightly low at 7,154 ppm, when the sufficiency level was 8,334 ppm; sulphate was slightly deficient; magnesium was marginally sufficient; and all of the other nutrients were sufficient. Epsom salt was applied in irrigation on July 19 to supply 5.8 lb magnesium and 7.6 lb sulphate/acre. The third petiole test, taken on August 3, showed deficiency in zinc and phosphate, which was remedied on August 7 by an aerial application of 0.2 lb Z, 1.5 lb P_2O_5, and 6 lb S/acre. The fourth petiole test, taken on August 14, showed nitrate was deficient at 2,712 ppm when sufficiency was 6,150 ppm, and all of the other nutrients were sufficient.

Sugar beets were harvested on October 10 starting with the Commercial Trial and the Experimental Trial harvest was completed on October 11. The foliage was flailed and the crowns were removed with rotating knives. 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. Sugar beet performance in both trials was compared to the check varieties ACH Seeds 'Crystal 217R', Betaseed 'Beta 4490R', Hilleshog/Syngenta 'HM 2992Rz', and Holly Hybrids 'Acclaim R'. Reports of previous years' Oregon State University variety trials are available online at www.cropinfo.net.

Results

Surge irrigation approximately once a week maintained the soil water tension wetter than 50 centibar through the growing season (Fig. 1).

Less curly top virus infection was seen in the beet trials this year than in recent years. Powdery mildew foliar symptoms were observed on the sugar beet foliage in these trials, and became more severe in September and early October.

Variety results were grouped by seed company for the Commercial Trial (Table 1) and the Experimental Trial (Table 2). The root weights were tared 10 percent, as explained above. The beets from the border rows in the trials, topped the same and dug with the same harvester, ranged from 1.7 to 2.7 percent tare, plus from 1 to 5 lb of dirt was commingled per ton of beets, so the actual yields were slightly higher than is reported here.

Root yield in the Commercial Trial averaged 48.1 tared ton/acre, with an average sugar content of 16.8 percent (Table 1). The varieties yielding among the highest root yield in the Commercial Trial were 'Beta 4023R' with 53.8 ton/acre, 'Beta 8600' with 53.6 ton/acre, Crystal '316R' with 53.2 ton/acre, and 'HH Meridian R' with 52.0 ton/acre.

Root yield in the Experimental Trial averaged 48.0 tared ton/acre with an average sugar content of 17.1 percent (Table 2). The varieties yielding among the highest root yield in the Experimental Trial were 'HH 06HX621 R' with 55.6 ton/acre, and 'HH Acclaim R' with 53.3 ton/acre.

Within each seed company's varieties, the varieties are ranked in descending order of estimated recoverable sugar in pounds per acre. A computer problem at the tare lab at Paul, Idaho resulted in 514 samples lost out of 944 taken. Too many plots were missing sugar data to perform a statistical analysis of the lab results. Lab and calculated data reported here are from two to eight replications of available data. Graphical comparisons of the data from the other locations of the Commercial (Fig. 2-5) and Experimental (Fig. 6-9) trials show that the partial data available from the Malheur location generally follow the same trends seen at the other locations.

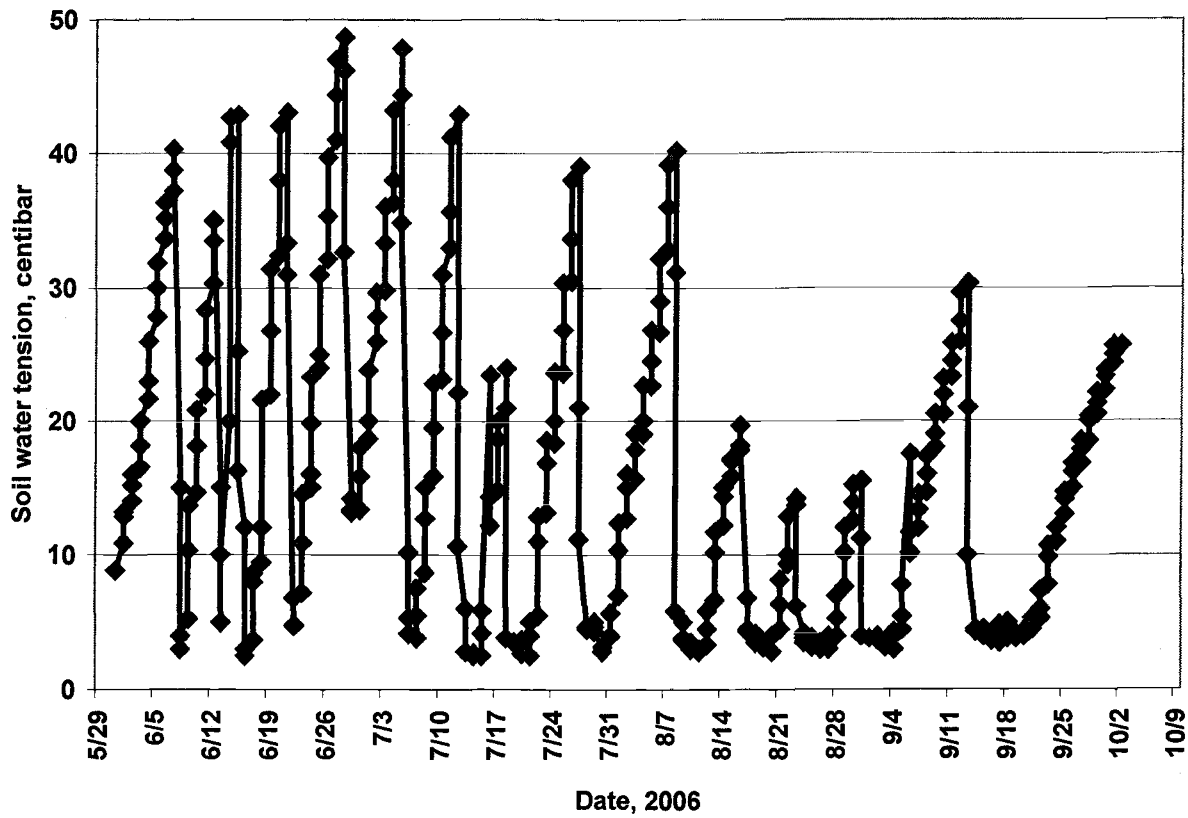

Figure 1. Soil water tension during the 2005 growing season in the commercial sugar beet trial at Oregon State University, Malheur Experiment Station, Ontario, OR.

Table 1. Field performance of commercial sugar beet varieties in the Oregon State University Variety Trial at Malheur Experiment Station, Ontario, OR, 2006.

Variety	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar	
	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre
ACH Seeds							
Crystal 316R	53.2	16.6	17,718	0.775	84.6	281	14,987
Crystal 217R	50.1	15.9	16,726	0.832	83.7	267	13,992
Crystal 333R	50.1	16.7	16,597	0.833	83.8	280	13,922
Betaseed							
Beta 8600	53.6	16.8	18,116	0.825	84.0	283	15,218
Beta 4720R	53.8	16.0	17,286	0.828	83.8	268	14,481
Beta 4023R	50.3	16.8	16,964	0.869	83.4	280	14,143
Beta 4216R	49.9	16.6	16,516	0.837	83.8	278	13,838
Beta 4773R	46.1	17.3	16,126	0.810	84.3	292	13,592
Beta 4910R	45.0	17.9	15,870	0.793	84.6	303	13,425
Beta 4199R	45.1	17.3	15,583	0.878	83.3	288	12,990
Beta 4490R	44.8	17.6	15,396	0.821	84.2	296	12,959
Hilleshog/Syngenta							
HM PM90	49.7	17.8	17,668	0.711	85.7	305	15,134
HM 2996Rz	50.2	17.0	17,081	0.757	84.9	289	14,502
HM PM21	47.5	17.4	16,627	0.732	85.3	297	14,185
HM 2991Rz	46.5	17.3	16,098	0.639	86.5	299	13,924
HM 2988Rz	46.4	17.3	16,208	0.692	85.8	297	13,909
HM 2999Rz	48.1	16.7	16,211	0.782	84.5	282	13,698
HM 2993Rz	46.6	16.7	15,995	0.761	84.8	283	13,568
HM Owyhee	47.9	16.5	15,735	0.761	84.7	280	13,341
HM 2992Rz	47.5	17.4	15,668	0.810	84.3	294	13,207
HM 2984Rz	45.2	16.2	14,351	0.762	84.7	275	12,152
Holly Hybrids							
HH Meridian R	52.0	16.1	16,795	0.838	83.6	269	14,057
HH Phoenix R	50.4	16.2	16,376	0.829	83.8	271	13,717
HH Eagle R	48.1	16.7	16,125	0.799	84.3	281	13,588
HH Acclaim R	50.1	16.1	16,018	0.792	84.3	271	13,502
HH Condor R	43.3	16.9	14,889	0.710	85.5	289	12,732
HH 142 R	46.7	16.3	14,942	0.821	83.9	273	12,540
Seedex							
SX Cascade	48.5	17.2	16,760	0.719	85.4	294	14,325
SX 1522 Rz	47.9	17.0	16,535	0.750	85.0	289	14,060
SX Raptor Rz	47.5	16.5	15,762	0.834	83.8	277	13,213
SX Puma	45.7	16.6	15,027	0.692	85.7	284	12,876
SX Mammoth Rz	43.4	17.6	15,210	0.804	84.4	297	12,840
Mean	48.1	16.8	16,213	0.782	84.5	284	13,707
LSD (0.05)	2.26	na[a]	na	na	na	na	na

[a]na = not available due to the loss of data at Paul, ID.

Table 2. Field performance of experimental sugar beet varieties in the Oregon State University Variety Trial at Malheur Experiment Station, Ontario, OR, 2006.

	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar	
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre
ACH Seeds							
Crystal 594R	52.4	17.0	17,793	0.759	84.9	288	15,107
Crystal 595R	52.3	16.6	17,325	0.753	84.9	282	14,704
Crystal 611R	48.4	17.1	16,369	0.724	85.4	292	13,971
Crystal 596R	48.1	17.0	16,531	0.805	84.3	286	13,930
Crystal 599R	47.1	17.4	16,527	0.887	83.3	290	13,764
Crystal 597R	47.7	17.4	16,549	0.898	83.1	289	13,750
Crystal 217R	49.4	16.7	15,952	0.786	84.4	281	13,466
Betaseed							
Beta 5YK0028	49.2	17.5	17,873	0.760	85.0	297	15,184
Beta 6YK0032	47.8	17.8	17,449	0.745	85.2	304	14,871
Beta 6YK0031	47.5	17.3	16,453	0.834	83.9	290	13,808
Beta 4YK0025	47.1	17.4	16,284	0.814	84.2	293	13,714
Beta 6YK0030	44.8	17.3	15,862	0.862	83.6	289	13,257
Beta 4490R	43.6	16.8	13,963	0.878	83.3	280	11,624
Hilleshog/Syngenta							
HM 2992Rz	46.6	17.4	16,221	0.710	85.6	298	13,886
HM 1339Rz	46.0	17.0	15,693	0.796	84.4	286	13,243
Holly Hybrids							
HH 06HX621 R	55.6	16.3	17,883	0.823	83.9	273	15,007
HH Acclaim R	53.3	16.5	17,765	0.790	84.4	279	14,993
HH 06HX620 R	48.3	17.8	16,992	0.672	86.2	306	14,642
HH 05HX555 R	49.8	17.2	17,088	0.754	85.0	292	14,521
HH 06HX623 R	51.7	16.3	16,867	0.798	84.2	274	14,215
HH 06HX626 R	45.1	18.0	16,222	0.646	86.5	312	14,040
HH 06HX625 R	46.0	16.7	15,160	0.751	84.9	283	12,874
HH 06HX624 R	43.0	17.5	14,835	0.784	84.6	296	12,555
HH 06HX622 R	41.4	17.4	14,423	0.747	85.1	296	12,276
Seedex							
SX 1524	47.3	18.2	16,858	0.603	87.1	316	14,687
SX 1523	51.0	16.7	16,966	0.793	84.4	281	14,323
SX 1525	46.6	16.7	15,664	0.782	84.5	282	13,233
Mean	48.0	17.1	16,500	0.777	84.65	289.7	13,970
LSD (0.05)	2.27	na[a]	na	na	na	na	na

[a]na = not available due to the loss of data at Paul, ID.

