Special Report 1055

June 2004

Malheur Experiment Station Annual Report 2003

Oregon State UNIVERSITY | Agricultural Experiment Station

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Common names and manufacturers of chemical products use 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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Malheur Experiment Station Special Report
2003 Research

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2003 WEATHER REPORT

Erik B. G. Feibert and Clinton C. Shock
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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, connected 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 is linked to 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 10-inch-deep by 4-ft-diameter pan over 24 hours. Evapotranspiration (Et) for each crop is calculated by the AgriMet computer using data from the AgriMet weather station and the Kimberly-Penman equation (Wright 1982). Reference Et is calculated for a theoretical 12- to 20-inch-tall crop of alfalfa assuming full cover for the whole season. Alfalfa mean Et is calculated for an alfalfa crop assuming a 15 percent reduction to account for cuttings. Evapotranspiration for all crops is calculated using the reference Et and factors for each crop that vary during the season depending on the degree of cover.

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 refer to the years preceding and up to, but not including, the current year.

2003 Weather

The total precipitation for 2003 (8.78 inches) was lower than the 10-year and 59-year averages (Table 1).

The highest temperature for the year was 110°F on July 22, higher than the record of 108°F on August 4, 1961 (Table 2). The lowest temperature for the year was 15°F occurring on various dates in February, November, and December. Average monthly maximum and minimum air temperatures for all months except April, May, and November were higher than the 10-year and 60-year averages (Table 2). July had 13 days with maximum air temperatures equal to or above 100°F.

The months of June, July, August, and October had 17, 18, 11, and 69 percent more growing degree days (50° to 86°F), respectively, than the 17-year average (Table 3). The total number of growing degree days in 2003 (3,443) was the second highest since measurements started being taken in 1986 (3,446 in 1988). Compared to 1994 (the second highest for growing degree days in the last 13 years) the growing degree days in 2003 accumulated more rapidly in July and then again in October (Fig. 1). In 1994 the growing degree days accumulated more evenly during the season. July had the highest number of degree days in the above-optimal range (86° to 104°F) since 1991 (Table 4). The total number of degree days in the above-optimal range in 2003 (130) was second to 1994 with 147.

The months of January, and April through October had total wind runs lower than the 10-year and 55-year averages (Table 5). Total pan-evaporation for June and July were 20 and 11 percent higher than the 10-year and 54-year averages (Table 6). Total Et for all crops in 2003 was higher than the 10-year average (Table 7).

From March through November the average monthly maximum and minimum 4-inch soil temperatures were lower than the 10-year and 35-year averages (Table 8). In January, February, and December the average monthly maximum and minimum 4-inch soil temperatures were higher than the 10-year and 35-year averages. The difference in soil temperature between 2003 and the averages is probably influenced by the installation of turf around the weather station in October of 1997.

The last spring frost (≤32°F) occurred on May 19, 21 days later than the 27-year average date of April 28; the first fall frost occurred on October 11, 7 days later than the 27-year average date of October 4 (Table 9).

The maximum air temperature in 2003 was 110°F on July 22, surpassing the previous record of 108°F on August 4, 1961 (Table 10).

Total snowfall for 2003 (4.5 inches) was the lowest in the last 10 years and the lowest since 1943 (Table 11).

References

Wright, J.L. 1982. New evapotranspiration crop coefficients. J. Irrig. Drain. Div., ASCE 108:57-74.

Table 1. Monthly precipitation at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2003.

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
10-yr avg	1.72	0.97	0.94	1.04	1.24	0.71	0.47	0.15	0.31	0.71	1.01	1.37	10.64
60-yr avg	1.35	0.96	0.95	0.80	1.03	0.78	0.26	0.38	0.49	0.70	1.16	1.32	10.19

Table 2. Monthly air temperature, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	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	49	40	58	40	74	50	75	50	98	64	98	64	110	73	101	74	94	59	87	65	73	45	57	40
Lowest	28	21	39	15	44	20	47	28	59	32	69	45	86	55	84	51	58	35	47	23	37	15	27	15
2003 avg	41	31	48	28	58	35	62	39	73	46	85	55	97	62	92	59	82	48	72	42	47	27	43	30
10-yr avg	37	24	44	26	55	31	64	37	73	46	80	51	91	58	90	54	81	47	66	36	48	28	38	24
59-yr avg	35	20	43	25	55	31	64	37	74	45	82	52	91	58	90	55	80	46	65	36	48	28	37	22

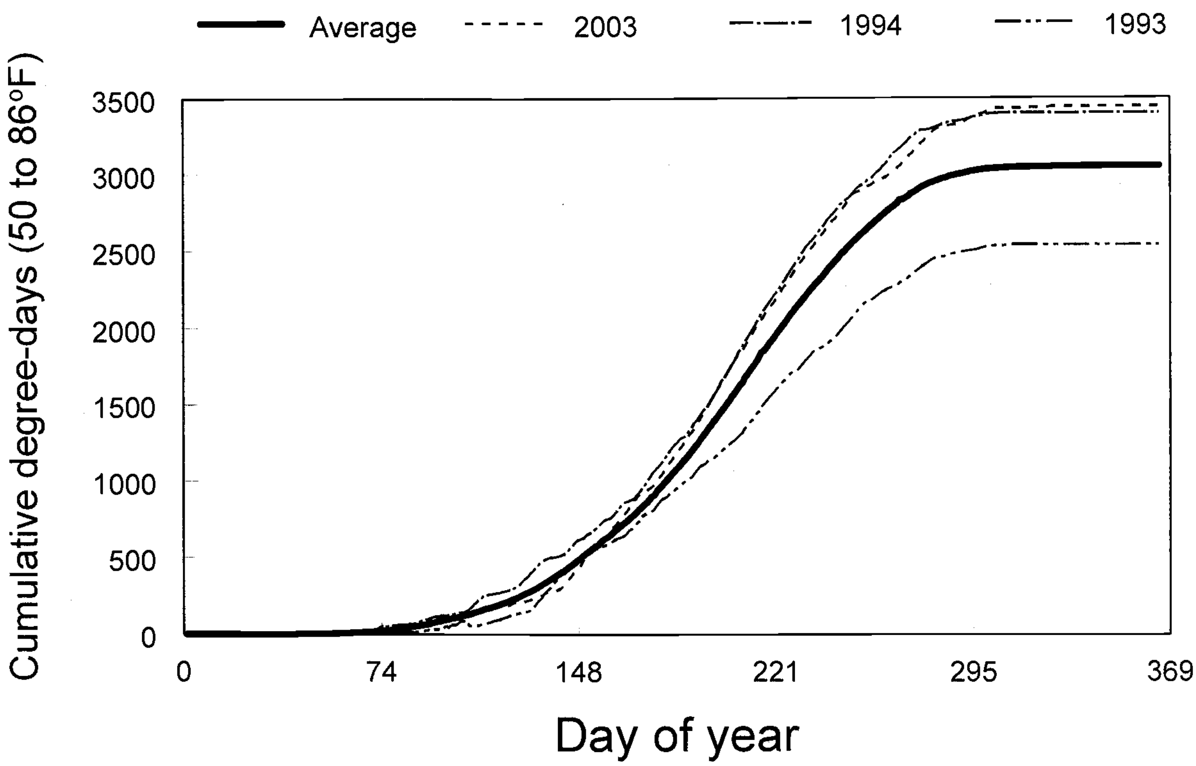

Figure 1. Cumulative growing degree days (50-86°F) over time for selected years compared to 13-year average, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 3. Monthly total growing degree days (50-86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2003.

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
17-year avg	0	6	53	152	324	510	720	682	435	166	13	1	3,064

Table 4. Monthly total degree days in the above ideal 86 -104°F range, Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2003.

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
13-yr avg	0	2	7	38	34	6	0	87

Table 5. Wind-run daily totals and monthly totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Daily	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	------------------- miles -------------------											
Mean	33	71	87	69	56	49	44	35	30	36	60	79
Max.	106	196	250	131	126	100	110	82	135	133	158	204
Min.	5	17	20	29	21	13	10	10	6	6	18	23
Annual total	------------------- miles -------------------											
2003	1,029	1,995	2,684	2,066	1,730	1,457	1,365	1,078	886	1,108	1,794	2,450
10-yr average	1,634	1,897	2,393	2,500	2,326	1,987	1,800	1,737	1,616	1,815	1,596	1,842
55-yr average				2,151	1,941	1,574	1,479	1,336	1,259	1,293		

Table 6. Pan-evaporation totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Totals	April	May	Jun	Jul	Aug	Sep	Oct	Total
Daily	------------------- inches -------------------							
Mean	0.18	0.27	0.38	0.40	0.33	0.24	0.17	
Max.	0.33	0.47	0.48	0.64	0.49	0.41	0.31	
Min.	0.08	0.09	0.26	0.08	0.14	0.03	0.03	
Annual	------------------- inches -------------------							
2003	5.51	8.22	11.30	12.48	10.09	7.21	5.30	60.11
10-yr avg	6.03	8.82	9.42	11.29	10.72	7.38	4.32	57.98
55-yr avg	5.61	7.71	8.90	11.13	9.64	6.30	3.24	52.53

Table 7. Total Et (acre-inches/acre), Malheur Experiment Station, Oregon State University, Ontario, OR, 1992-2003.

Year	Reference Et	Alfalfa (mean)	Winter grain	Spring grain	Sugar beet	Onion	Potato	Dry bean	Field corn	1st year poplar	2nd year poplar	3rd year + poplar
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	44.0
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	32.0	32.4	22.5	29.6	24.3	37.9	45.9
10-year average	55.1	41.4	23.2	24.8	33.4	28.5	26.6	20.4	27.2	24.2	37.7	45.3

Table 8. Monthly soil temperature at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	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	40	39	43	42	49	46	57	51	85	65	75	67	79	73	76	71	72	68	65	62	46	43	44	43
Lowest	34	32	35	33	37	34	45	37	53	49	67	61	70	62	70	64	60	56	48	44	36	34	34	33
2002 avg	37	36	39	37	44	41	51	46	61	55	71	64	74	68	73	68	65	61	57	53	42	38	39	37
10-yr avg	33	32	38	35	49	41	59	49	69	58	77	65	84	72	82	72	74	65	60	52	44	41	35	34
35-yr avg	33	32	38	34	50	41	61	48	72	58	81	66	89	74	87	73	76	63	60	51	44	39	34	33

Table 9. Last and first frost (≤32°F) dates and number of frost-free days, Malheur Experiment Station, Oregon State University, Ontario, OR, 1990-2003.