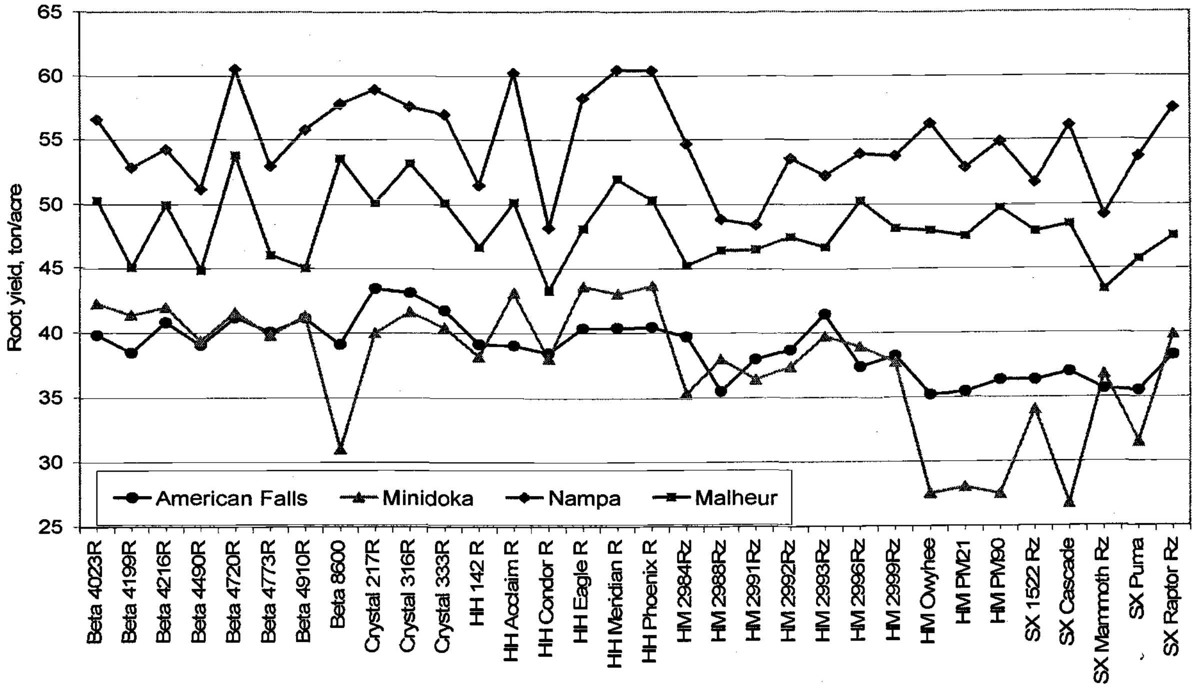

Figure 2. Commercial Trial root yield from sugar beets grown at four locations.

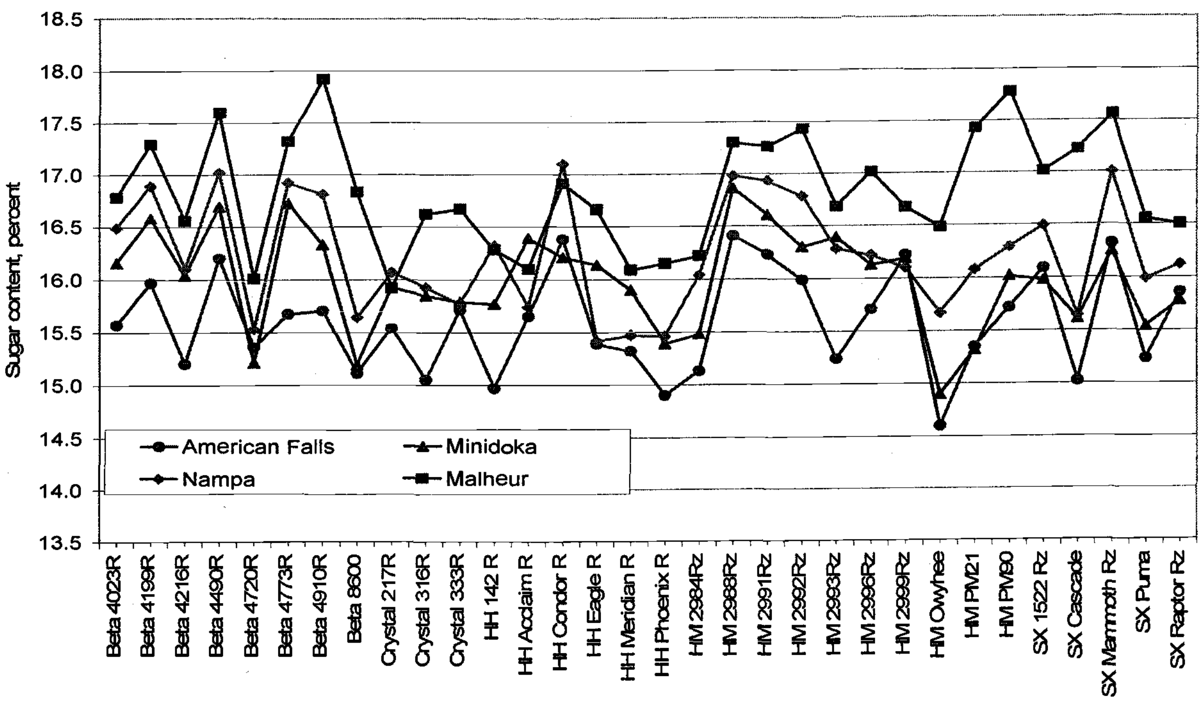

Figure 3. Commercial Trial sugar content from sugar beets grown at four locations.

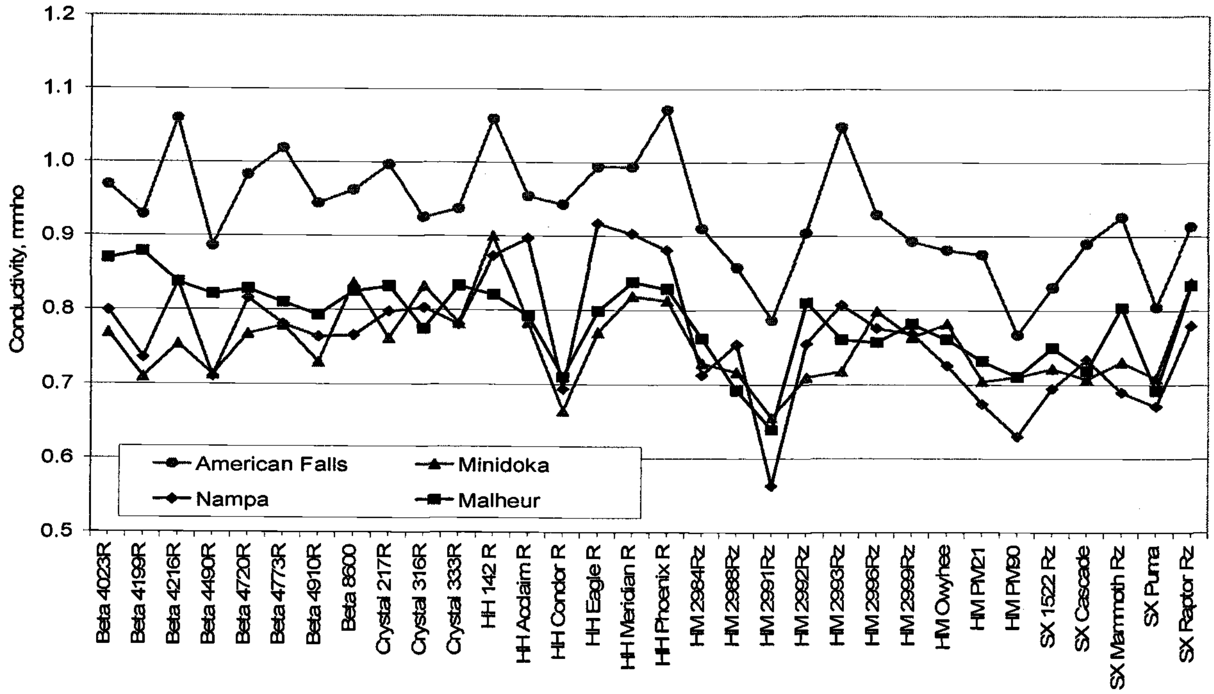

Figure 4. Commercial Trial conductivity for sugar beets grown at four locations.

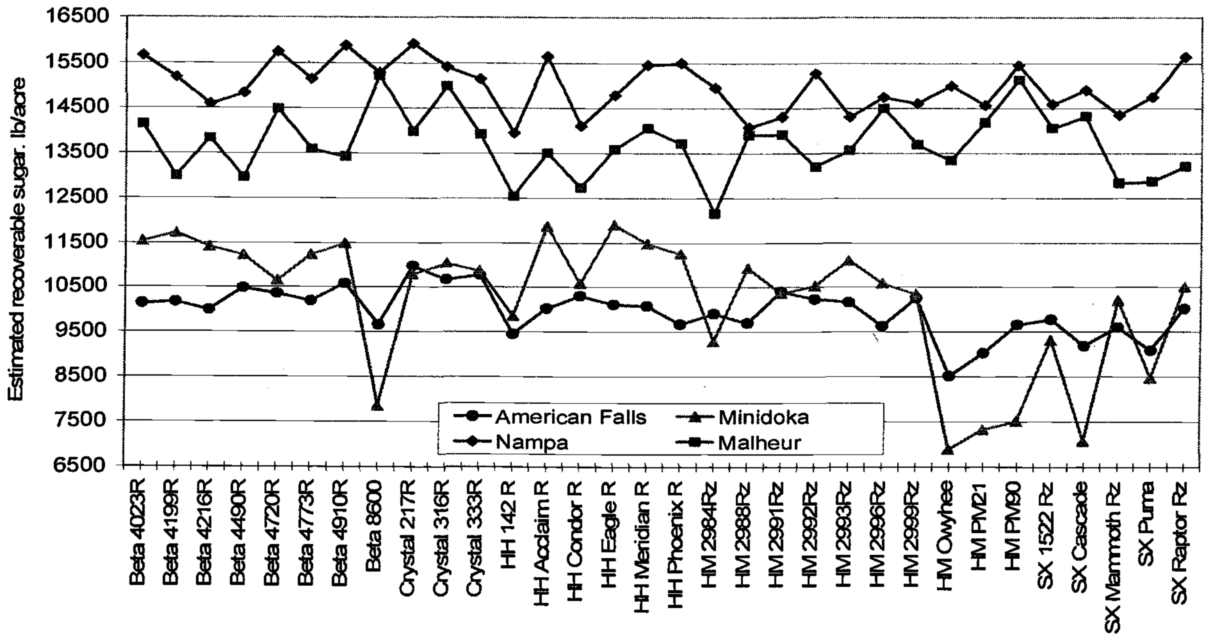

Figure 5. Commercial Trial estimated recoverable sugar from sugar beets grown at four locations.

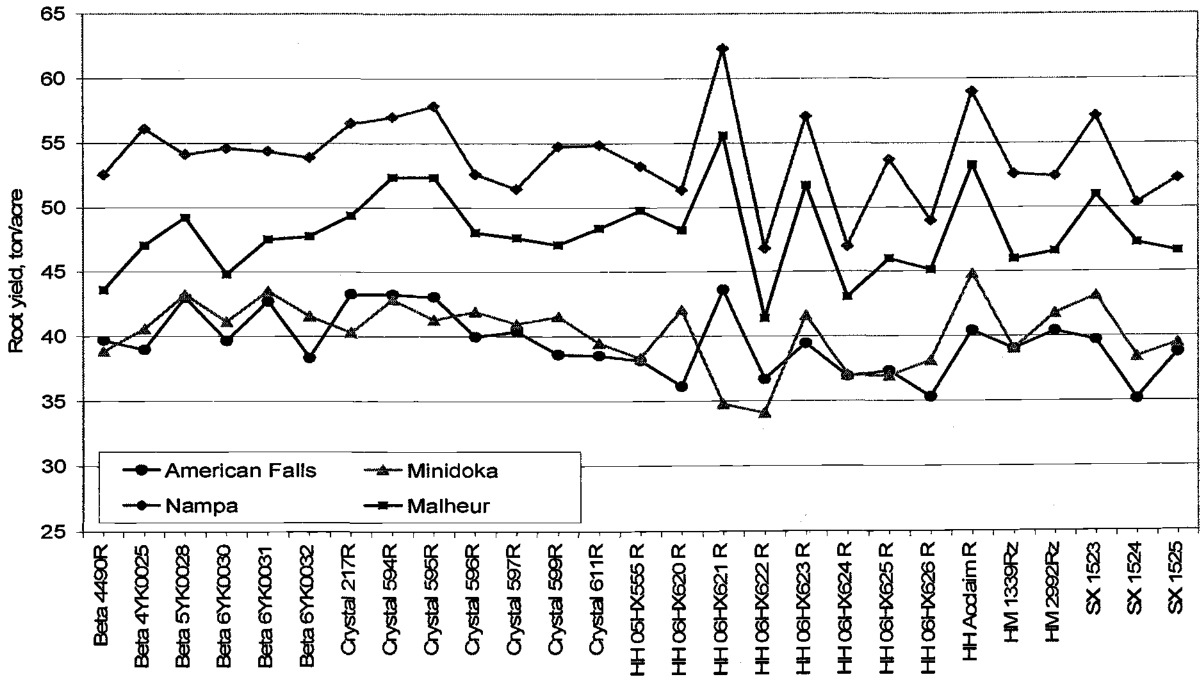

Figure 6. Experimental Trial root yield from sugar beets grown at four locations.

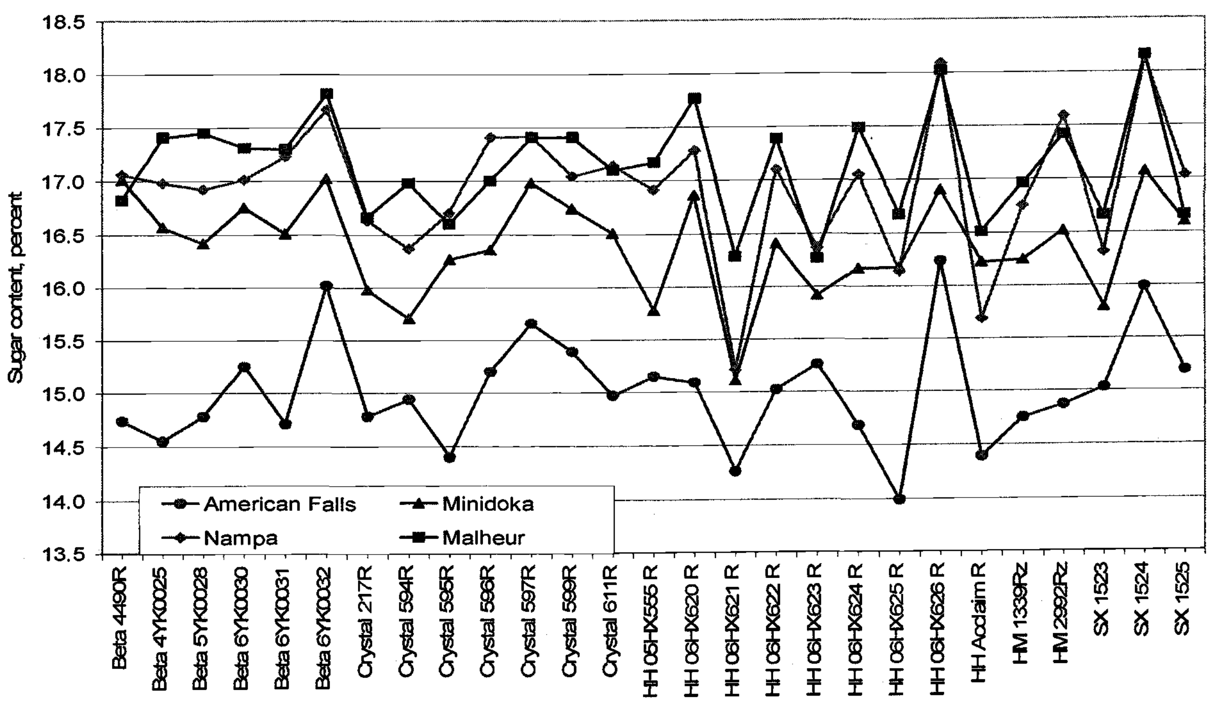

Figure 7. Experimental Trial sugar content of sugar beets grown at four locations.

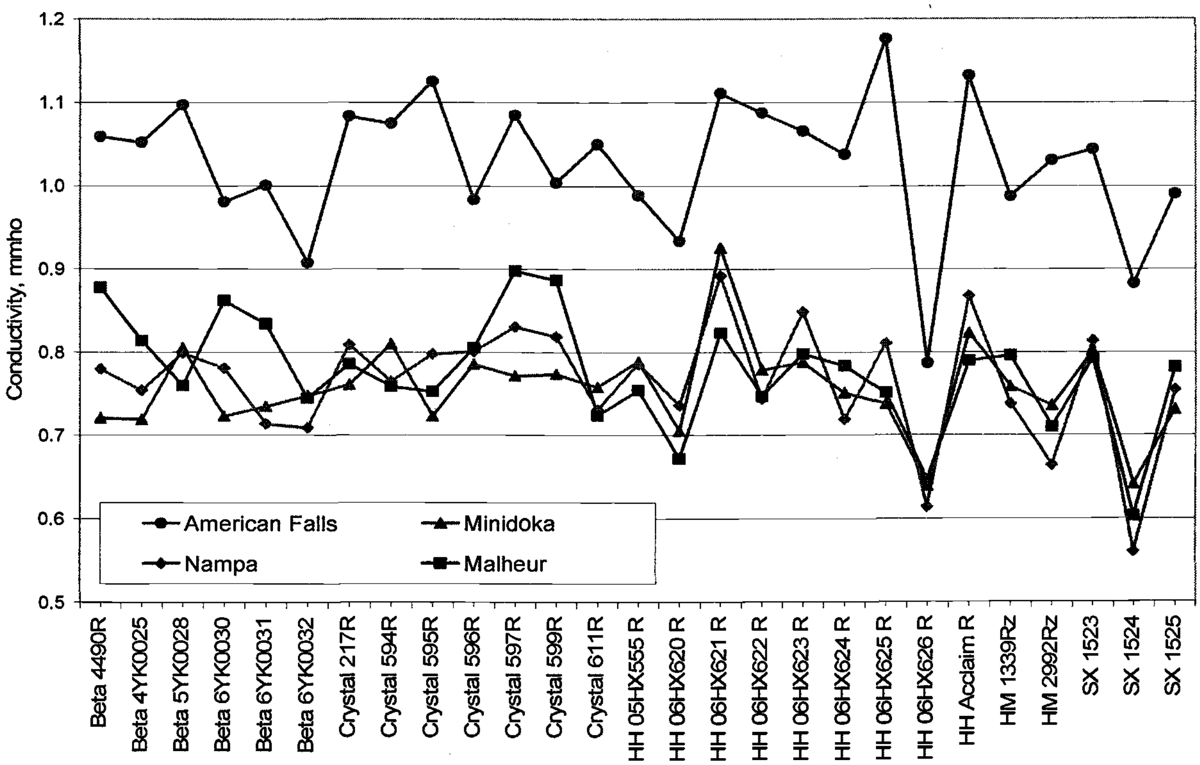

Figure 8. Experimental Trial conductivity of sugar beets grown at four locations.

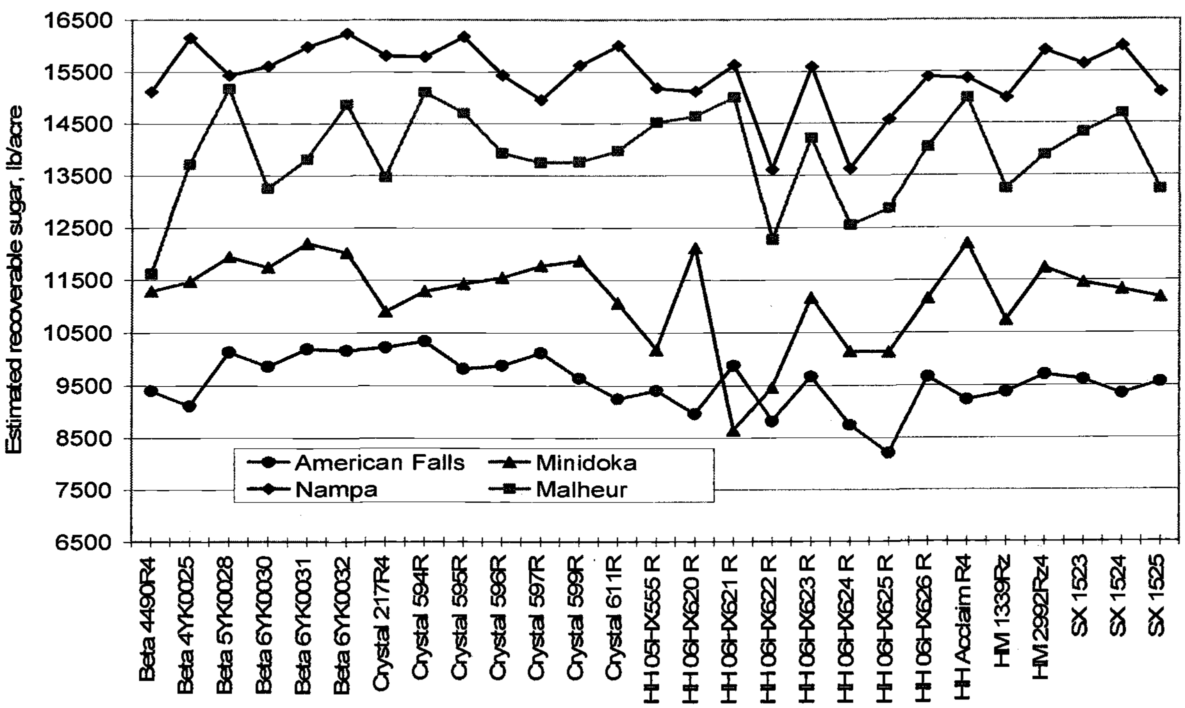

Figure 9. Experimental Trial estimated recoverable sugar from sugar beets grown at four locations.

TEFF (*Eragrostis tef*) VARIETY PERFORMANCE

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Introduction

In years when the water supply is short or if an emergency crop is needed due to crop failure, or producers desire a quick growing annual forage in mid-summer, few options are available to them. Teff (*Eragrostis tef*) is a warm season annual grass that has the potential to be a viable alternative, but further research is needed on this new crop. The objective of this trial was to examine the differences in teff varieties used as a warm season forage crop in the Pacific Northwest.

Methods

The teff experiment was planted on June 6, 2006 on Nyssa silt loam at the Malheur Experiment Station on a field that was in teff the previous year. Seedbed preparation included disking and cultivating. Seed was broadcast at a rate of 6 lb/acre by using a hand fertilizer spreader. The experimental design was a randomized complete block. Varieties included in the experiment were 'Dessie' and 'Pharoah' from First Line Seeds, 'VA-T1-Brown' from Hankins Seed, 'Tiffany' from Target Seeds, and 'X9' and 'XP10' from United Seed. The experiment was conducted at three locations: Ontario and Klamath Falls, Oregon, and Othello, Washington. Results only from the Ontario site are given in this report.

Nitrogen was applied at the rate of 100 lb N/acre (urea), with half applied on June 7 (at planting) and half on July 26 (just after the first harvest). Treatments were replicated six times. A soil test taken prior to planting indicated that the soil contained 312 lb/acre N in the top two feet, 15 ppm P (Olson method), 242 ppm K, 25 ppm SO_4/acre, and 3.1 percent organic matter.

The experiment was irrigated starting on June 7 with a microsprinkler irrigation system using R10 Turbo (Nelson Irrigation Corp., Walla Walla, Washington) sprinkler heads. Sprinkler heads were placed every 12.5 ft on the sides of the plot to provide uniform coverage. To monitor soil moisture content, Watermark soil moisture sensors model 200SS (Irrometer Co. Inc., Riverside, CA) were installed at 12- and 24-inch depths to monitor soil water tension. Sensors were connected to a 900M Watermark data logger (Irrometer Co. Inc., Riverside, CA) equipped with a thermister to correct soil moisture calculations for soil temperature.

Weed control included hand weeding of barnyard grass and the use of bromoxynil (Bronate Advanced®) on June 28 at 1 pt/acre (which is the labeled rate for wheat) to control broadleaf weeds. No crop injury was apparent after spraying.

Teff was harvested when seed heads were beginning to emerge. Harvest of the first cutting occurred on July 25 and the second harvest occurred on September 12, 2006. Plots were harvested using a Jari sickle bar mower set to cut the teff at a height of 3 inches. Plots were 20 ft long by 2.5 ft wide. A sample of approximately 1.0 lb of forage was taken from each plot and oven dried to determine moisture and calculate dry matter (DM) yield.

Dried samples were ground to 2-mm-sieve size in a Wiley Mill (Arthur H. Thomas Co.) and to 1-mm-sieve size in an Udy Mill (UDY Corp.) before being analyzed in a near infrared spectrophotometer (NIRS) (NIRSystems) to determine forage quality. Treatment significance was based on an Analysis of Variance (ANOVA) F test at the P = 0.05 level. If this analysis indicated significant treatment effects then Least Significant Difference (LSD) values were calculated based on alpha at 0.05.

Results

The amount of irrigation water and precipitation the plots received in 2006 from planting to first harvest was 15.14 inches, and the amount applied between first and second harvest was 14.12 inches, with a total of 29.26 inches. Irrigation rate was 0.12 inch/hour. This is the second year that teff was produced in this field, and since there are no registered herbicides to control annual grasses, barnyard grass was a serious problem this year.

Results from the first harvest taken July 26 are found in Table 1. Yields between varieties were not significantly different and ranged from 2.70 to 3.06 ton/acre. Lodging from a wind storm made harvest difficult. Harvest of teff should be done before significant lodging occurs, if possible. Lodging ranged from 42 to 78 percent and was not significantly different between varieties. Many of the quality traits were not significantly different, including crude protein, acid detergent fiber (ADF) and relative feed quality (RFQ), with mean values of 11.9, 42.3, and 91.0 percent, respectively. Compared to the irrigation and nitrogen study last year, hay quality dropped. Crude protein dropped from 17 to 12 percent, ADF increased from 30 to 40, neutral detergent fiber (NDF) increased slightly from 58 to 61, relative feed value (RFV) dropped from 100 to 85, and RFQ dropped from 108 to 91. Decreased quality may be related to the fact that 2006 was a hotter summer than 2005. The mean maximum temperature averaged over the months of June, July, and August was 3°F warmer in 2006 than in 2005.

A lower value of NDF or ADF indicates better quality hay. Teff X9 produced significantly lower NDF than Tiffany, XP10, and Pharoah, but was not significantly different than VA-T1 Brown, or Dessie. This corresponded to a significantly higher RFV in X9 than Tiffany, XP10, and Pharoah but was not significantly different than VA-T1 Brown, or Dessie. No significant variety differences were found in any of the yield or quality parameters measured. Probably the most interesting thing is the decrease in crude protein from the first harvest. Figure 1 shows that not much water was leached through the profile. Irrigation was done every 2 to 3 days. The soil test showed 312 lbs of nitrogen at the beginning of the experiment, which should have been adequate even without the 50 lb N/acre applied prior to planting and after the first harvest. The crop appeared to be nitrogen deficient.

No significant variety differences were found in yield of either first or second cuttings, with yields ranging from 4.6 to 5.4 ton/acre (see Table 3). Converting those yields to 12 percent dry matter teff produced 5.3 to 6.1 ton/acre in 97 growing days.

Conclusion

Teff appears promising as an alternative annual forage grass. Teff grew well during the warm summer weather in Malheur County. Minimal differences between varieties occurred in the six that were tested. The RFV in 2006 averaged 85 and 86 for first and second harvests, respectively. The RFQ averaged 91 and 90 for first and second harvests, respectively. General feed quality was less in 2006 than 2005 and that may have been due to the hotter summer. Barnyard grass was the most difficult weed to control in the teff.

Acknowledgement

This research was supported by a grant from the Agricultural Research Foundation.