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
1976-2002 Avg	April 28	October 4	159

Table 10. Record weather events at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1943-2003.

Record event	Measurement	Date
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
Lowest soil temperature at 4-inch depth	12°F	Dec 24, 25, and 26, 1990

Table 11. Annual snowfall totals at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2003.

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	10-yr avg	60-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	17.2	18.5

FIFTH YEAR RESULTS OF THE 1999-2003 ALFALFA FORAGE VARIETY TRIAL

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Ontario, OR, 2003

Introduction

Increasing dairy herds in Oregon and Idaho, and increasing exports of alfalfa cubes, compressed bales, and pellets to nations across the Pacific create a marketing opportunity for premium and supreme quality hay. Quality hay can be obtained by cutting alfalfa early, in the pre-bud to bud stage, but before flowering. Total yield will be lower than it could be with cutting later. However, when there is strong demand for high quality hay, the increased market value may more than compensate for lower yield.

Producing premium quality hay involves increased risk. Repeated early cutting reduces stored carbohydrate in the roots and can result in thinning stands or a shorter life of the stand. Alfalfa stressed by repeated early cutting is more susceptible to pests and diseases that may be present in the field. Varieties can vary in their ability to withstand frequent cutting, diseases, and insects.

In this 5-year trial, 12 proprietary varieties were compared to 2 public check varieties for production of high quality hay. The purpose of this trial was to identify alfalfa varieties that can remain productive when cut early for high quality hay. The trial was established on a marginally productive, alkaline soil with sprinkler irrigation, characteristic of a soil and irrigation system often used for alfalfa hay production.

Methods

The trial was established in September 1998, on Nyssa silt loam that had not been deep plowed. Details of this trial's establishment are in a previous annual report (Eldredge et al. 2000), which is also posted on the internet at: http://www.cropinfo.net/AnnualReports/1999/alf99A2est.htm.

Plots were 20 ft long by 5 ft wide, separated at their ends by 3-ft alleys, with each variety replicated five times in a randomized complete block design. Fall regrowth was mowed with a flail mower and removed from the field on November 14, 2002 to reduce soil cover and improve herbicide spray penetration and effectiveness. Soil cover during winter can also promote rodent colonization of the alfalfa stand.

The alfalfa was harvested on May 7, June 18, July 17, and August 12, 2003. The cuttings were taken when the majority of the plants were at bud stage, with some plants in some plots in early bloom. At each cutting date, a 3-ft by 20-ft swath was cut from the center of each plot using a flail mower, and the alfalfa was weighed. Ten random samples of alfalfa were collected over the entire field before each cutting, dried in a forage drier at 140°F with forced air, and re-weighed to determine the moisture content at each cutting. Yield was reported based on alfalfa hay at 88 percent dry matter. Sprinkler irrigation was resumed the day after each cutting date.

Samples of the stems from approximately 1 ft of row per plot were taken on June 18, just before the second cutting, to measure forage quality. The forage dryer fan motor failed before the samples were dry, so those samples were discarded. Another set of samples were taken from each plot on August 11, just before the fourth cutting, and dried in the forage drier. The dried forage samples were ground to pass a 1-mm screen, subsampled, and sent to the Oregon State University Forage Quality Lab at Klamath Falls, Oregon, where they were reground to pass a 0.5-mm screen. Near infrared spectroscopy (NIRS) was used to estimate percent crude protein, percent acid detergent fiber (ADF), and percent neutral detergent fiber (NDF). Relative feed quality (RFQ) was calculated by the formula:

$$RFQ = \{[88.9 - (ADF * 0.779)] * (120/NDF)\}/1.29$$

Quality standards based on RFQ are: Supreme, RFQ higher than 180, Premium, RFQ 150-179; Good, RFQ 149-125; Fair, RFQ 124-100; and Low, RFQ 99 or lower. Hay with a higher RFQ requires less grain or feed concentrate to formulate the dairy ration.

Results and Discussion

The average fifth-year total hay yield was 4.36 ton/acre (Table 1). There were no significant differences in hay yield between varieties in any cuttings. The crude protein, which averaged 23.6 percent in the fourth cutting, ranged from 22.5 percent for 'Lahontan' to 24.6 percent for 'W-L 325 HQ'. Acid detergent fiber, ADF, averaged 26.7 percent. Neutral detergent fiber, NDF, averaged 32.1 percent. All varieties produced Premium quality hay in the fourth cutting, with RFQ higher than 179.

Over the 5 years, hay yield averaged 5.6 ton/acre/year (Table 2). Information on the disease, nematode, and insect resistance of the varieties in this trial was provided by the participating seed companies and/or the North American Alfalfa Improvement Council (Table 3). Most alfalfa varieties have some resistance to diseases and pests that could limit hay production in northeastern Malheur County. 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.

References

Eldredge, E. P., C.C. Shock, and L. D. Saunders. 2000. First year yield of the 1999-2003 alfalfa forage variety trial. Malheur Experiment Station Annual Report, Oregon State University Agricultural Experiment Station Special Report 1015:12-15.

Table 1. Alfalfa variety hay yields and fourth cutting crude protein*, ADF*, NDF*, relative feed value, and relative feed quality for 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	5/7	6/18	7/174	8/12	2003 total	Crude protein	ADF†	NDF‡	Relative feed quality
	Cutting date								
	ton/acre§					% of DW¶			RFQ
W-L 325HQ	1.25	1.43	1.08	0.98	4.74	24.6	25.8	31.1	207.1
Surpass	1.28	1.36	1.00	1.02	4.65	24.1	26.8	32.2	197.6
Gold Plus	1.10	1.35	1.03	1.06	4.54	23.1	29.0	34.7	178.5
Tango	1.17	1.42	1.07	0.88	4.53	22.9	27.6	33.1	192.1
Wrangler	1.13	1.37	0.98	0.99	4.47	23.5	27.2	32.6	193.3
G9722	1.17	1.29	0.96	0.98	4.40	23.2	27.2	32.8	192.1
ZX9453	1.13	1.32	1.01	0.87	4.33	23.3	27.1	32.5	196.0
DK 142	1.06	1.33	1.02	0.92	4.33	23.1	27.3	32.9	192.3
Rambo	1.06	1.33	0.96	0.92	4.27	23.7	26.3	31.6	201.6
Emperor	1.13	1.29	0.91	0.90	4.23	24.3	24.3	29.4	222.8
Archer II	1.14	1.30	0.94	0.85	4.22	23.7	26.7	32.1	198.6
Plumas	1.06	1.20	0.98	0.94	4.18	23.8	25.4	30.8	210.6
Multi-5301	0.99	1.27	0.91	0.93	4.11	24.4	25.1	30.1	214.7
Lahontan	1.02	1.18	0.95	0.92	4.07	22.5	27.7	33.0	192.2
Mean	1.12	1.32	0.99	0.94	4.36	23.6	26.7	32.1	199.2
LSD(0.05)	NS††	NS	NS	NS	NS	NS	NS	NS	NS

*Based on percent of dry weight.
† ADF: acid detergent fiber.
‡NDF: neutral detergent fiber.
§Yield at 88 percent dry matter.
¶DW: dry weight.
††NS: not significant.

Table 2. Forage yield of alfalfa varieties over 5 production years, Malheur Experiment Station, Oregon State University, Ontario, 2003.

Variety	1999	2000	2001	2002	2003	5-year Total	5-year Average
	ton/acre*						
Surpass	3.68	7.43	6.35	7.08	4.65	29.19	5.84
Rambo	4.22	7.41	6.28	6.84	4.27	29.02	5.80
Tango	4.42	7.61	5.76	6.38	4.53	28.70	5.74
ZX9453	3.83	7.68	6.19	6.62	4.33	28.65	5.73
Emperor	4.55	7.60	5.76	6.46	4.23	28.60	5.72
W-L 325 HQ	4.36	7.82	5.37	6.30	4.74	28.59	5.72
G9722	4.57	7.54	5.63	6.38	4.40	28.52	5.70
Archer II	4.62	7.52	5.81	6.32	4.22	28.49	5.70
DK 142	4.25	7.32	5.66	6.52	4.33	28.08	5.62
Gold Plus	3.75	7.71	5.42	6.24	4.54	27.66	5.53
Wrangler	4.37	6.86	5.53	6.26	4.47	27.49	5.50
Plumas	3.85	7.29	5.66	6.34	4.18	27.32	5.46
Multi-5301	3.99	7.52	4.79	5.86	4.11	26.27	5.25
Lahontan	4.20	6.17	5.25	5.68	4.07	25.37	5.07
Mean	4.19	7.39	5.68	6.38	4.36	28.00	5.60
LSD (0.05)	NS	0.67	NS	NS	NS	NS	NS

*Yield at 88 percent dry matter.

Table 3. Variety source, year of release, fall dormancy, and level of resistance to pests and diseases for 14 varieties in the 1999-2003 forage variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Source	Release year	FD†	Pest resistance rating‡ BW	FW	VW	PRR	AN	SAA	PA	SN	AP	RKN
Lahontan	public	54	6§	MR	LR	-	LR	-	MR	LR	R	-	-
Wrangler	public	84	2	R	R	LR	HR	LR	HR	HR	-	-	-
Surpass	Andrews Seed	85	3	HR	HR	R	R	MR	-	R	-	-	-
Rambo	ABI Alfalfa	95	3	HR	HR	R	HR	HR	MR	R	R	R	-
DK 142	DeKalb	96	4	HR	HR	R	HR	R	R	HR	R	HR	-
Tango	Eureka Seeds	97	6	MR	HR	HR	HR	HR	HR	HR	MR	-	R
WL 325 HQ	W-L Research	97	3	HR	HR	R	HR	HR	R	R	R	R	-
Archer II	ABI Alfalfa	98	5	R	HR	HR	R	HR	R	MR	R	LR	R
Emperor	ABI Alfalfa	98	4	HR	HR	HR	HR	HR	MR	R	-	HR	-
Gold Plus	MBS Inc.	98	4	HR	HR	R	HR	HR	HR	HR	HR	R	-
Multi-5301	Geertson Seed	98	4	R	HR	R	MR	HR	-	R	-	R	-
Plumas	Eureka Seeds	98	4	R	HR	R	HR	HR	HR	R	HR	R	MR
ZX9453	ABI Alfalfa	-	5	-	HR	R	R	MR	R	R	HR	-	MR
G9722	Geertson Seed	-	6	R	R	-	R	-	R	HR	-	-	-

†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: root knot nematode (Northern).