Table 1. Teff yield and quality results for the first harvest (July 26) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Yield[a]	Lodging	Crude protein	ADF	NDF	RFV	RFQ
	ton/acre	%	%				
X9	2.9	68	12.5	41.8	60.2	87	94
VAT 1 Brown	2.9	42	12.2	42.2	60.4	86	92
Dessie	3.0	78	12.6	42.2	60.3	86	91
Tiffany	3.0	65	11.2	42.3	62.3	84	92
XP10	3.1	52	11.0	42.8	62.8	82	89
Pharoah	2.7	70	11.8	42.5	61.2	85	91
LSD (0.05)	NS	NS	NS	NS	1.5	3	NS

[a]Yield is presented on 100 percent dry matter basis. To convert to 88 percent dry matter divide yield by 0.88.

Table 2. Teff yield and quality results for the second harvest (September 12) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Yield[a]	Lodging	Crude protein	ADF	NDF	RFV	RFQ
	ton/acre	%	%				
X9	2.4	0	8.2	42	61.8	85	90
VAT 1 Brown	2.4	0	8.7	41.5	62.0	85	90
Dessie	2.1	0	8.9	41.5	62.1	85	88
Tiffany	2.1	0	8.1	41.8	61.6	85	89
XP10	1.9	0	8.1	40.8	61.0	87	90
Pharoah	1.9	0	8.1	41.2	60.6	87	91
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

[a]Yield is presented on 100 percent dry matter basis. To convert to 88 percent dry matter divide yield by 0.88.

Table 3. Teff yield for both harvests (July 26 and September 12) at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Yield[a]
	ton/acre
X9	5.4
VAT 1 Brown	5.3
Dessie	5.1
Tiffany	5.1
XP10	5.0
Pharoah	4.6
LSD (0.05)	NS

[a]Yield is presented on 100 percent dry matter basis. To convert to 88 percent dry matter divide yield by 0.88.

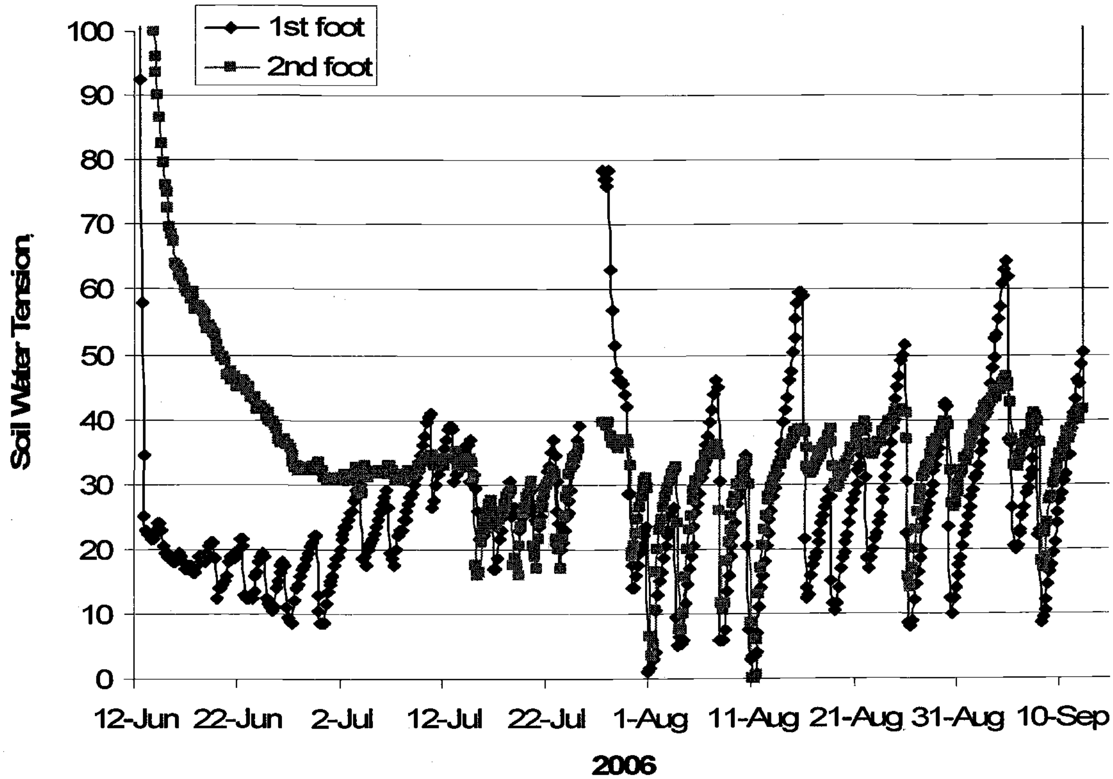

Figure 1. Soil moisture tension (cb) at the 1-ft and 2-ft levels in the experiment at the Malheur Experiment Station, Oregon State University, Ontario, OR, in 2006.

2006 WINTER ELITE WHEAT TRIAL

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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 69 lb available nitrogen (N) per acre in the top 2 ft of soil. The top foot of soil contained 25 ppm phosphorus (P), 313 ppm potassium (K), and 16 ppm sulfate (SO_4)/acre, 2,442 ppm calcium (Ca), 501 ppm magnesium (Mg), 107 ppm sodium (Na), 1.7 ppm zinc (Zn), 7 ppm iron (Fe), 5 ppm manganese (Mn), 0.6 ppm copper (Cu), 0.4 ppm boron (B), pH 7.4, and 0.98 percent organic matter. Pre-plant fertilizer was broadcast in on September 8, 2005 to apply 50 lb N/acre, 50 lb P_2O_5/acre, 50 lb SO_4/acre, 50 lb elemental S/acre, 1 lb Cu/acre, and 1 lb B/acre. 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, 3 of which were club types, and 5 with resistance to imazamox herbicide for use in the BASF "Clearfield®" system (designated SWW-CF). 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 24, 2005, with a small plot grain drill, in plots 5 by 20 ft, and the field was recorrugated. Seed was planted at a seeding rate of 30 live seed/ft^2, corresponding to approximately 110 lb/acre. Rainfall in October after planting totaled 0.30 inch and in early November an additional 1.16 inch of rain fell by the time of emergence on November 11. Urea fertilizer was applied by aerial applicator to supply 100 lb N/acre on March 31, 2006.

Broadleaf weeds were controlled with Bronate® herbicide at 1qt/acre applied on May 20. Alleys were cut with a sickle bar mower on June 13. Plant height at maturity was measured in the trial on July 10. The alleys were recut with a Hege plot combine on July

17 and the resulting length of each plot was measured and recorded. The plots were harvested on July 18 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 22 (Day of Year [DOY] 142) for 'BZ 6W99-456' to June 4 (DOY 155) for 'OR12042037' (Table 1). Height at maturity ranged from 35 inches tall for 'Gene' to 43 inches tall for 'Tubbs-06', 'Rod', and 'ID99-435'. No lodging was observed in any plots. Test weights in this trial ranged from 64 lb/bu for BZ 6W99-456 to 59 lb/bu for 'Chukar'. Protein content of the grain ranged from 11 percent for Gene to 9 percent for 'ID99-419'.

Yield ranged from 111 bu/acre for 'OR2030411' to 80 bu/acre for 'ARS97135-9' (Table 1). Among the highest yielding wheat varieties were OR2030411, Tubbs-06, 'OR2020787', 'OR2030238', 'OR2010239', 'ID99-419', 'Stephens', 'OR2030239, ORI2042037, 'ORH010918', 'ORH010920', 'ORH010083', 'Weatherford', 'ORH010085', Rod, 'ORH010837', 'Idaho 587', 'ORCF-102', 'Madsen', 'OR2010241', and 'OR9901619'. Stephens, a check variety in this trial, and the most commonly grown variety in this production area, continues to show high yield performance, placing it among the top yielding varieties in the trial.

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, yield, test weight, protein, plant height, and 50 percent heading date. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Identification	Market class[a]	Yield	Test weight	Protein	Mature height	50% heading
		bu[b]/acre	lb/bu	%	inch	day of 2006
OR2030411	SWW	111.2	60.9	10.1	38	149
Tubbs-06	SWW	110.0	61.1	9.7	43	145
OR2020787	SWW	109.9	60.9	10.7	39	147
OR2030238	SWW	109.5	60.2	10.1	38	147
OR2010239	SWW	108.5	60.0	9.8	40	152
ID99-419	SWW	106.8	61.5	9.2	40	153
Stephens	SWW	106.6	61.2	10.5	38	145
OR2030239	SWW	106.1	60.3	10.1	38	147
ORI2042037	SWW-CF	105.8	60.8	9.9	41	155
ORH010918	SWW	105.1	61.0	10.3	36	143
ORH010920	SWW	103.3	61.4	10.6	35	144
ORH010083	SWW	102.9	62.1	10.9	38	151
Weatherford	SWW	102.8	61.3	10.0	41	147
ORH010085	SWW	102.1	62.2	10.6	37	150
Rod	SWW	101.2	61.2	9.5	43	150
ORH010837	SWW	99.2	60.6	10.1	36	147
Idaho 587	SWW-CF	99.1	60.8	9.8	39	150
ORCF-102	SWW-CF	99.0	61.0	9.9	41	151
Madsen	SWW	99.0	61.8	10.4	38	150
OR2010241	SWW	97.8	61.7	10.4	40	151
OR9901619	SWW	97.7	60.1	9.7	42	152
Westbred 528	SWW	96.5	62.7	10.4	38	148
OR2030554	SWW	96.4	60.7	9.4	37	151
ORI202183C	SWW-CF	96.1	61.2	10.0	39	150
Masami	SWW	95.1	61.8	9.5	40	148
OR9900553	SWW	95.0	61.1	10.5	37	150
ID99-435	SWW	94.5	61.2	10.1	43	147
ARSC96059-1	SWW	94.3	62.6	9.8	40	150
ID92-22407A	SWW	93.2	61.0	10.1	41	149
Tubbs	SWW	93.2	61.1	9.6	42	150
Brundage 96	SWW	92.3	60.6	9.4	37	147
Chukar	Club	92.1	59.4	9.7	41	154
ORCF-101	SWW-CF	91.3	61.2	10.1	38	150
Gene	SWW	88.8	59.6	11.0	35	144
ORSS-1757	SWW	88.2	60.3	9.5	38	144
Simon	SWW	88.2	61.0	10.1	40	147
BZ 6W99-456	SWW	86.5	63.8	10.6	35	142
Coda	Club	81.8	61.5	9.4	40	154
ARS99123	Club	81.5	61.3	10.7	38	145
ARS97135-9	SWW	80.0	59.6	10.3	38	153
Mean		97.7	61.1	10.1	39	149
LSD[c] (0.05)		14.6	0.05	0.6	2	n/a[d]

[a]SWW = Soft white winter, SSWW = Super-soft white winter, SWW-CF = Soft white winter with resistance to imazamox herbicide. [b]60-lb bushel. [c]Least Significant Difference at *alpha* $P \leq 0.05$.
[d]n/a = not applicable.

OPTIMIZING NITROGEN USE AND EVALUATING ETHEPHON USE IN WAXY BARLEY

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Introduction

Treasure Valley Renewable Resources is in the process of putting a grain fractionation plant in Ontario, Oregon and one of their primary interests includes contracting barley that has fully waxy starch, and is high in beta-glucan fiber and protein. Very little research has been done on growing barley for high protein and response of barley varieties to nitrogen application. Previous work by Brad Brown, Cereal Specialist, University of Idaho at Parma, has shown that 'Merlin' and 'Salute', spring genotypes developed by WestBred (Bozeman, MT), are among the best waxy cultivars available. A fall barley genotype would work best in our rotational system due to higher yields. Unfortunately, there are currently no fall waxy barley cultivars available. Research needs to be done so producers know how to apply nitrogen for optimum yield and protein and yet prevent environmental contamination from excessive nitrate. The purpose of this trial was to determine winter survival of two fall-planted spring waxy barley varieties, and compare yield and quality under different dry urea nitrogen treatments applied late winter, dry urea and fluid urea at heading, and evaluate ethephon growth regulator use for reducing lodging while maintaining yield.

Methods

The experiment was planted on Owyhee silt loam at the Malheur Experiment Station on a field that grew potatoes the previous year. A second location of the experiment was planted by Brad Brown with the University of Idaho at Parma, Idaho but not reported here. Seedbed preparation included disking, cultivating and furrowing. Soil samples were collected prior to fall tillage and showed 41 lb/acre nitrogen (N) in the top 3 ft of soil, in the top foot of soil 21 ppm phosphorus (P) (Olson method), 387 ppm potassium (K), 20 ppm sulfate (SO_4), 2,378 ppm calcium (Ca), 373 ppm magnesium (Mg), 2 ppm zinc (Zn), 8 ppm iron (Fe), 8 ppm magnesium (Mn), 0.8 ppm copper (Cu), 0.8 ppm boron (B), and 1.25 percent organic matter. The field was planted on October 25, 2005 with a plot drill on 30-inch beds with 3 drill rows per bed.

The experimental design was a randomized complete block design with three replications. The treatment design was a split plot design with varieties as the whole plots being varieties, and the sub-plots were an incomplete factorial design of late winter applications of 0, 60, 120, or 180 lb N/acre combined with treatments of 0 or 40 lb N/acre dry urea, 40 lb N/acre fluid urea foliarly applied at the 50 percent heading stage, and Ethephon 2® (ethephon) (FarmSaver.com LLC) applied at boot stage at 1.5 pt/acre plus 40 lb N/acre fluid urea foliarly applied. The late winter application of 180 lb N/acre treatment applied to Merlin and Salute did not receive any other treatments. Late winter N applications were hand applied February 13. The ethephon application was sprayed at boot stage on May 10. Heading applications were made May 26. Heading was designated when 50 percent of the heads had emerged from the boot.