§Fall Dormancy: 1 = Norseman, 2 = Vernal, 3 = Ranger, 4 = Saranac, 5 = DuPuits, 6 = Lahontan, 7 = Mesilla, 8 = Moapa 69, 9 = CUF 101.

‡Pest Resistance Rating: >50% = HR (high resistance), 31-50% = R (resistant), 15-30% = MR (moderate resistance), 6-14% = LR (low resistance)

SECOND YEAR RESULTS OF THE 2002-2006 DRIP IRRIGATED ALFALFA FORAGE VARIETY TRIAL

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Introduction

The purpose of this trial is to compare the productivity of alfalfa varieties in the Treasure Valley area of Malheur County, to test the hay quality of the varieties, and provide information about the adaptation of alfalfa hay production to drip irrigation. In this trial, over of 5 years, 10 proprietary varieties are being compared to 2 public check varieties. This trial was established with a portable sprinkler irrigation system and then grown with a subsurface drip-irrigation system.

Methods

The trial was established on Owyhee silt loam where winter wheat was the previous crop and alfalfa had not been grown in that field for more than 10 years. The alfalfa seed was planted on June 20, 2002, at a rate of 20 lb/acre, in plots 20 ft long by 5 ft wide, separated at their ends by 3-ft alleys, with each variety replicated five times in a randomized complete block design. Pathfinder (Nelson Irrigation Corp., Walla Walla, WA) drip tape (15 mil thick, 0.22 gal/min/100-ft flow rate, 12-inch emitter spacing) was shanked in at a depth of 12 inches on 30-inch spacing between the drip tapes. Portable mini-sprinklers (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) were used to provide uniform irrigation for germination and seedling establishment. Full details of the establishment of this trial can be found on the internet at: www.cropinfo.net/AnnualReports/2002/B5aDripAlf02.htm.

Irrigations before first cutting were managed by manually starting and stopping the drip irrigation system based on the appearance of the soil. After the first cutting, six Watermark sensors (Irrometer Co. Inc., Riverside, CA), connected to an AM400 data logger (M.K. Hansen, East Wenatchee, WA), were installed at 12-inch depth in the center of six alfalfa plots, midway between drip tapes. Crop evapotranspiration (Et) was calculated based on data collected by an AgriMet (U.S. Bureau of Reclamation, Boise, ID) weather station located on the Malheur Experiment Station. Water applied was measured by a totalizing water meter on the inlet of the irrigation system.

The alfalfa was harvested at bud stage on May 7, June 12, July 14, August 8, and September 12, 2003. A 3-ft by 20-ft swath was cut from the center of each plot using a flail mower, and the alfalfa was weighed. Ten samples of alfalfa were hand cut from border areas of plots over the entire field on the same day just before each cutting, quickly weighed, dried in a forage drier at 140°F with forced air, and re-weighed 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 June 12, before the second cutting, to measure forage quality. The forage quality samples were dried, ground to pass a 1-mm screen, subsampled, and sent to the Oregon State University Forage Quality Lab at Klamath Falls, Oregon, where they were reground to pass a 0.5-mm screen. Near infrared spectroscopy (NIRS) was used to estimate percent crude protein, percent acid detergent fiber (ADF), and percent neutral detergent fiber (NDF). Relative feed quality (RFQ) was calculated by the formula:

$$RFQ = \{[88.9 - (ADF * 0.779)] * (120/NDF)\}/1.29$$

Quality standards based on RFQ are: Supreme, RFQ higher than 180; Premium, RFQ 150-179; Good, RFQ 149-125; Fair, RFQ 124-100, and Low, RFQ below 99. Hay with a higher RFQ requires less grain or feed concentrate to formulate the dairy ration.

Fall regrowth was mowed with a flail mower and removed from the field on November 6, 2003, to reduce soil cover and improve herbicide spray penetration and effectiveness. Alfalfa cover during winter can also promote rodent colonization of the alfalfa stand.

Results and Discussion

Three irrigations, on March 21, April 14, and April 21, applied a total of 1.5 inches of water before first cutting. Irrigation before first cutting caused the alfalfa to grow quickly and lodge before the first flower buds appeared.

Rodents chewing holes in the drip tape were a problem in this trial. During the winter, voles burrowed down to the drip tape and chewed holes that were found and repaired at the first irrigation. During the period of regrowth after the second cutting, a gopher moved into the plot area and caused extensive damage to tapes in the border plots at the bottom end of the trial. The gopher was removed and the tapes were spliced to repair the leaks.

Soil moisture was monitored at the 12-inch depth after first cutting (Fig. 1). Sensor data show that the sensors did not respond until a heavy irrigation in early June moved water into the centers of the alfalfa beds. From mid-June to early July, irrigations were not sufficient to prevent gradual drying. After the third cutting on July 14 the soil in the sensor areas became moist and remained in the –15 to –30 kPa (centibar) range for the rest of the season.

Irrigations in April did not match the AgriMet crop Et value (Fig. 2). Because of the early season deficit, the total amount of irrigation applied through the growing season never caught up with the predicted accumulated Et value. Season-long AgriMet alfalfa Et totaled 43.75 inches. The drip-irrigation system applied 31.21 inches, as calculated from the water meter measurement, or 71.4 percent of crop Et. After the second cutting, water applications matched the Et curve. The actual irrigation water available to the alfalfa during the growing season was something less than 71.4 percent of crop Et because some water ran off the plot area when there were leaks caused by rodents.

The average second-year total hay yield was 8.15 ton/acre (Table 1). The first cutting average yield was 2.38 ton/acre, with 'Ruccus', 'Tango', 'Orestan', 'Somerset', 'Plumas', 'SX1005A', and 'SX1001A' yielding among the highest. In the second cutting 'Masterpiece', Tango, Ruccus, and SX1001A were among the highest yielding varieties. In the third cutting, Masterpiece, Ruccus, and Tango were among the highest yielding varieties. In the fourth cutting, Ruccus, 'Lahontan', Tango, and Orestan were among the highest yielding. In the fifth cutting, Ruccus, Tango, and Masterpiece were among the highest yielding varieties.

The crude protein averaged 21.7 percent in the second cutting, and ranged from 20.5 percent for Ruccus to 22.6 percent for Lahontan. Acid detergent fiber, ADF, averaged 33.4 percent. Neutral detergent fiber, NDF, averaged 39.5 percent. Relative feed value averaged 148.7, with Lahontan, SX1001A, SX1005A, and Somerset producing hay with RFQ scores higher than 151.

Total hay production in the first 2 years was highest with the varieties Ruccus, at 11.70 ton/acre, Tango, at 11.42 ton/acre, Masterpiece, at 11.14 ton/acre, and Somerset, at 10.98 ton/acre (Table 2).

Information on the disease, nematode, and insect resistance of the varieties in this trial was provided by the participating seed companies and/or the North American Alfalfa Improvement Council (Table 3). Most alfalfa varieties have some resistance to diseases and pests that could limit hay production in our area. 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.

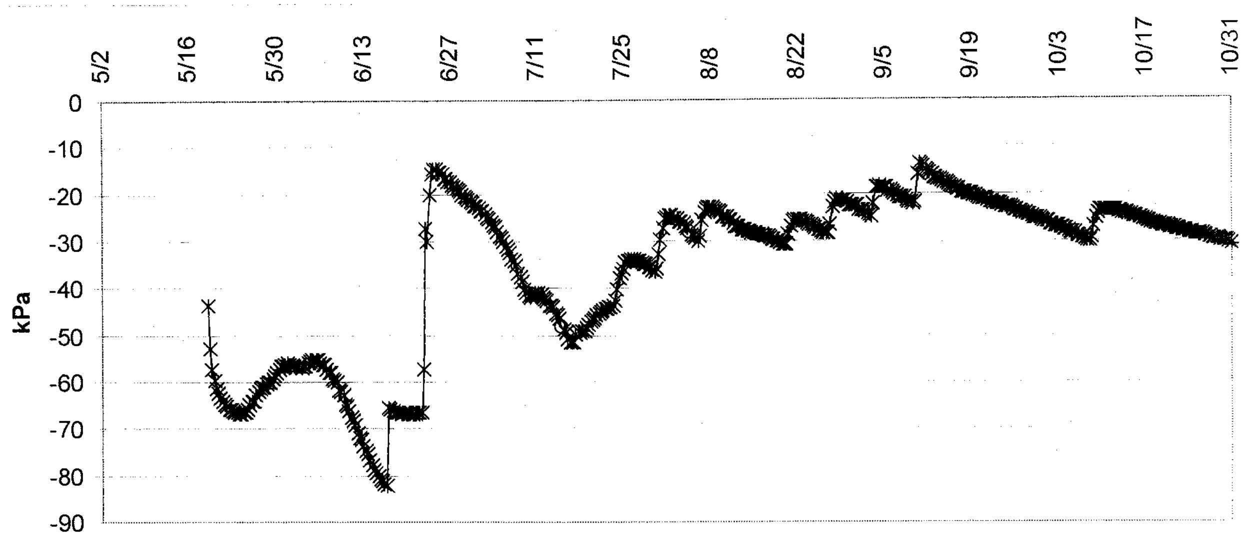

Figure 1. Soil moisture in the drip irrigated alfalfa variety trial during the 2003 growing season, Malheur Experiment Station, Oregon State University, Ontario, OR.