Visual plant stand estimations were taken on April 12. Thirty flag leaves were taken from each plot and combined into one sample on May 25 and sent to Brookside Laboratory, New Knoxville, Ohio, for analysis. Twenty of those flag leaves were measured with a SPAD meter for greenness. The field was sprayed for weeds with Bronate® herbicide at 1 qt/acre applied May 11, 2006. The trial was furrow irrigated for 24 hours on May 2, May 19, June 1, June 15, and June 29. Plant height was measured on June 23, 2006. Plots were cut to size and harvested with a Hege combine on July 21 and 24.

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

Fall planting of these spring genotypes resulted in reduced plant stands. Coming out of the winter, Merlin had a 40 percent stand, which was better than Salute at 30 percent. Averaged over varieties, as N rate increased from 0 to 180 lbs N/acre the percent stand dropped from 43 to 32 percent, respectively. Covariate analysis using percent stand indicated that stand did not significantly influence yield. Salute yield was more than Merlin with no late winter N application; however Merlin and Salute did not differ in yield at the 120-lb N/acre rate (Fig. 1). Averaged over late winter N application rates and heading treatments, Salute produced fewer seeds per area, fewer seeds per pound (larger seeds), had lighter test weight, lower crude protein in the grain, higher beta glucan, was taller, lower in flag leaf N concentration, had lower SPAD meter readings (less green leaves), and lower seed moisture at harvest than Merlin (Table 1). Averaged over varieties and N applications at heading and ethephon treatment, increasing late winter N rate from 0 to 120 lb/acre resulted in a maximum increase in yield of 24.6 bu/acre. The yield increase came from increased seed numbers (33 percent) and increased seed weight (4 percent). Increasing N rate further from 120 to 180 lb N/acre actually decreased yield by 11.7 bu/acre, even though lodging did not occur.

Averaged over late winter N treatments and varieties, applying 40 lb N/acre of fluid urea increased seed yield by 7.5 bu/acre. The increase caused by the heading application was larger when no late winter N was applied and smaller when late winter applications were made (Fig. 2). Grain protein was significantly increased by late winter fertilizer applications but not by heading applications (Table 2 and Fig. 3). Ethephon reduced plant height by almost 2 inches but it had no influence on lodging since there was no lodging in this experiment. Ethephon did not influence yield, but did significantly reduce seed weight and, more importantly, reduced beta glucan content by 0.6 percent compared to the control, the fluid urea treatment (Table 3). Averaged across varieties, increasing late winter N rate had a consistent influence on both leaf N percentage as well as the SPAD metering readings (Fig. 4). The ANOVA indicated that variety influenced SPAD meter results but did not influence the leaf N percentage as the late winter N application rate was increased.

Conclusion

Merlin was more winter hardy and maintained yield under high N conditions better than Salute. Stand reductions show that fall planting of either variety is risky. Salute yielded more with less N and with higher N prices that is important. Merlin, being hulless, had higher test weights, higher protein, and more seeds per pound. Salute was much taller and produced much more straw than Merlin. Salute has a more upright growth habit compared to Merlin, while Merlin has a more decumbent growth pattern. Salute has higher beta glucan and lower protein content than Merlin.

Applying the correct amount of late winter N is important to yield and quality. In this experiment late winter N application rate was more important than the heading N applications. Yield can still be increased with N applied as late as heading; however, maximum yield was attained by the late winter application. Ethephon can reduce plant height without decreasing yield, which could help reduce lodging; however, it also significantly reduced the beta glucan content, an important component of the seed.

Acknowledgement

This research was supported by a grant from Treasure Valley Renewable Resources, Oregon Grains Commission, Barley for Rural Development, and Micro Flo (now owned by Arysta).

Table 1. Waxy barley yield and quality results of Merlin and Salute averaged over late winter nitrogen rate, heading nitrogen rate, and ethephon treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Yield[a]	Seed # per area	Seed weight	Test weight	Crude protein	Beta glucan	Plant height	Flag leaf N	Spad meter	Harv. moist-ure	Stand
	bu/acre	seed # per ft^2	seed # per lb	lb/bu	%	%	inches	%		%	%
Salute	106.6	1,375	9,348	53.4	12.1	5.9	39	3.6	43.7	6.6	35
Merlin	103.6	1,433	10,015	61.8	13.2	5.4	26	3.8	50.1	8.7	45
LSD (0.05)	NS	70	121	0.2	0.5	0.4	0.8	0.1	1.1	0.3	4

[a]Yield and protein were corrected to a 12 percent moisture basis.

Table 2. Barley yield and quality results of harvest on July 20 as influenced by late fall nitrogen rate and averaged over varieties, heading nitrogen, and ethephon treatments at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Late winter nitrogen rate	Yield[a]	Seed # per area	Seed weight	Test weight	Crude protein	Beta glucan	Plant height	Flag leaf N	Spad meter	Harv. moist-ure	Stand
lb/acre	bu/acre	seed # per ft^2	seed # per lb	lb/bu	%	%	inches	%		%	%
0	90.1	1,177	9,481	57.8	12.1	5.57	29.2	3.2	43.6	7.8	43.4
60	111.1	1,476	9,645	57.6	12.5	5.59	33.3	3.7	47.1	7.6	39.9
120	114.7	1,561	9,874	57.4	13.3	5.80	34.3	4.1	49.0	7.4	38.5
180	103.0	1,398	9,862	57.2	13.4	5.67	35.9	4.3	51.3	7.5	31.8
LSD (0.05)	6.9	100	175	NS	0.8	NS	1.1	0.2	1.5	NS	5.1

[a]Yield and protein were corrected to a 12 percent moisture basis, 48 lb = bushel.

Table 3. Barley yield and quality results of harvest on July 20 as influenced by late fall nitrogen rate and averaged over varieties and late fall nitrogen treatments, at the Malheur Experiment Station, Oregon State University, Ontario, Oregon, 2006.

Treatment	Yield[a]	Seed # per area	Seed weight	Test weight	Crude protein	Beta glucan	Plant height	Harvest moisture
	bu/acre	seed # per ft^2	seed # per lb	lb/bu	%	%	inch	%
No nitrogen	100.3	1,330	9,615	57.5	12.5	5.59	33.9	7.6
40 lb N/acre dry urea	106.1	1,399	9,568	57.8	12.6	6.06	32.6	7.6
40 lb N/acreliquid urea	107.8	1,434	9,644	57.7	12.9	5.79	32.5	7.4
40 lb N/acre liquid urea plus ethephon	107.8	1,478	9,921	57.5	12.6	5.19	30.6	7.8
LSD (0.05)	6.9	100.3	175	NS	NS	0.5	1.1	NS

[a]Yield and protein was corrected to a 12 percent moisture basis, 48 lb = bushel.

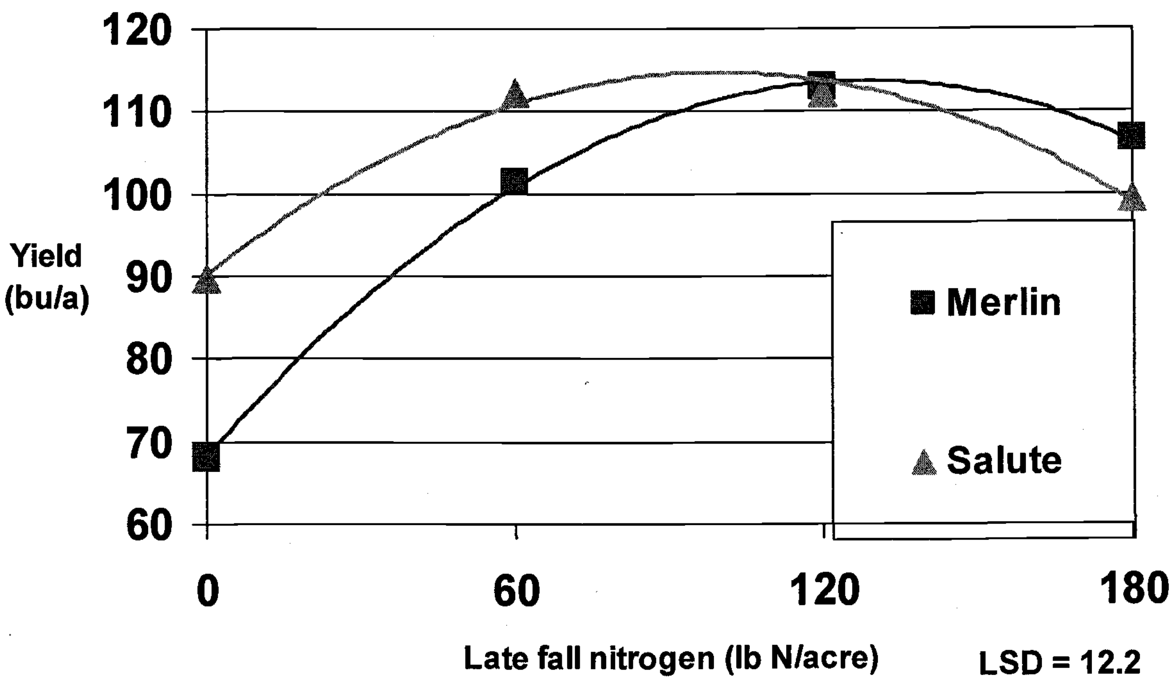

Figure 1. Yield of barley as influenced by late winter N application rate (lb N/acre urea) with no heading applications applied. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

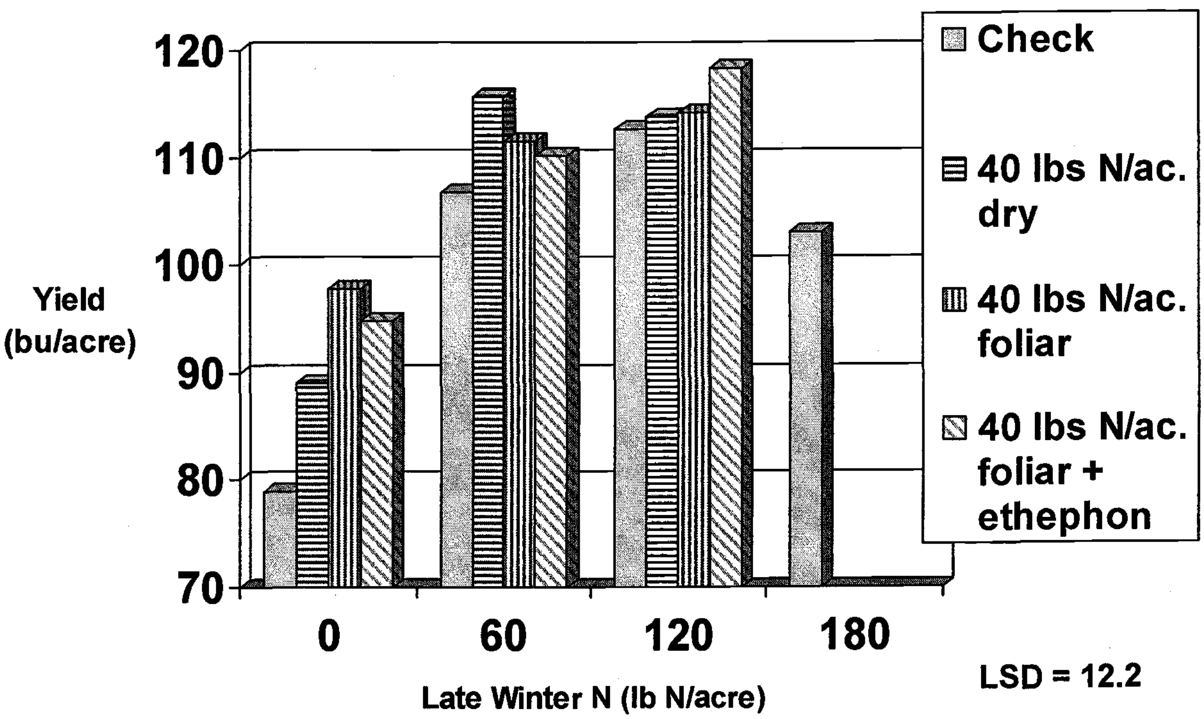

Figure 2. Averaged over varieties, barley yield as influenced by late winter N rate , heading nitrogen rates (dry and fluid urea), and ethephon at Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

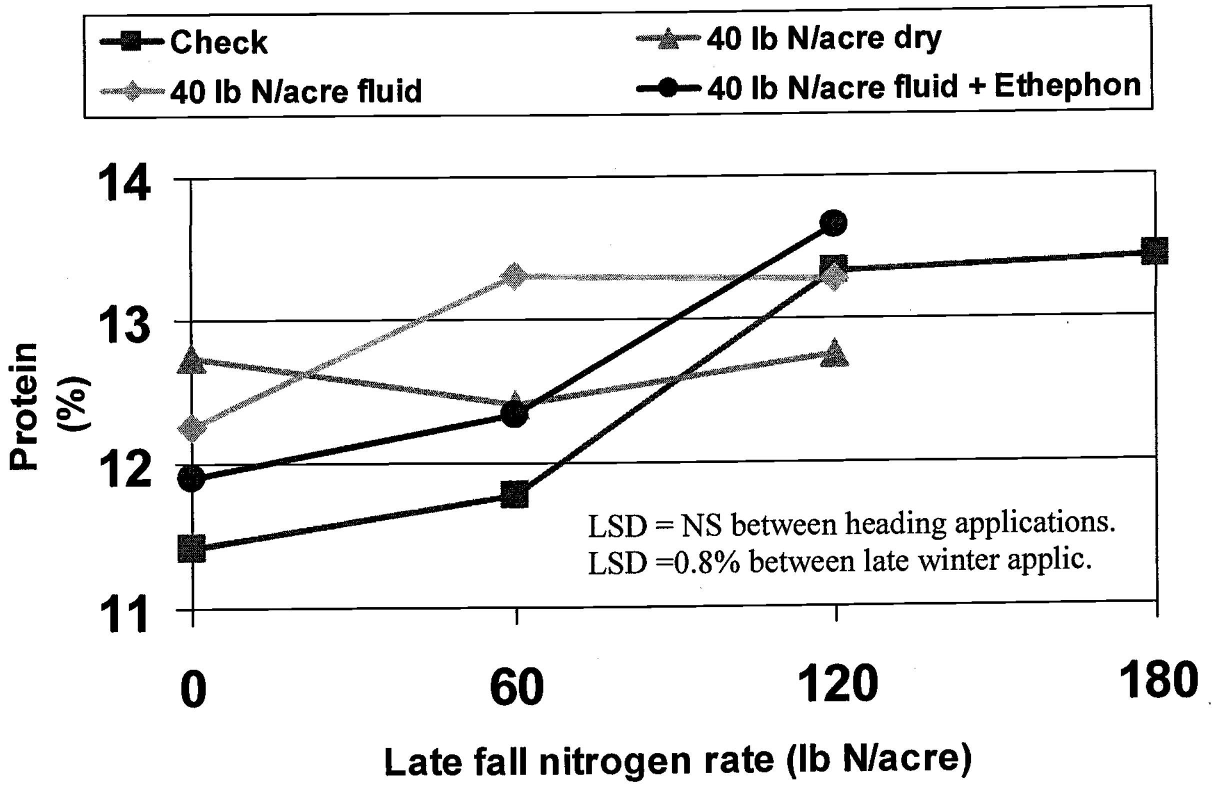

Figure 3. Grain protein averaged over varieties as influenced by late winter nitrogen rate, heading nitrogen (dry and fluid urea), and ethephon at Malheur Experiment Station, Ontario, OR, 2006.

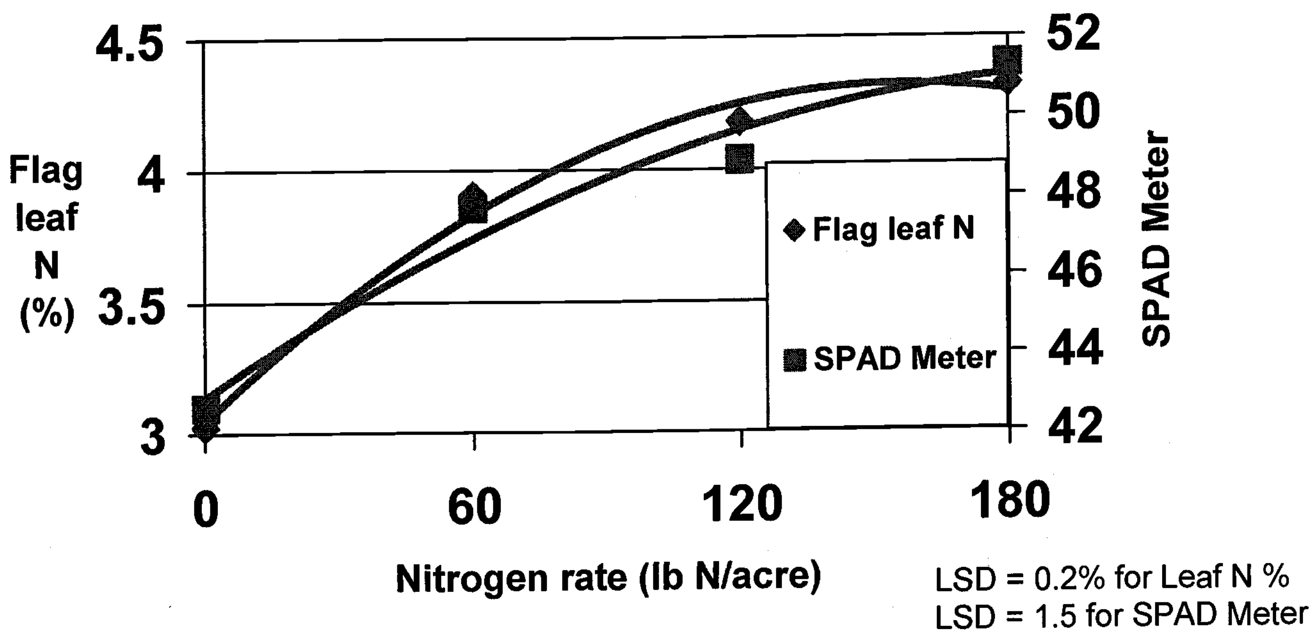

Figure 4. Flag leaf nitrogen and SPAD meter readings as influenced by late winter nitrogen application rate averaged over varieties Malheur Experiment Station, Ontario, OR, 2006.

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

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Introduction

Treasure Valley Renewable Resources is in the process of putting a grain fractionation plant in Ontario, Oregon and one of their primary interests includes contracting barley that has fully waxy starch, and is high in beta-glucan fiber and protein. Very little research has been done on growing barley for high protein and response of barley varieties to nitrogen application. Previous work by Brad Brown, Cereal Specialist for University of Idaho at Parma, has shown that 'Merlin' and 'Salute', spring genotypes that were developed by WestBred (Bozeman, MT), are among the best waxy cultivars available. A fall barley genotype would work best in our rotational system due to higher yields obtained. Unfortunately, right now there are no fall waxy barley cultivars available. Pat Hayes, barley breeder at Oregon State University (OSU), has started a winter waxy breeding project. Waxy barley would fit into the Treasure Valley cropping system as a rotational crop where traditionally wheat and corn were grown. Pat Hayes indicated the current fall non-waxy genotypes that are either standards in the industry or are very high yielding for the Treasure Valley include 'Strider' released by OSU, 'Maja' (Stab 113) released by Agrisource, 'Eight-Twelve' released by the University of Idaho, and 'Sunstar Pride' released by Sunderman Breeding. Brad Brown has planted spring barley genotypes in the fall with a fair degree of success, including Merlin and Salute. The purpose of this trial was to determine winter survival of two fall-planted spring waxy barley varieties to compare yield and quality to the four barley industry standard varieties when heading nitrogen was foliarly applied.

Methods

The experiment was planted on Owyhee silt loam at the Malheur Experiment Station on a field that grew field corn the previous year. Seedbed preparation included disking, cultivating, and furrowing. Soil samples were collected prior to fall tillage and showed 31 lb/acre nitrogen (N) in the top 2 ft of soil, in the top foot of soil 25 ppm phosphorus (P) (Olson method), 313 ppm potassium (K), 16 ppm sulfate (SO_4), 2,442 ppm calcium (Ca), 501 ppm magnesium (Mg), 1.75 ppm zinc (Zn), 5.25 ppm iron (Fe), 5 ppm magnesium (Mn), 0.6 ppm copper (Cu), 0.4 ppm boron (B) and 1.0 percent organic matter. Fall fertilizer rates applied per acre were 50 lb/N, 50 lb/P, 50 lb/SO_4, 50 lb/elemental S, 1 lb/Cu, and 1 lb/B on August 8, 2005. The field was planted on October 24, 2005 with a plot drill on 30-inch beds with 3 drill rows per bed. The experimental design was a randomized complete block design with four replications. Spring fertilizer was 100 lb/acre N as urea applied by aerial application on March 31, 2006. Visual plant stand estimations were taken on April 12. Eight flag leaves were taken from all plots and combined into one sample for each variety on May 25 and sent to Brookside Laboratory, New Knoxville, Ohio, for analysis. A heading N application of 74 lb N/acre of fluid urea was made on May 26, 2006, when most varieties had reached 50 percent heading. The field was sprayed for weeds with Bronate® herbicide at 1 qt/acre applied May 11, 2006. The trial was furrow irrigated for 24 hours on May 2, May 19, June 1, and June 14. Plant height was measured on June 23, 2006. Plots were cut to size and harvested with a Hege combine on July 21 and 24.

Response variables were compared using ANOVA and least significant differences at the 10 percent probability, LSD (0.10). Differences between response variables should be equal to or greater than the corresponding LSD (0.10) value before any variety is considered different from another in this trial.

Results

Plant stands of Salute (74 percent) and Merlin (61 percent) were significantly less than the winter varieties planted, which ranged from 89 to 90 percent (Table 1.). Flag leaf samples taken on May 25 revealed lower N levels (2.5 percent N) than the no-N plots (3.0 percent N) in another study this year that was looking at the response of Salute and Merlin to N. Considering 180 lb/acre of N applied prior to heading, it is interesting that N levels in the plant were so low. Flag leaf concentrations ranged from 2.5 to 3.0 percent depending on cultivar (Table 2). A heading N rate of 74 lb/acre foliar N was applied on May 26. Once heading occurred it was obvious that birds preferred eating the two-row barley varieties, Salute and Merlin, compared to the six-row cultivars. Bird netting was placed over all the plots to decrease damage.

Sunstar Pride had a later heading date than the other varieties (Table 1). This later heading date coupled with the heading N application done to all treatments on one date may have had a strong impact on seed yield and seed number. Sunstar Pride had significantly higher yield than Strider and all other varieties in the test (Table 2). Variety research conducted by the University of Idaho at Parma has shown that Strider generally yields as well as Sunstar Pride. Sunstar Pride, with significantly lower grain protein levels (Table 2) than all other cultivars, suggest that most of the heading N went toward yield. Strider significantly outyielded all other varieties in the trial except Sunstar Pride. Salute had the third highest yield and its mean was higher than Eight-Twelve and Maja, although not significantly different. Salute also significantly outyielded Merlin in this low N environment. Merlin, the only hulless variety in the trial, had significantly higher test weight and seed moisture as well as fewer seeds per pound (higher seed weight). Merlin was also significantly shorter than any other variety in the trial and had the lowest yield of the trial.

Conclusion

When applying N at heading in a variety trial, careful attention to growth stage is important to reduce the likelihood of giving a yield advantage to late maturing cultivars such as Sunstar Pride. Literature recommends applying N after 50 percent heading in wheat. Sunstar Pride put its N into increasing seed number and consequently yield. Even though Merlin was the lowest yielder it had significantly higher grain protein content than any other cultivar in the test. Strider outyielded Salute and Merlin by 15.6 percent and 32 percent, respectively. Further research needs to be conducted to see how different barley varieties respond to heading N applications.

Acknowledgement

This research was supported by a grant from Treasure Valley Renewable Resources.

Table 1. Barley stand on April 12, maturity, heading date, and plant height on July 23 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Plant maturity	Date of 50% heading	Plant height	Plant stand
	date	date	inch	%
Sunstar Pride	Aug. 5	May 28	28	89
Strider	July 27	May 18	31	89
Salute	July 27	May 21	30	74
Eight-Twelve	July 24	May 18	29	89
Maja (Stab 113)	July 25	May 16	33	90
Merlin	July 25	May 21	20	61
LSD (0.10)	2 days	N/A[a]	3	5

[a]N/A = Not available since not replicated.

Table 2. Barley yield and quality results. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

Variety	Yield[a]	Seed # per area	Seed weight	Crude protein	Flag leaf N	Harvest moisture	Test weight
	bu/acre	Seed # per ft^2	seed # per lb	%	%	%	lb/bu
Sunstar Pride	135.3	2,102	11,270	8.3	2.5	7.7	52.2
Strider	99.5	1,677	12,270	11.1	2.6	7.0	49.4
Salute	83.9	1,308	11,290	11.1	2.5	7.6	53.6
Eight-Twelve	75.9	1,189	11,400	10.3	2.7	7.6	51.0
Maja (Stab113)	73.1	1,194	11,870	10.9	3	7.3	50.6
Merlin	67.5	866	9,330	12.1	2.5	9.5	61.6
LSD (0.10)	14.4	260	770	0.9	N/A[b]	0.5	0.7

[a]Yield is corrected to a 12 percent moisture basis, bu = 48 lb.
[b]N/A = Not available since not replicated.

YELLOW NUTSEDGE NUTLET PRODUCTION IN RESPONSE TO NUTLET PLANTING DEPTH

Clinton C. Shock, Joey Ishida, and Erik Feibert
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Ontario, OR, 2006

Introduction

Yellow nutsedge has become a major problem weed in agricultural land in the Treasure Valley. Control of yellow nutsedge is difficult because reproduction is mainly by rhizomes and tubers (nutlets) and nutlet production is intense. Control of yellow nutsedge will partly rely on nutlet destruction by fumigation. Information on the depth at which most nutlets are produced and the maximum depth from which nutlets will emerge is essential for managing tillage and fumigation operations. This trial tested nutlet emergence, nutlet production, and depth of production for nutlets planted at different depths.

Materials and Methods

The experimental design was a randomized complete block with four replicates. The treatments were nine planting depths starting at 2 inches and increasing in 2-inch increments. Each plot consisted of a 10-inch-diameter PVC pipe, 24 inches long. The pipes were cut lengthwise on two opposing sides. The pipes were then reassembled by taping the cut sides. The pipes were arranged in two parallel rows with 18 pipes in each row. The pipes were placed in a trench and the trench was filled so the top of the pipes were at ground level. The pipes were filled with soil and then drip-irrigated for 30 minutes. Each pipe was irrigated with one emitter with a 1 gal/hour flow rate. On May 5, sprouted nutlets were collected from a field severely infested with yellow nutsedge. Two sprouted nutlets were planted at each pipe center, 3 inches apart at the treatment depth. Planting holes were made with a soil probe to the correct depth. After planting, the pipes were irrigated for 15 minutes. 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 May 5 to the last irrigation on October 10.