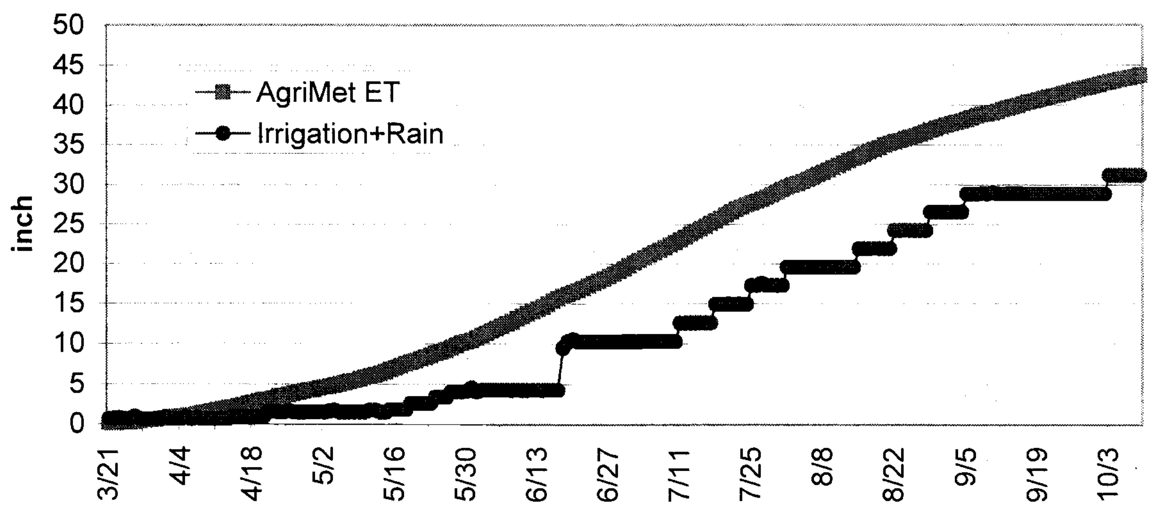

Figure 2. Irrigation applied plus rain in summer of 2003 compared to the AgriMet Et calculation for alfalfa forage, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 1. Alfalfa variety hay yields and second cutting crude protein*, ADF*, NDF*, and relative feed quality for 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	Cutting date 5/7	6/12	7/14	8/8	9/12	2003 total	Crude protein	ADF‡	NDF§	Relative feed quality
	ton/acre†						% of DW¶			RFQ
Ruccus	2.56	2.04	1.76	1.36	1.38	9.10	20.5	35.1	41.7	137.5
Tango	2.54	2.06	1.74	1.30	1.26	8.96	21.9	33.6	39.7	147.3
Masterpiece	2.38	2.12	1.80	1.18	1.24	8.72	20.9	33.5	39.6	147.6
Somerset	2.50	2.00	1.66	1.24	1.06	8.54	21.8	32.6	38.6	153.2
Orestan	2.54	1.86	1.66	1.28	1.14	8.44	21.8	33.2	39.5	148.5
Lahontan	2.24	1.84	1.66	1.32	1.18	8.14	22.6	31.9	37.8	157.6
Plumas	2.40	1.92	1.60	1.10	1.02	8.06	21.8	34.3	40.1	144.5
SX1001A	2.36	2.02	1.64	1.06	0.88	7.96	22.4	32.4	38.3	155.0
SX1005A	2.38	1.94	1.54	1.02	0.88	7.74	22.1	32.5	38.5	153.8
SX1002A	2.30	1.80	1.56	1.08	0.96	7.72	21.9	33.2	39.5	149.1
SX1004A	2.18	1.82	1.52	1.02	0.88	7.46	21.9	33.5	39.3	149.1
SX1003A	2.18	1.80	1.42	1.02	0.90	7.00	21.2	34.4	41.0	141.7
Mean	2.38	1.93	1.63	1.17	1.07	8.15	21.7	33.4	39.5	148.7
LSD (0.05)	0.21	0.14	0.11	0.11	0.14	0.54	NS	1.6	2.2	10.8

*Based on percent of dry weight. †Yield at 88 percent dry matter.
‡ ADF: acid detergent fiber. §NDF: neutral detergent fiber. ¶DW: dry weight.

Table 2. Alfalfa variety hay yields in the first and second years of the 2002-2006 drip-irrigated alfalfa variety forage trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	2002* yield	2003 yield	Cumulative yield
	ton/acre†		
Ruccus	2.60	9.10	11.70
Tango	2.46	8.96	11.42
Masterpiece	2.42	8.72	11.14
Somerset	2.44	8.54	10.98
Plumas	2.64	8.06	10.70
Orestan	2.24	8.44	10.68
Lahontan	1.98	8.14	10.12
SX1005A	2.36	7.74	10.10
SX1001A	2.10	7.96	10.06
SX1002A	1.90	7.72	9.62
SX1004A	2.12	7.46	9.58
SX1003A	2.00	7.00	9.00
Mean	2.27	8.15	10.42
LSD (0.05)	0.4	0.54	0.79

*Two cuttings, 8/6 and 9/5/2002.
†Yield at 88 percent dry matter.

Table 3. Variety source, year of release, fall dormancy, and level of resistance to pests and diseases for 12 varieties in the 2002-2006 drip-irrigated forage variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

		Release		Pest Resistance rating‡									
Variety	Source	year	FD†	BW	FW	VW	PRR	AN	SAA	PA	SN	AP	RKN
Orestan	public	1934	3§	R	-	-	-	-	-	-	-	-	-
Lahontan	public	1954	6	MR	LR	-	LR	-	MR	LR	R	-	-
Tango	Eureka Seeds	1997	6	MR	HR	HR	HR	HR	HR	HR	MR	-	R
Plumas	Eureka Seeds	1997	4	HR	HR	R	HR	HR	R	R	HR	R	MR
Masterpiece	Simplot Agribusiness	2000	4	HR	HR	R	HR	HR	R	-	HR	R	R
Somerset	Croplan Genetics	2000	3	HR	HR	HR	HR	HR	R	-	R	HR	-
Ruccus	Target Seed	2001	5	R	HR	R	HR	MR	R	R	R	-	MR
SX1001A††	Seedex	-	-	-	-	-	-	-	-	-	-	-	-
SX1002A	Seedex	-	-	-	-	-	-	-	-	-	-	-	-
SX1003A	Seedex	-	-	-	-	-	-	-	-	-	-	-	-
SX1004A	Seedex	-	-	-	-	-	-	-	-	-	-	-	-
SX1005A	Seedex	-	-	-	-	-	-	-	-	-	-	-	-

‡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).

†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: root knot nematode (Northern).

§Fall Dormancy: 1 = Norseman, 2 = Vernal, 3 = Ranger, 4 = Saranac, 5 = DuPuits, 6 = Lahontan, 7 = Mesilla, 8 = Moapa 69, 9 = CUF 101.

††Experimental varieties, not released, pest resistance data not available.

RELATIONSHIP BETWEEN WATER STRESS AND SEED YIELD OF TWO DRIP-IRRIGATED ALFALFA VARIETIES

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Ontario, OR 2003

Summary

Two alfalfa varieties ('Tango' and 'Accord') were grown for seed using subsurface drip irrigation with four evapotranspiration (Et_c) replacement levels: 80, 60, 40, and 20 percent of the accumulated water needs. After the start of flowering the alfalfa was irrigated every 3-4 days at the corresponding Et_c replacement level. In the 2003 season, Tango seed yield was highest at 67 percent of Et_c replacement or 24.1 inches of applied water and Accord seed yield was highest at 64 percent of Et_c replacement or 21.6 inches of applied water.

Introduction

Past work at the Malheur Experiment Station in the 1980's demonstrated that water stress was associated with high alfalfa seed yields. There is a strategic balance between the amount of water needed to sustain growth and productivity and water stress sufficient for the alfalfa plant to remain reproductive rather than vegetative. Achieving uniform water stress down the length of the field with furrow irrigation is problematic because water application is not uniform. Alfalfa in areas of the field where more water soaks into the soil remains vegetative, while alfalfa in dry areas can become excessively dry. Subsurface drip irrigation applies water more uniformly allowing for uniform water stress. Subsurface drip irrigation also has environmental benefits compared to furrow irrigation, due to 1) more efficient water use, 2) elimination of deep percolation of water, and 3) elimination of runoff losses of water and nutrients. The purpose of this experiment was to determine the level of deficit irrigation that optimizes seed yield of two alfalfa varieties.

Methods

Establishment Procedures

Alfalfa was grown for seed on a Nyssa silt loam of modest fertility and productivity. The site was chosen to be representative of fields used for alfalfa seed production. The field was previously planted to wheat. Two varieties of alfalfa were planted on April 6, 2000 at 2 lb/acre in 30-inch rows. Tango, with a dormancy rating of six was planted in the upper half of the field and Accord, with a dormancy of four was planted in the lower half of the field. The alfalfa was irrigated with drip tape (T-Tape TSX 515-16-340) buried at 12-inch depth between two alfalfa rows. 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. In 2000 the field was irrigated uniformly the whole season. The seed was harvested with a commercial combine.

2003 Procedures

Alfalfa Irrigation
On March 10 the field was groundhogged once. The field was sprayed with Prowl on March 11. The alfalfa was flailed on May 1 to delay flowering. On May 2, the field was groundhogged twice to thin the plant stand. Flower bud break started June 7. Approximately 2 acre-inches of water were applied to all plots on May 23 and June 2. After June 7, the alfalfa was irrigated at four levels of alfalfa crop evapotranspiration (ET_c) replacement (20, 40, 60, and 80 percent) with five replicates of each treatment (Table 1). Each treatment was irrigated every 3-4 days to replace the percentage of the Et_c deficit that had accumulated since the last irrigation. Irrigations were terminated on August 20.

Each plot consisted of eight alfalfa rows, 480 ft long, with two subplots corresponding to the two alfalfa varieties. Each plot was irrigated separately by its own pressure regulator, electronic solenoid valve, and water meter. Water meters were read before and after each irrigation.

Alfalfa Et_c was calculated with a modified Penman equation (Wright 1982) and peak alfalfa crop coefficients using data collected at the Malheur Experiment Station by an AgriMet weather station (U.S. Bureau of Reclamation, Boise, ID) adjacent to the field. The Et_c was estimated and recorded from dormancy break on March 10 until the final irrigation on August 18. After the alfalfa was flailed, the Et_c was adjusted using crop coefficients. The crop coefficients were derived from weekly measurements of the percent ground cover until full cover was achieved.

Determination of Soil Water Content
Volumetric soil water content was determined by one Gro-Point soil moisture sensor (Environmental Sensors Inc., Escondido, CA) installed at 12-inch depth and one at 20-inch depth in each plot. The Gro-Point sensors were installed horizontally halfway between the drip tape and the alfalfa row in the plot center. Sensors were located 70 ft from the center of the field in the Tango subplots. Sensors were connected by buried cables to electronic communication boards housed in two locations in the field. The electronic communication boards were connected by a cable to a personal computer allowing the soil water content to be read and logged every hour.

Alfalfa Seed Yields
On August 19, biomass samples were taken in each subplot by cutting the plants at ground level in 3.3 ft of one row. The samples were weighed, oven dried, and weighed again. The dried samples were separated into stems, leaves, and seed pods.

The alfalfa was desiccated with Boa (Paraquat dichloride) at 0.63 lb ai/acre and Reglone (Diquat) at 0.5 lb ai/acre on August 29. On September 12, 66 ft of each subplot was harvested with a small plot combine (52-inch width). The harvested seed was cleaned to separate the plant debris from the seed. The seed and the debris were weighed. A subsample of 2001 and 2002 seed from each plot was analyzed for quality by the Oregon State University Seed Laboratory on June 30, 2003. A 400-seed sample was taken from each subsample and analyzed for germination, hard seed, abnormal seed, and dead seed.

Lygus bug monitoring and control
Lygus bugs were monitored twice weekly by taking three 180° sweeps with an insect net in each plot. The total number of early and late instars and adults was counted at each location. When the total number of insects (early and late instars, and adults) reached four per sweep, insecticides were applied (Table 1).

Table 1. Aerial insecticide applications for lygus bug control, Malheur Experiment Station, Oregon State University, Ontario, OR.

Date	Product	Rate lb ai/acre
June 11	Capture	0.1
June 11	Cygon	0.5
June 26	Metasystox-R	0.5
July 16	Dibrom	0.9
July 16	Warrior	0.02
August 4	Capture	0.032
August 8	Dibrom	1.4
August 8	Warrior	0.03

Results and Discussion

Differential Irrigation
The total Et_c from dormancy break to the start of flowering (March 10 to June 6) was 11.4 inches, substantially higher than the approximately 4 inches applied uniformly to all plots (Fig. 1a). After the start of flowering, the treatments were clearly differentiated in terms of cumulative amount of water applied over time (Fig. 1b). The total amount of water applied after the start of flowering was 21.4, 16.2, 10.8, and 5.4 acre-inches per acre for treatments 1-4, respectively. The total Et_c from the start of flowering until the last irrigation was 26.8 acre-inches. The total Et_c for the season was 38.2 inches.

Soil moisture was closely related to the irrigation treatments (Fig. 2). The average soil moisture content at 12-inch depth from June 7 through August 20 was 31, 25, 23, and

20 percent for treatments 1-4, respectively. Soil moisture content at 12-inch depth for treatments 1-3 was similar during irrigations, but became lower between irrigations in accordance with the irrigation treatments. Soil moisture content at 12-inch depth for treatment 4 (irrigated at 20 percent Et_c), remained lower than for the other treatments during and after irrigations. Soil moisture content at 20-inch depth was lower than at 12-inch depth for all treatments (Fig. 3). Soil moisture content at 20-inch depth for treatments 1-3 was similar during and between irrigations. Soil moisture content at 20-inch depth for treatment 4 did not respond to irrigations.

Alfalfa Seed Yields

Alfalfa seed yield increased with increasing Et_c replacement (Fig. 4) and applied water (Fig. 5), reached a maximum, and then decreased. Tango seed yield was highest at 67 percent of Et_c replacement or 24.1 inches of applied water (total water applied from the start of the season) and Accord seed yield was highest at 64 percent of Et_c replacement or 21.6 inches of applied water.

Each year, seed pod dry matter as a percentage of total plant dry matter increased with increasing Et_c replacement, reached a maximum, and then decreased (Fig. 6). In 2003, seed pod dry matter was highest by 49 and 37 percent of Et_c replacement for Tango and Accord, respectively (Table 3).

The Et_c replacement that resulted in the highest seed yield increased over the years (Table 2). The Et_c replacement that resulted in the highest seed pod dry matter was lower in 2001 than in 2002 or 2003. Seed pod dry matter was maximized by lower Et_c replacement than seed yield in 2001 and 2003.

Germination decreased with increasing Et_c replacement for the 2001 and 2002 seed (Fig. 7). Seed defects (hard seed, abnormal seed, and dead seed) also increased with increasing Et_c replacement (Table 3).

Lygus bug insecticide applications were effective in maintaining the population below the economic threshold (four lygus bugs per 180° sweep) until around July 11 (Fig. 8).

Table 2. Highest calculated seed yields, and evapotranspiration (Et_c) replacement strategies resulting in highest seed yield and maximum percent seed pod dry matter for two alfalfa varieties in 3 years, Malheur Experiment Station, Ontario, OR.

	Tango			Accord		
Year	Highest seed yield	Et_c replacement for highest seed yield	Et_c replacement for highest % seed pod dry matter	Highest seed yield	Et_c replacement for highest seed yield	Et_c replacement for highest % seed pod dry matter
	lb/acre	--------- % Et_c ---------		lb/acre	-------- % Et_c ---------	
2001	643	39	32.7	736	45	20
2002	449	51	49.3	533	50	47.4
2003	251	67	48.7	303	64	37.2

Table 3. Effect of evapotranspiration replacement strategy on seed defects averaged over two varieties in 2001 and 2002, Malheur Experiment Station, Ontario, OR.

		Hard seed	Abnormal seed	Dead seed
2001				
	20	5.7	1.8	0.4
	40	6.9	3.4	4.3
	60	8.2	3	3.2
	80	12.7	4.7	7.1
LSD (0.05)		5.5	2.2	4.1
2002				
	0	12.1	5.4	5.8
	40	16.5	4.5	6.8
	60	24.8	4.2	12.7
	80	27.1	5.2	28.5
LSD (0.05)		6.9	ns	6.2

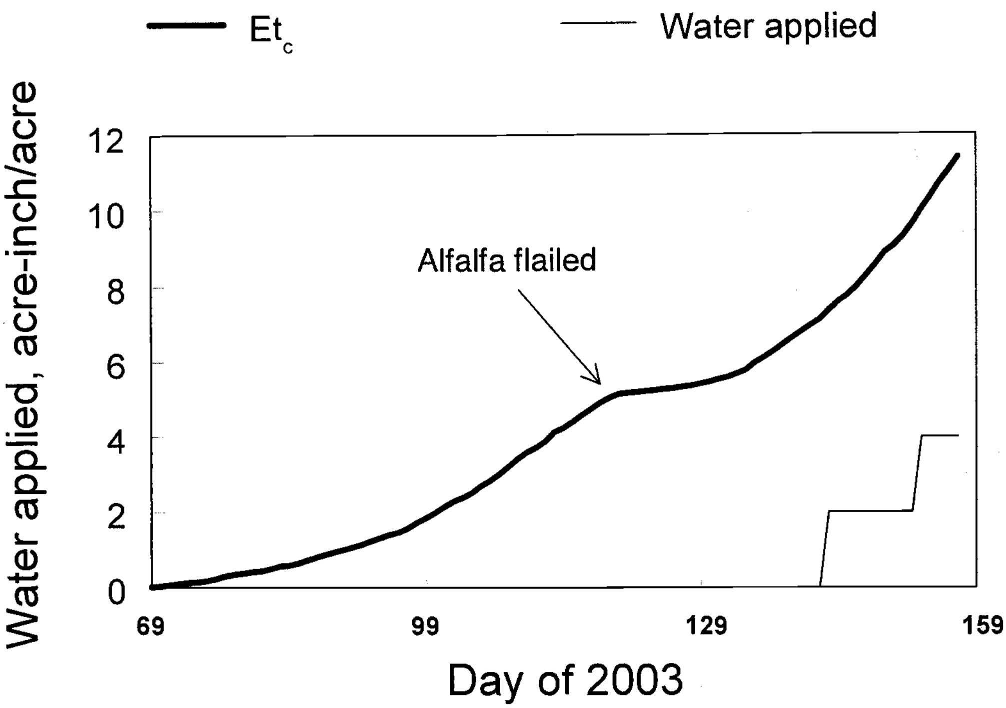

Figure 1a. Cumulative water applied from dormancy break to flowering compared to Et_c for alfalfa seed, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

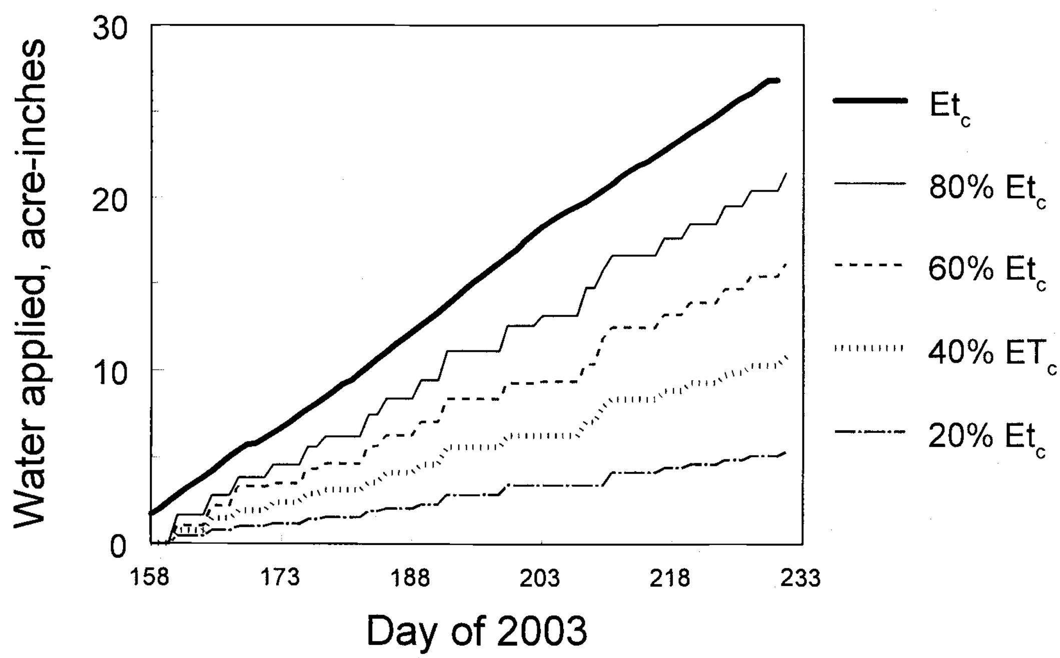

Figure 1b. Cumulative water applied after flowering compared to Et_c for alfalfa seed submitted to four drip-irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