On November 7, the pipes were dug up. Each pipe was opened along the precut sides and the soil column was cut vertically in 2-inch increments. The nutlets from each 2-inch depth increment were separated by washing and sieving. The nutlets from each 2-inch depth increment were counted and weighed.

To calculate the average nutlet depth, the number of nutlets recovered from each soil depth increment were assigned the average depth of that soil depth treatment. The number of nutlets recovered from the 0- to 2-inch depth in a pipe was multiplied by 1, the number of nutlets recovered from the 2- to 4-inch depth was multiplied by 3, etc.

Results and Discussion

Large numbers of nutlets were produced in each pipe. There was no significant difference between planting depths in the total number, total weight, average weight, and average depth of the nutlets produced (Table 1). On average, nutlets were produced at a 3.8-inch depth (Table 1). Below the 4- to 6-inch depth, nutlet production decreased sharply with increasing depth (Fig. 1).

The results show that regardless of the depth of nutlet emergence, new nutlets form mostly in the upper 6 inches of soil.

Table 1. Nutlet production and average depth of nutlets produced by yellow nutsedge plants originating from nutlets planted at nine depths. Malheur Experiment Station, Oregon State University, Ontario, OR.

Planting depth	Nutlets produced	Total nutlet weight	Average nutlet weight	Average depth of nutlets produced
inches	No./ ft^2	oz/ft^2	g	inches
2	2,067	9.80	0.14	3.64
4	1,896	9.33	0.14	3.66
6	2,050	9.63	0.14	3.88
8	2,316	12.54	0.15	4.26
10	2,001	10.89	0.16	3.66
12	1,802	9.65	0.15	3.83
14	1,523	8.65	0.16	4.08
16	1,694	8.60	0.15	4.10
18	1,421	7.54	0.15	3.15
average	1,863	9.63	0.15	3.81
LSD (0.05)	NS	NS	NS	NS

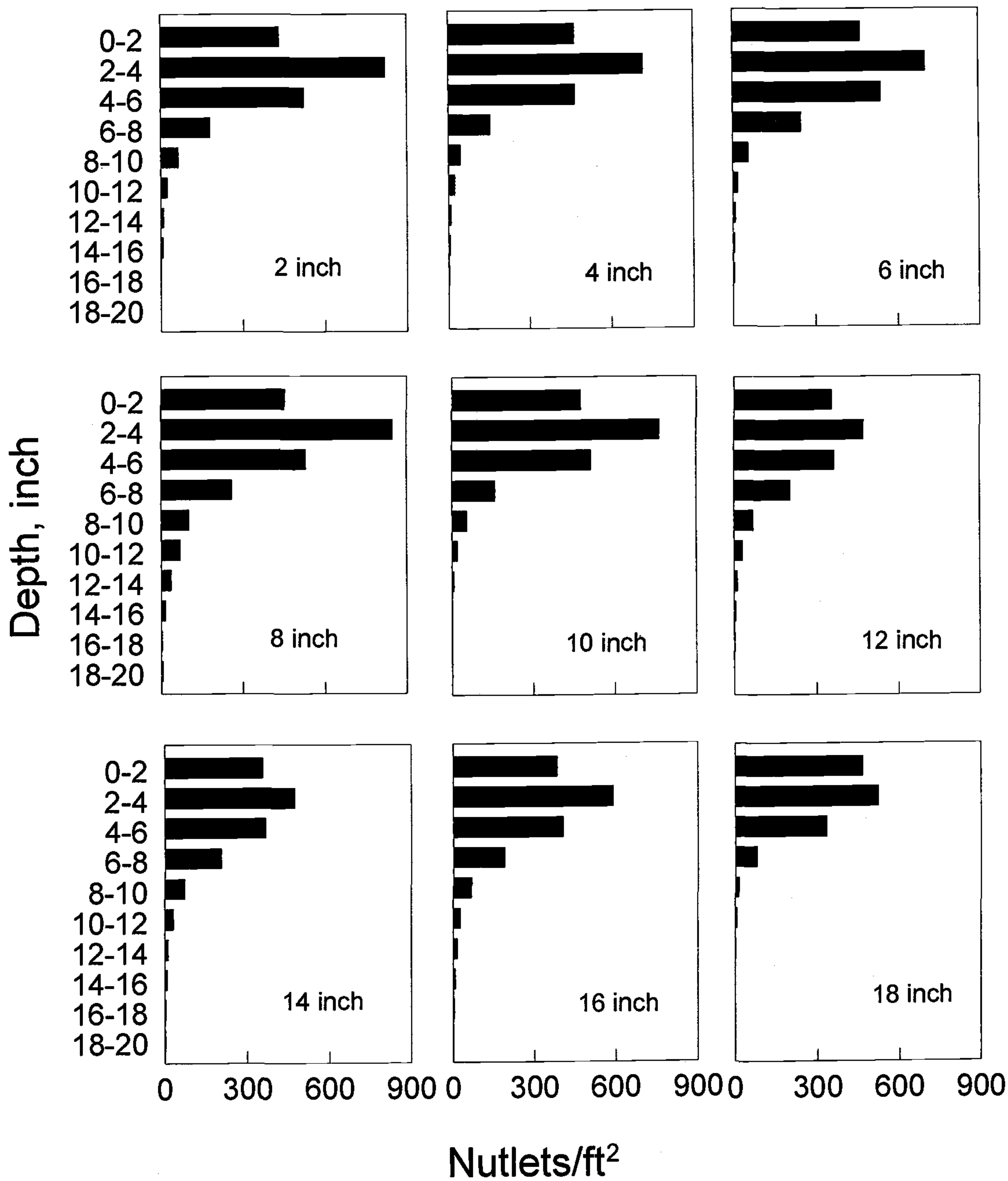

Figure 1. Distribution of yellow nutsedge nutlets by depth from nutlets planted at nine depths. Malheur Experiment Station, Oregon State University, Ontario, OR.

YELLOW NUTSEDGE NUTLET LOSS OF VIABILITY WITH DESICCATION UNDER CONTROLLED AND FIELD CONDITIONS

Clinton C. Shock, Joey Ishida, and Erik B.G. Feibert
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Ontario, OR, 2006

Introduction

Yellow nutsedge has become a major problem weed in agricultural land in the Treasure Valley. Control of yellow nutsedge is difficult because reproduction is mainly by rhizomes and tubers (nutlets) and nutlet production is intense. One control method being investigated is nutlet desiccation. Yellow nutsedge is a stream edge or marsh plant, which suggests that nutlets might not be adapted to withstand drought. Allowing the nutlets to desiccate on the surface soil in the late summer after a wheat crop might result in high nutlet destruction. Soil surface layers typically become quite hot in midsummer, so a summer fallow might also dramatically reduce viable nutlet numbers. This preliminary trial tested the destruction of nutlets by desiccation under controlled conditions and in the field.

Materials and Methods

Controlled conditions

Two laboratory desiccation trials were conducted in 2006: one at 104°F in February and March and one at 86°F in April and May. Nutsedge nutlets for both trials were collected from a field severely infested with yellow nutsedge approximately 2 miles from Malheur Experiment Station. For the 104°F trial, nutsedge nutlets were collected on February 13 and 14. For the 86°F trial, nutsedge nutlets were collected from March 20 to March 28. The nutlets were washed with distilled water and patted dry with paper towels to remove free moisture. The experimental design was a randomized complete block with four replicates. The treatments were two desiccation temperatures, each with an unheated check and four heat durations. The durations of desiccation were 1, 3, 5, and 7 days at 104°F and 3, 7, 14, and 21 days at 86°F. We used 100 nutlets for each replicate of each temperature and duration combination (plot). The 100 nutlets for each plot were weighed, placed in tin cans and placed in a convection oven set at the respective temperature.

After drying, the nutlets were removed from the oven, weighed, and placed on filter paper in a petri dish. The nutlets were covered with another filter paper and 8 ml of distilled water was added. The petri dishes were sealed with plastic wrap and placed in a box in a dark walk-in cooler set to maintain air temperature at 80°F. Four days after nutlets were placed in the cooler, daily counts of the sprouted nutlets were initiated. After the sprouted nutlets were counted, they were removed from the petri dishes and discarded. The 104°F treatment was started on February 23 and the last nutlet count was made on

March 20. The 86°F treatment was started on March 30 and the last nutlet count was made on May 19.

Field conditions
The trial was conducted on a field severely infested with yellow nutsedge approximately 2 miles from the Malheur Experiment Station. The field was furrow irrigated during the summer of 2006. The last irrigation was on July 7. On July 18, the field was flailed and disked. The two treatments were disking once a week for 5 weeks and no disking. The experimental design was a randomized complete block with eight replicates. On September 5, three cores (4.25 inch diameter) were taken at 0- to 4-inch and 4- to 8-inch depth in each plot center. The nutlets from each sample were separated by washing and sieving. Nutlets were placed in open plastic bags in a dark cooler at 40°F.
The field was divided into plots 16 ft wide and 50 ft long. The disking treatment plots were disked on September 7, September 13, September 20, September 27, and October 4. On October 16, core samples were taken in each plot as described previously.

On November 29, the nutlets in the core samples taken before the disking treatments were counted and weighed. On December 1, 100 nutlets sampled before the disking treatments from each plot were put in petri dishes between two layers of filter paper and 6 ml of water was added. The petri dishes were sealed with plastic wrap and placed in a dark, walk-in cooler at 80°F. On December 4, the first of four counts were made of sprouted nutlets in all petri dishes of the predisking samples. Sprouted nutlets were discarded, the petri dishes were resealed and placed in the cooler. The last count was made on December 15. On December 11, nutlets from the samples taken after disking were counted, weighed, and placed in petri dishes as described previously. On December 18, the first of three germination counts was made on the post-disking samples as described previously. The last post-disking count was made on December 22.

Results and Discussion

Controlled conditions
Nutlet weight loss increased with increasing desiccation duration up to 3 days at 104°F and up to 7 days at 86°F (Table 1).

Eighty-one percent of the undesiccated nutlets sprouted within the first 6 days after being placed in the cooler (Fig. 1). The desiccation treatments appeared to slightly delay sprouting, resulting in a prolonged sprouting interval. Nutlets that did not sprout decomposed.

With desiccation at 104°F, rotted nutlets increased with increasing duration of desiccation up to 3 days. With desiccation at 86°F, rotten nutlets increased with increasing duration of desiccation up 21 days.

With desiccation at 104°F, a maximum destruction of 89 percent of the initial nutlets was achieved after 3 days. With desiccation at 86°F, a maximum destruction of 66 percent of the initial nutlets was achieved after 21 days.

Since soil surface temperatures can exceed 120°F, some reduction in nutlet numbers should be possible with field cultivation practices.

Field conditions

There was no significant difference between treatments in nutlet viability after disking at either depth (Table 2). The weather during most of the disking treatment period was cool and wet. A total of 0.64 inch of precipitation occurred during the disking period. Nutlet desiccation earlier in the summer might be more effective in reducing nutlet viability than desiccation in September.

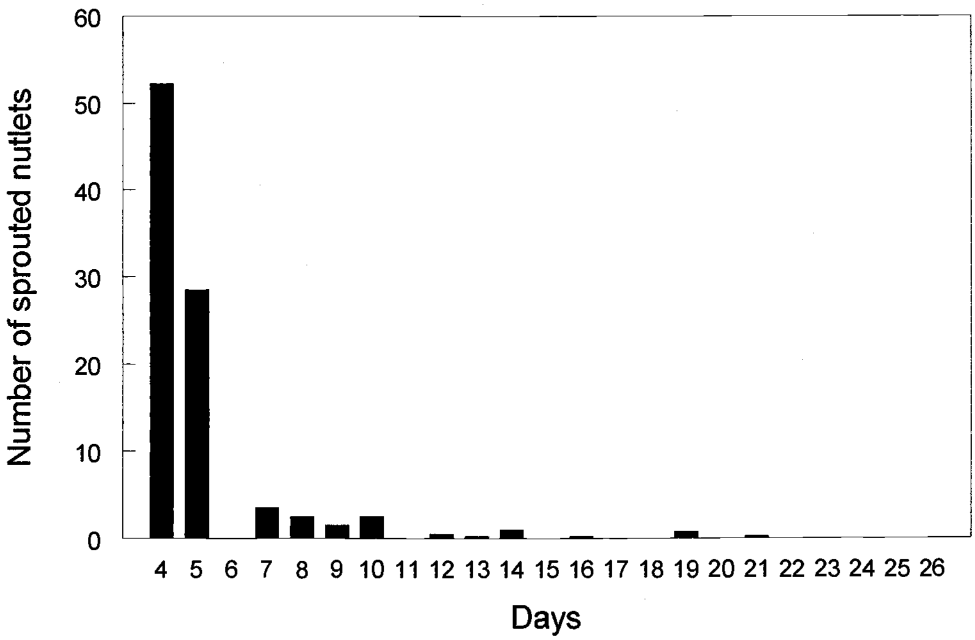
Table 1. Nutlet weight loss, sprouting, and decomposition in response to desiccation temperature and duration under controlled conditions. Malheur Experiment Station, Oregon State University, Ontario, OR.

		100 nutlet weight				
Temperature	Duration	Initial	Final	Weight loss	Sprouted	Rotted
°F	days	---------- grams	----------		%	%
104	undesiccated	11.9			93.8	6.3
	1	13.3	8.4	4.9	43.5	56.5
	3	13.4	7.8	5.7	10.3	89.8
	5	14.1	8.1	6.0	5.0	95.0
	7	13.3	7.6	5.7	1.3	98.8
	average				15.0	
LSD (0.05)		1.2	NS	0.5	9.3	9.3
86	undesiccated	12.6			94.0	6.0
	3	13.5	9.2	4.4	89.8	10.3
	7	14.0	8.5	5.5	65.5	34.5
	14	13.6	8.0	5.6	41.3	58.8
	21	14.5	8.5	6.0	33.8	66.3
	average				57.6	
LSD (0.05)		NS	NS	0.9	25.0	25.0

Table 2. Yellow nutsedge nutlet response to desiccation in the field. Malheur Experiment Station, Oregon State University, Ontario, OR.