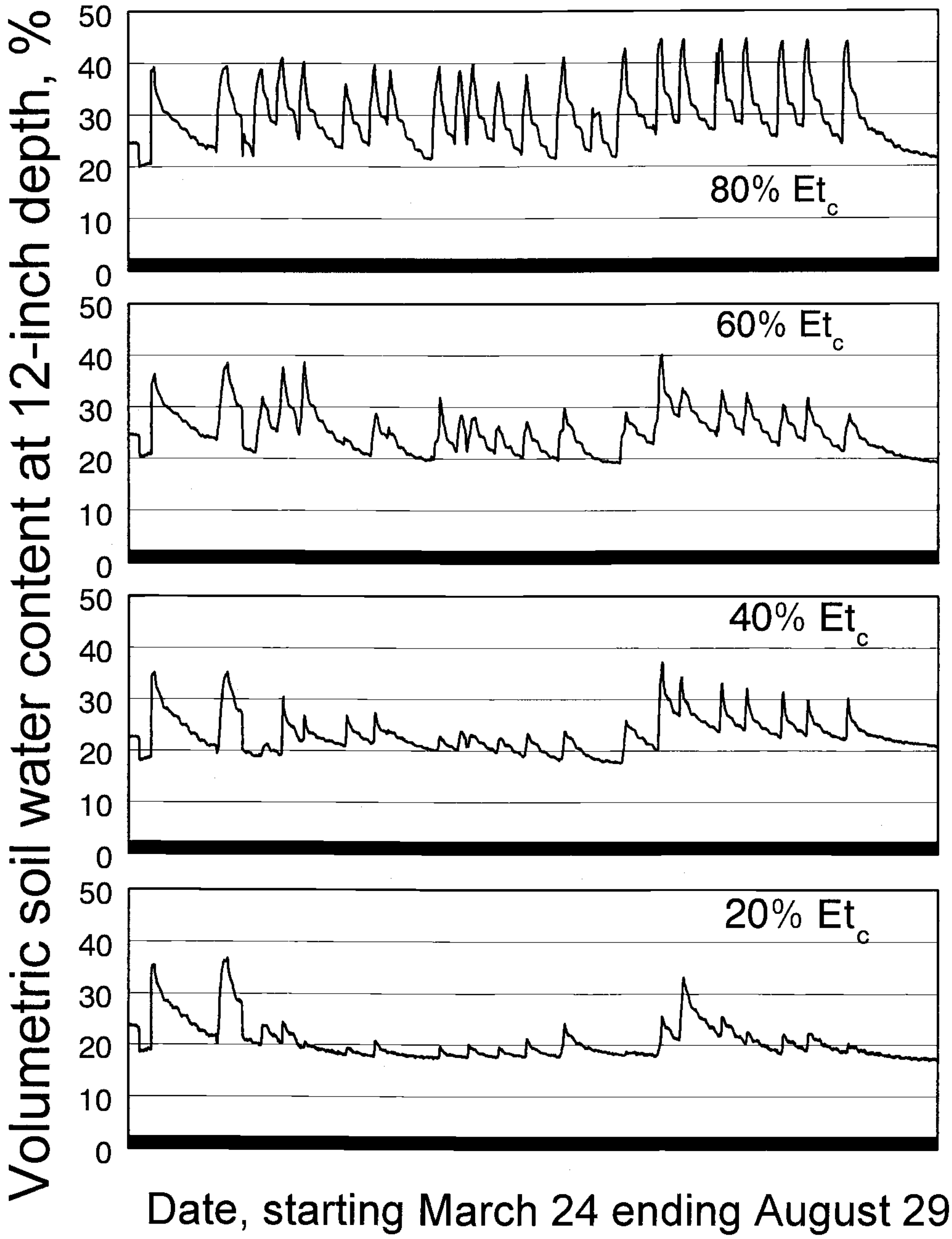

Figure 2. Soil moisture response to irrigation treatment in a drip-irrigated alfalfa seed field, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

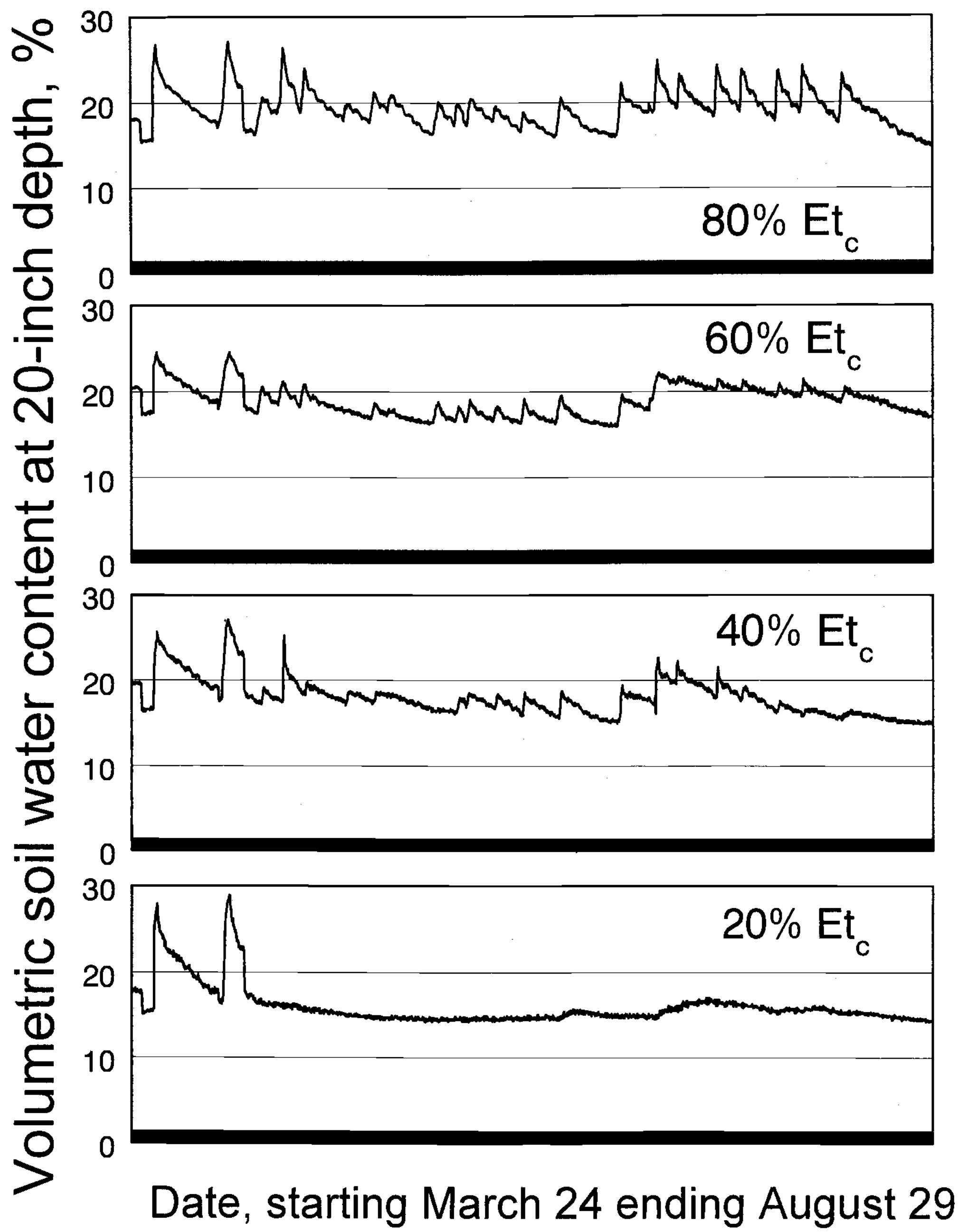

Figure 3. Soil moisture response to irrigation treatment in a drip-irrigated alfalfa seed field, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

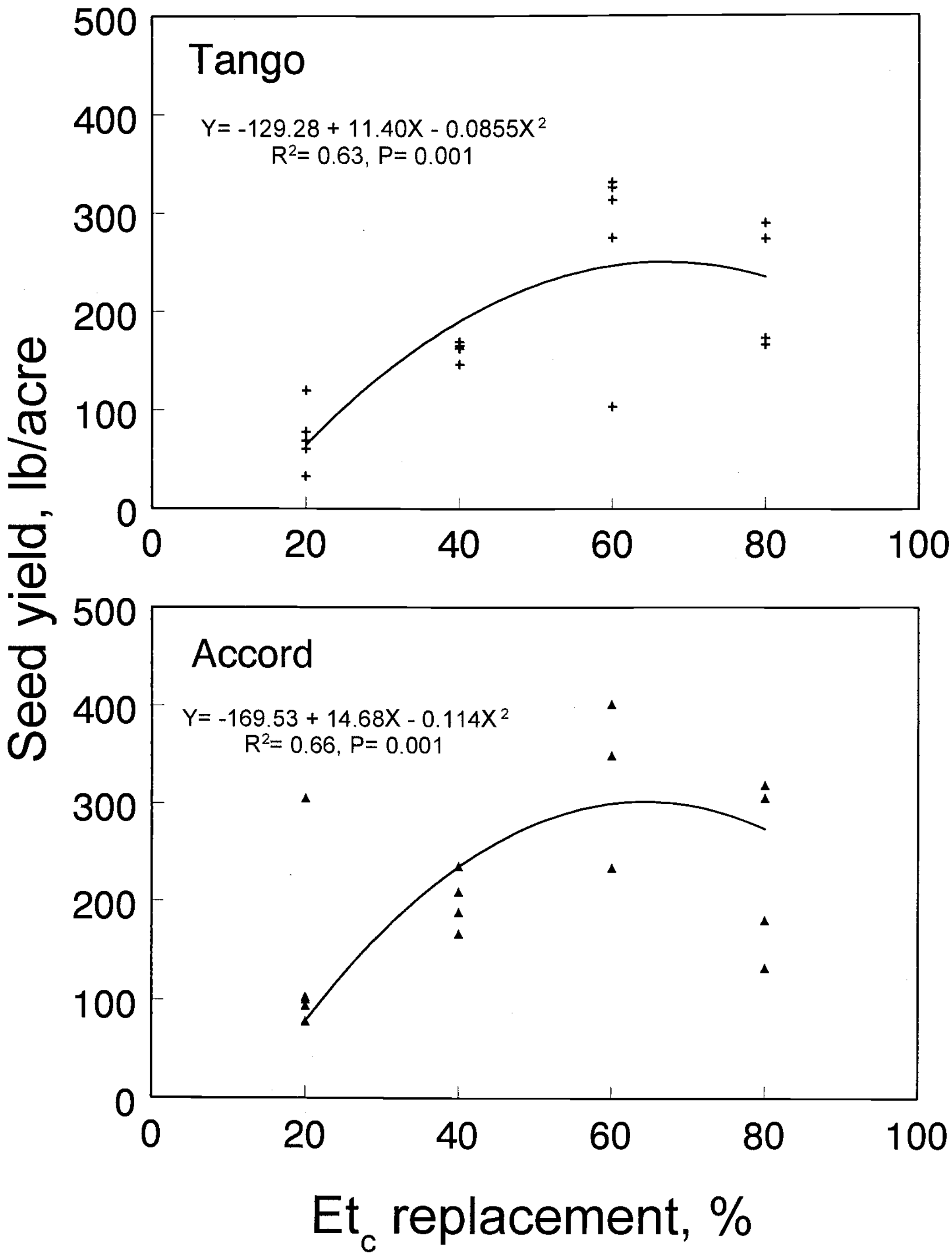

Figure 4. Alfalfa seed yield response to Et_c replacement, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

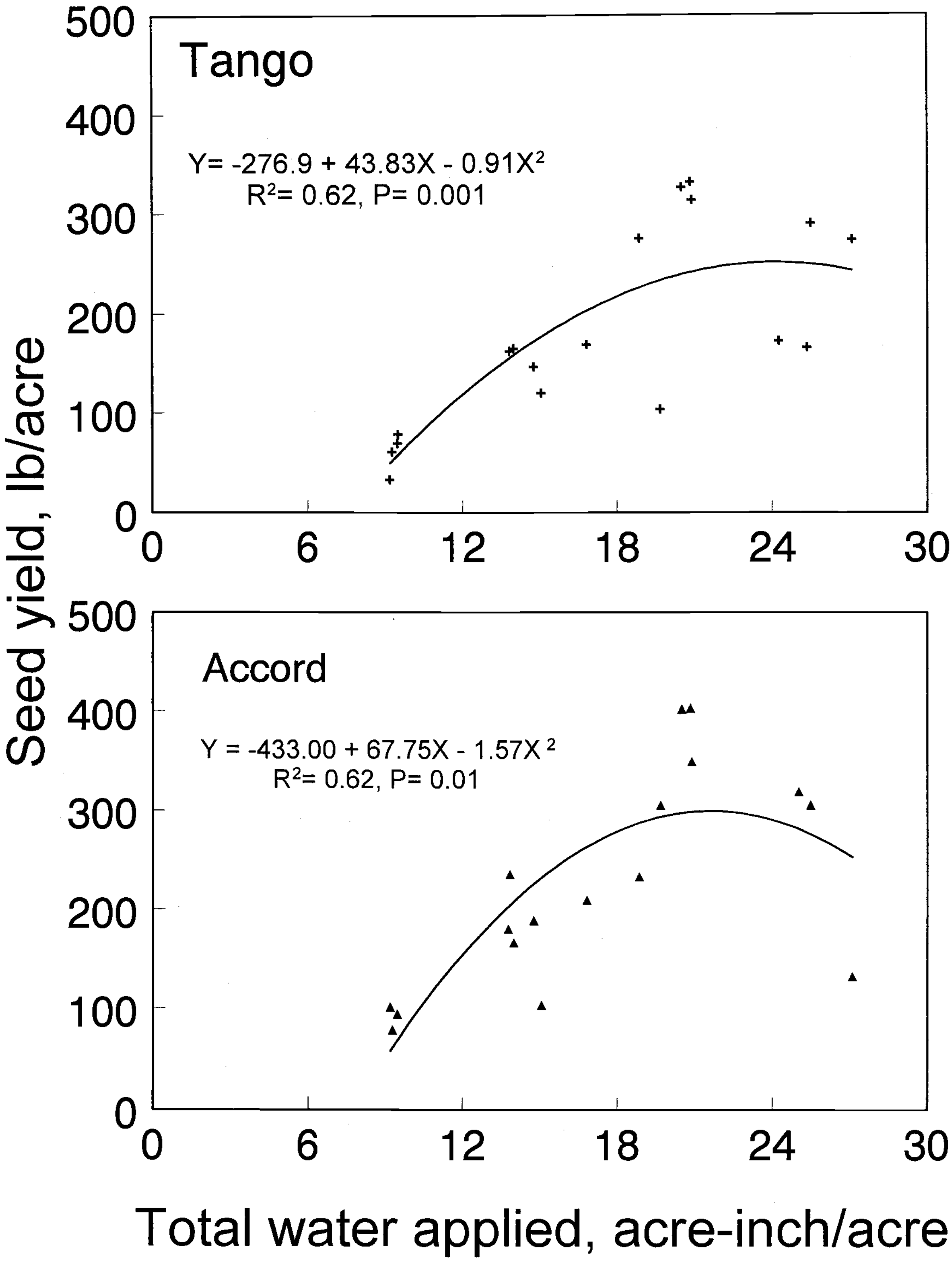

Figure 5. Alfalfa seed yield response to total water applied from the start of the season, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

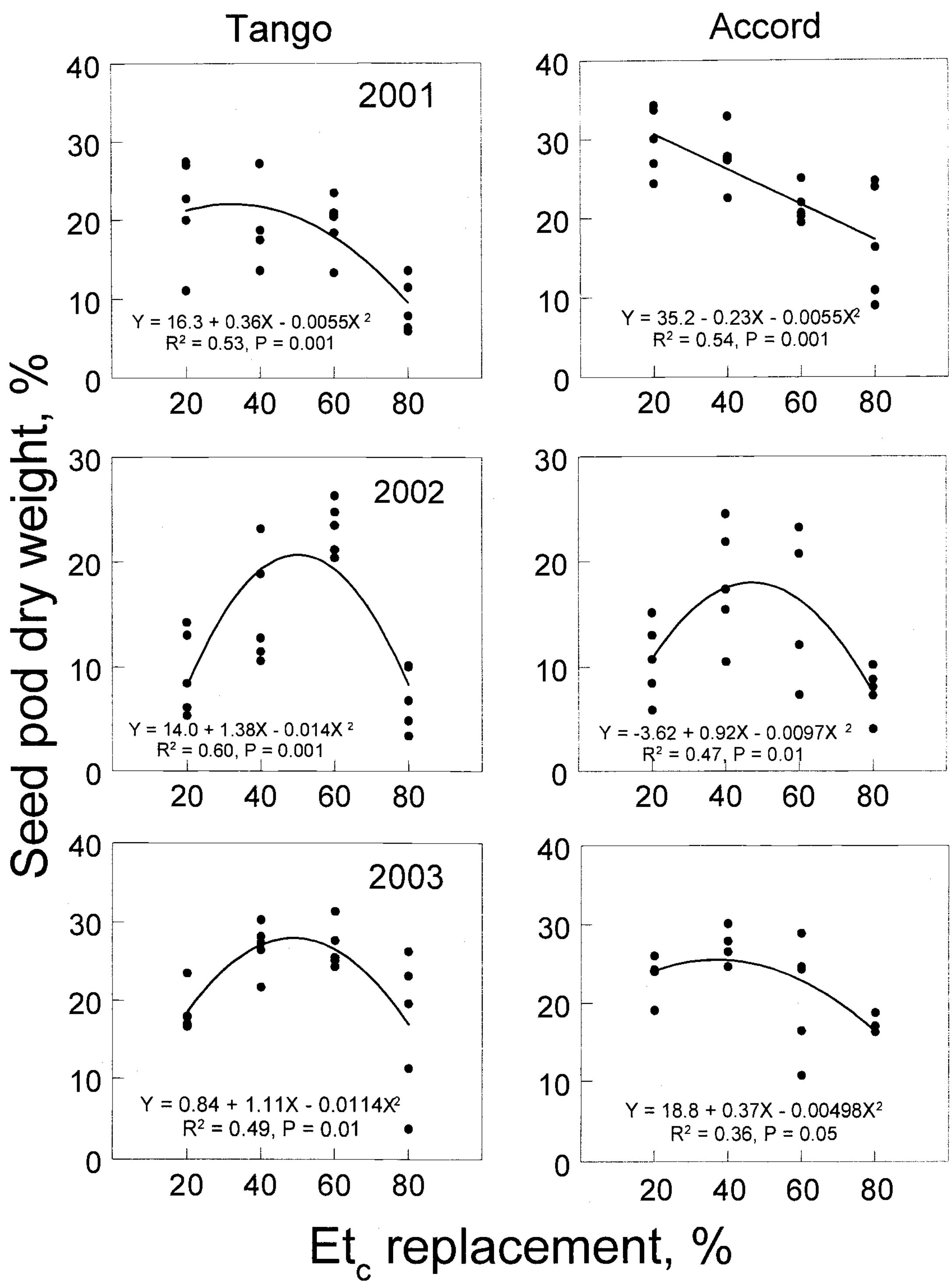

Figure 6. Response of alfalfa seed pod dry matter fraction to Et_c replacement in 2001, 2002, and 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