	Before disking				After disking				Difference[a]	
	Count		Germination		Count		Germination		Germination	
Treatment	0-4 inch depth	4-8 inch depth	0-4 inch depth	4-8 inch depth	0-4 inch depth	4-8 inch depth	0-4 inch depth	4-8 inch depth	0-4 inch depth	4-8 inch depth
	Nutlets/ft^2		------ % ------		Nutlets/ft^2		------ % ------		------ % ------	
No disking	785.6	143.1	52.8	42.1	882.1	121.8	56.6	92.5	-3.8	-50.5
Disking	599.9	163.4	54.4	46.1	852.6	152.3	35.1	84.9	19.4	-38.8
LSD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a]Difference in germination: germination before disking minus germination after disking.



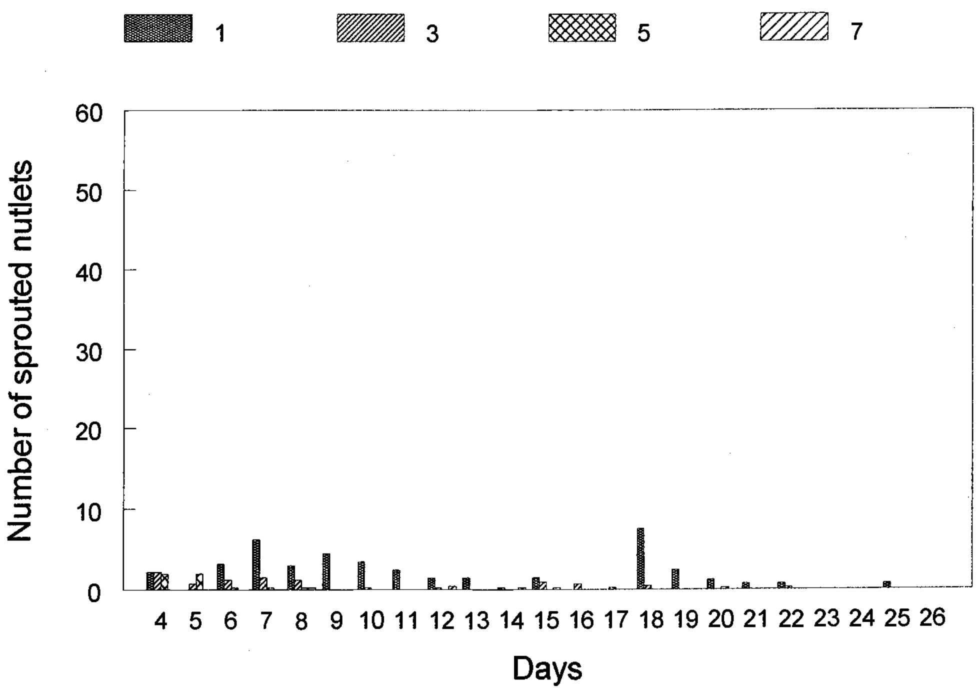


Figure 1. Nutlet sprouting over time for undesiccated nutlets (top graph) and nutlets desiccated at 104°F for 1 to 7 days prior to being placed in growing medium (bottom graph).

YELLOW NUTSEDGE NUTLET VIABILITY IN RESPONSE TO FUMIGATION

Clinton C. Shock, Joey Ishida, and Erik Feibert
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Ontario, OR, 2006

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 is difficult because reproduction is mainly by rhizomes and tubers (nutlets) and nutlet production is intense. Control of yellow nutsedge will partly rely on nutlet destruction by fumigation. Growers and others have suggested that Telone® C-17 could enhance the control of nutsedge if applied prior to Vapam®. Others have suggested that Dual Magnum® could be applied following Vapam to enhance nutsedge control. Consequently, all three products were tested alone and in combination for their effectiveness in reducing nutlet viability.

Materials and Methods

The trial was conducted in a field severely infested with yellow nutsedge, approximately 2 miles from the Malheur Experiment Station. On September 1, 2006, the field was furrow irrigated. The field was disked on September 7. The experimental design was a randomized complete block with four replicates. The treatments were seven fumigants or fumigant combinations and an untreated check (Table 1). Each plot was 16 ft wide and 60 ft long. On September 8, 3 core (4.25 inch diameter) samples, 1 ft apart were taken in the plot center. The core samples were divided into 2 depths: 0- to 12-inches and 12- to 16-inches. The nutlets from each sample were separated by washing and sieving. The nutlets were counted and weighed. Nutlets were placed in open plastic bags in a dark cooler at 40°F.

On September 12, Telone C-17 was shanked in to the respective plots at 23 gal/acre (238 lb ai/acre). Telone C-17 was shanked in at 18-inch depth using equipment with shanks 20 inches apart.

On October 6, Vapam was shanked in to the respective plots at 50 gal/acre (213 lb ai/acre). Vapam was shanked in at 10- to 12-inch depth and 5- to 6-inch depth using equipment with shanks spaced 5 inches apart.

On October 26, Dual Magnum was broadcast on the soil surface to the respective plots at 2 pt/acre (1.9 lb ai/acre). Following the Dual Magnum application, the field was disked twice. On October 27, the field was plowed to a 10-inch depth by Simplot Growers Solutions to thoroughly mix the Dual Magnum into the treated plots. Dual

Magnum is not a registered treatment for plow down preceding onion. It was tested here only as a potential treatment for future registration. The use of this treatment does not constitute a recommendation to use this product.

On November 14, the field was roller harrowed twice. Core samples were taken on October 20, in the same number, size, and depth as before fumigating. The nutlets were counted and weighed. Nutlets were placed in open plastic bags in a dark cooler at 40°F.

On December 8, 100 visually healthy prefumigation nutlets from each plot were put in petri dishes between two layers of filter paper and 6 ml of water was added. The petri dishes were sealed with plastic wrap and placed in a dark, walk-in cooler at 80°F. On December 11, the first of four counts was made of sprouted nutlets in all petri dishes of the prefumigation samples. After counting, the sprouted nutlets were discarded, the petri dishes were resealed and placed in the cooler. The last count was made on January 2. From January 8 to 10, nutlets from the postfumigation samples were placed in petri dishes as described previously. On January 16 the first of three germination counts was made on the postfumigation samples as described previously. The last postfumigation count was made on January 23. In the spring of 2007, the field will be furrowed, irrigated, and nutsedge emergence will be counted.

Results and Discussion

The field had substantially more nutlets in the 0- to 12-inch depth than at the 12- to 16-inch depth. All treatments, except Dual Magnum alone, significantly reduced nutlet viability at the 0- to 12-inch depth (Table 1). Vapam alone or combinations of Vapam with Telone C-17 or Dual Magnum resulted in the largest decrease in nutlet viability at the 0- to 12-inch depth. There was no significant difference in nutlet viability between fumigant treatments at the 12- to 16-inch depth.

All these treatments will be evaluated in the field in the spring of 2007. We expect the treatment effects will show more pronounced differences in the spring because we will be able to evaluate nutlet emergence over larger areas, rather than the small 4-inch soil cores evaluated to date. Dual Magnum may be more effective in the spring, since it is a sprout inhibitor.

Dual Magnum is not a registered treatment for plow down preceding onion. It was tested here only as a potential treatment for future registration. The use of this treatment does not constitute a recommendation to use this product.

Table 1. Nutlet counts and germination in response to fumigation. Malheur Experiment Station, Oregon State University, Ontario, OR, 2006.

	Before				After			
	Count		Germination		Count		Germination	
Treatment	0-12 inch depth	12-16 inch depth	0-12 inch depth	12-16 inch depth	0-12 inch depth	12-16 inch depth	0-12 inch depth	12-16 inch depth
	-- nutlets/ft^2 --		------ % ------		-- nutlets/ft^2 --		------ % ------	
Telone C-17	1,505.3	23.3	61.3	2.8	1,837.2	38.6	11.2	4.2
Vapam	1,319.5	33.5	52.4	5	1,649.4	35.5	1.4	0
Dual Magnum plowed down[a]	2,129.5	20.3	59	20.8	2,562.9	38.6	22.9	16.3
Telone C-17, Vapam	1,835.2	15.2	65.6	0	992.7	66	2.3	25
Telone C-17, Dual Magnum[a]	1,139.9	28.4	65.2	45	1,322.6	23.3	11.3	0
Vapam, Dual Magnum	1,091.1	5.1	72.8	25	1,424.1	66	3.5	7.5
Telone C-17, Vapam, Dual Magnum[a]	535.9	8.1	70.7	0	218.2	10.2	7.1	0
Untreated Check	845.5	13.2	59.6	50	1,799.6	175.6	36.6	9.3
LSD (0.05)	1,145.4	NS	17.8	NS	1,803.7	135.8	14.4	NS

[a]Not a registered application method.

APPENDIX A. HERBICIDES AND ADJUVANTS

Trade Name	Common or Code Name	Manufacturer
Balan	benefin	UAP
Basagran	bentazon	BASF Ag Products
Betamix	desmedipham + phenmedipham	Bayer CropScience
Boa	paraquat dichloride	Griffin LLC
Bronate	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	metolachlor	Syngenta
Eptam	EPTC	Syngenta
Goal, Goal 2XL, 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
Permit	halosulfuron	Monsanto
Plateau	imazapic	BASF Ag Products
Poast, Poast HC	sethoxydim	BASF Ag Products
Prefar	bensulide	Gowen Company
Progress	desmedipham + phenmedipham + ethofumesate	Bayer CropScience
Prowl, Prowl H_2O	pendimethalin	BASF Ag Products
Reglone	diquat dibromide	Syngenta
Roundup, Roundup Ultra Roundup UltraMax	glyphosate	Monsanto
Royal MH-30	maleic hydrazide	Chemtura Corp.
Select	clethodim	Valent
Sencor	metribuzin	Bayer CropScience
Sinbar	terbacil	DuPont
Stinger	clopyralid	Dow Agrosciences
Treflan	trifluralin	Dow Agrosciences
UpBeet	triflusulfuron	Dupont

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES

Trade Name	Common or Code Name	Manufacturer
Admire	imidacloprid	Bayer CropScience
Asana	esfenvalerate	DuPont
Aza-Direct	azadirachtin	Gowan Company
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 Agroscience
Gaucho	imidacloprid	Gowan Company
Gem	trifloxystrobin	Bayer CropScience
Headline	pyraclostrobin	BASF Ag Products
Kocide	copper hydroxide	Griffin
Lannate	methomyl	DuPont
Lorsban, Lorsban 15G	chlorpyrifos	Dow Agroscience
Malathion	malathion	UAP
MSR	oxydemeton-methyl	Gowan Company
Mustang	zeta-cypermethrin	FMC
Pristine	pyraclostrobin + boscalid	BASF Ag Products
Quadris	azoxystrobin	Syngenta
Regent	fipronil	BASF
Ridomil Gold MZ	metalaxyl	Syngenta
Success	spinosad	Dow Agrosci.
Super-Six	liquid sulfur	Plant Health Tech.
Tanos	famoxadone + cymoxanil	Du Pont
Telone C-17	dichloropropene + chloropicrin	Dow Agrosci.
Telone II	dichloropropene	Dow Agrosci.
Temik 15G	aldicarb	Bayer Cropscience
Thimet	phorate	BASF Ag Products
Thiodan	endosulfan	UCPA
Topsin M	thiophanate-methyl	Cerexagri, Inc.
Tops-MZ	thiophanate-methyl	UAP
Vapam	metham sodium	Amvac
Vydate, Vydate L	oxamyl	DuPont
Warrior	cyhalothrin	Syngenta
Warrior T	cyhalothrin	Syngenta

APPENDIX C. COMMON AND SCIENTIFIC NAMES OF CROPS, FORAGES, AND FORBS

Common names	Scientific names
alfalfa	*Medicago sativa*
barley	*Hordeum vulgare*
bluebunch wheatgrass	*Pseudoroegneria spicata*
corn	*Zea mays*
dry edible beans	*Phaseolus spp.*
fernleaf biscuitroot	*Lomatium dissectum*
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*
Russian wildrye	*Psathyrostachys juncea*
sagebrush penstemon	*Penstemon speciosus*
sand penstemon	*Penstemon acuminatus*
Siberian wheatgrass	*Agropyron fragile*
soybeans	*Glycine max*
spearmint, peppermint	*Mentha sp.*
sugar beet	*Beta vulgaris*
sulfur buckwheat	*Eriogonum umbellatum*
supersweet corn	*Zea mays*
sweet corn	*Zea mays*
teff	*Eragrostis tef*
triticale	*Triticum* x *Secale*
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 sp.*
downy brome	*Bromus tectorum*
green foxtail	*Setaria viridis*
hairy nightshade	*Solanum sarrachoides*
kochia	*Kochia scoparia*
perennial pepperweed	*Lepidium latifolium*
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	
potato late blight	*Phytophthora infestans*
Insects	
alfalfa leaf cutting bee	*Megachile rotundata*
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*
stinkbug	*Pentatomidae* sp.
spidermite	*Tetranychus* sp.
sugar beet root maggot	*Tetanops myopaeformis*
western flower thrips	*Franklinella occidentalis*
willow sharpshooter	*Graphocephala confluens* (Uhler)