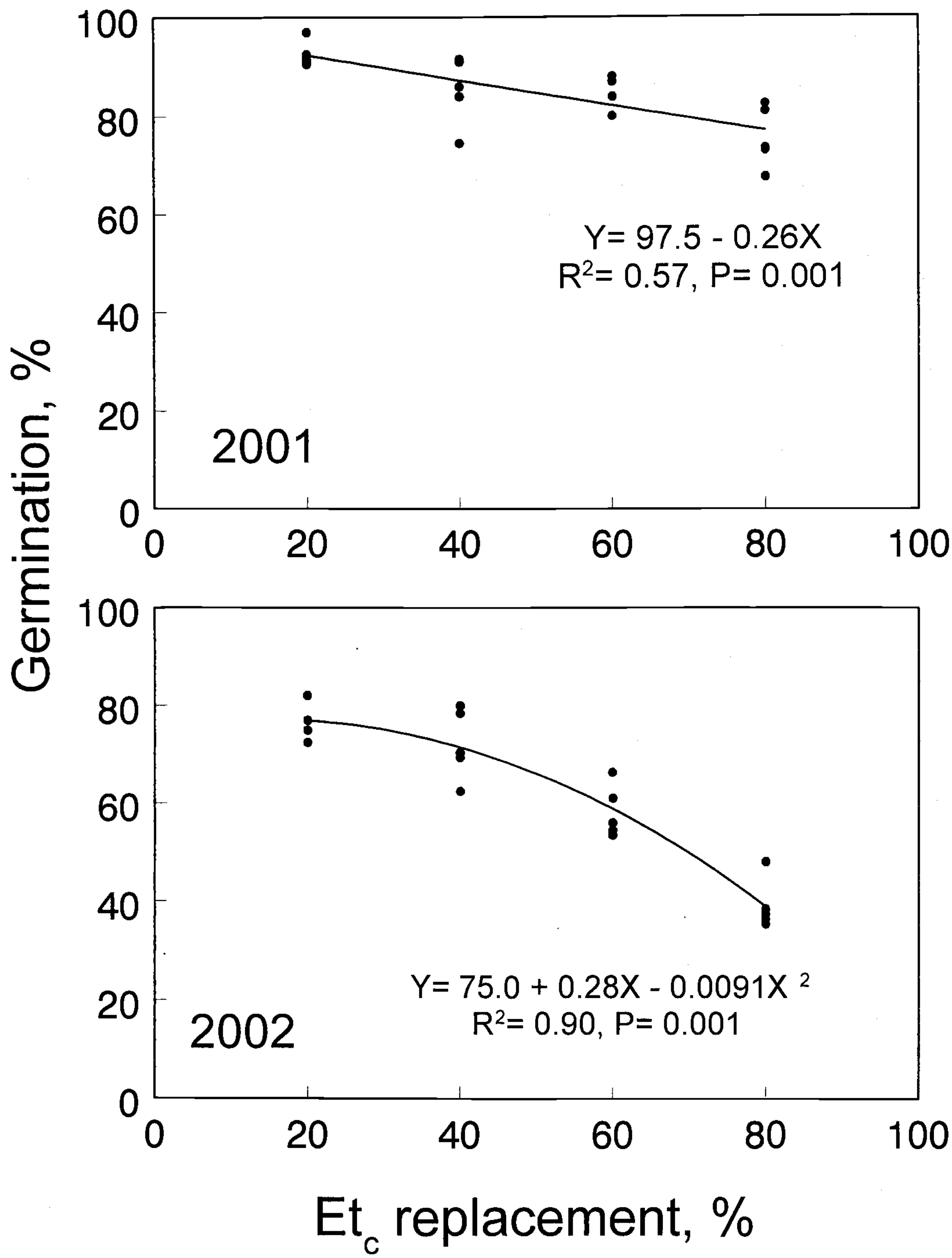

Figure 7. Effect of Et_c replacement strategy on seed germination averaged over two alfalfa varieties in 2001 and 2002, Malheur Experiment Station, Oregon State University, Ontario, OR.

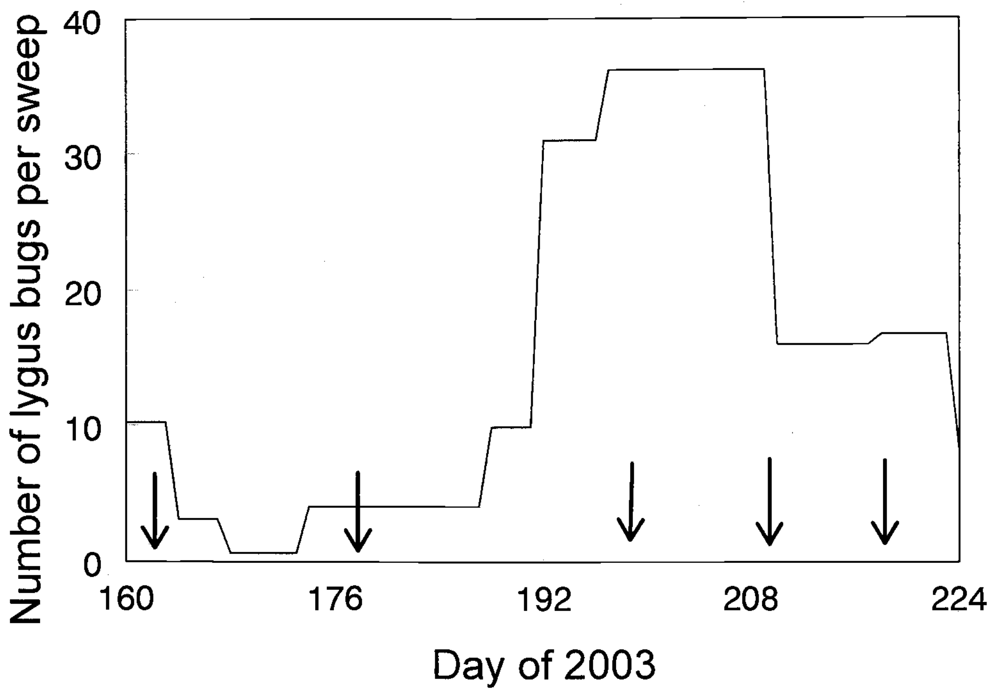

Figure 8. Alfalfa seed lygus bug population levels. Arrows denote insecticide applications. Malheur Experiment Station, Oregon State University, Ontario, OR.

WEED CONTROL AND CROP RESPONSE WITH OPTION® HERBICIDE APPLIED IN FIELD CORN

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Introduction

Weed control is important in field corn production to reduce competition with the current crop and to prevent the production of weed seed for future crops. Field trials were conducted to evaluate Option (foramsulfuron) herbicide applied alone and in various combinations for weed control and crop tolerance in furrow-irrigated field corn. Option is a new postemergence sulfonylurea herbicide that controls annual and perennial grass and broadleaf weeds in field corn. Option contains a safener that is intended to enhance the ability of corn to recover from any yellowing or stunting, which may be associated with the application of sulfonylurea herbicides.

Materials and Methods

Roundup UltraMax was applied preplant at 0.56 lb ae/acre to control volunteer wheat on May 21. Pioneer variety 'P-36N18' Roundup Ready (103-day relative maturity) field corn was planted with a John Deere model 71 Flexi Planter on May 22, 2003. Seed spacing was one seed every 7 inches on 30-inch rows. Plots were 10 by 30 ft and herbicide treatments were arranged in a randomized complete block with four replicates. Plots were sidedressed with 121 lbs N, 48 lbs phosphate, 62 lbs potash, 22 lbs sulfates, 1 lb Zn and B, 2 lbs Mn, and 30 lbs elemental S/acre on May 14. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Crop response and weed control were evaluated throughout the growing season. Crop height measurements were taken to evaluate herbicide injury. Height values were determined by measuring the distance from the ground to the first collar for 10 plants from the center two rows in each plot. Corn yields were determined by harvesting ears from 15-ft sections of the center two rows in each four-row plot on October 7. The harvested ears were shelled and grain weight and percent moisture content were recorded. Grain yields were adjusted to 12 percent moisture content. Data were analyzed using analysis of variance (ANOVA) and treatment means were separated using Fisher's protected least significant difference (LSD) at the 5 percent level ($P = 0.05$) for weed control and injury data and at the 10 percent level ($P = 0.10$) for corn yield data.

Option herbicide was applied early postemergence (EP) to corn at the V2 growth stage at rates of 0.0328 and 0.0382 lb ai/acre. The label rate for Option is 0.0328 lb ai/acre when susceptible weeds are at or below the maximum size as stipulated by the label. The higher rate of 0.0382 lb ai/acre is intended for use as a rescue treatment on weeds that are above labeled size. Option (0.0328 lb ai/acre) was also evaluated in EP combinations with Distinct (dicamba + diflufenzopyr), Callisto (mesotrione), Aatrex (atrazine), or Outlook (dimethenamid-P) herbicides. In addition, Option was applied EP following a preemergence (PRE) application of Topnotch (acetochlor). Comparison treatments included EP combinations of Clarion (nicosulfuron + rimsulfuron) plus Distinct, Accent (nicosulfuron) plus Distinct, Roundup UltraMax (glyphosate) applied EP followed by a second application at a late postemergence (LP) timing, and finally Topnotch applied PRE followed by an EP application of Roundup UltraMax. All postemergence Option applications included a methylated seed oil (MSO) at 1.0 percent v/v and 32 percent nitrogen at 2.5 percent v/v. In treatments where Distinct was applied postemergence without Option, a non-ionic surfactant (NIS) at 0.5 percent v/v and 32 percent nitrogen at 2.5 percent v/v were included.

Results and Discussion

Control of pigweed species (i.e., Powell amaranth and redroot pigweed) from herbicide treatments ranged from 95 to 100 percent on July 8 and was similar among herbicide treatments (Table 1). Option applied alone at either 0.0328 or 0.0382 lb ai/acre and when applied with Outlook provided 86 percent or less common lambsquarters control, which was significantly less than all other treatments on July 8. Option applied postemergence with Distinct, Callisto, or Aatrex or following a preemergence application of Topnotch gave 98 percent or greater common lambsquarters control when evaluated on July 8. Common lambsquarters control with postemergence Option was improved when preceded by a preemergence application of Topnotch. Hairy nightshade control was 94 percent or greater with all herbicide treatments. The only differences were with postemergence combinations of Clarion and Distinct or Accent and Distinct, which gave less hairy nightshade control than treatments with preemergence Topnotch applications, two postemergence applications of Roundup UltraMax, or when Option was applied with Callisto. Option applied postemergence with Distinct, Callisto, or Aatrex provided greater kochia control than when Option was applied alone or with Outlook. The postemergence combination of Option plus Distinct provided 11 percent greater barnyardgrass control than did the treatment of Accent plus Distinct. Barnyardgrass control with postemergence Option was improved when preceded by a preemergence application of Topnotch. The combination of Clarion and Distinct provided broadleaf weed control similar to Option and Distinct. Weed control was similar with Option alone regardless of rate. Both treatments incorporating Roundup UltraMax provided greater than 98 percent control of all weeds.

Weed control results from this trial suggest that Option should be applied postemergence in combination with or following a preemergence application of another herbicide in order to provide broad spectrum weed control in field corn. In terms of broad spectrum weed control, applying Option postemergence with Distinct or Aatrex or following preemergence Topnotch were some of the better combinations with Option.

Corn injury on June 14, 7 days after the EP applications, ranged from 0 to 10 percent (Table 2). No injury, as compared to the untreated control, was observed with the postemergence combination of Accent plus Distinct, or treatments including Roundup UltraMax, for which only the EP and PRE applications had been applied by June 14.

Injury was greatest with treatments containing Option. Injury with these treatments was characterized by slight stunting due to shortened internodes and slight yellowing of the foliage compared to the untreated control. Plant height data collected on June 16 showed measurable corn stunting associated with postemergence combinations of Option plus Distinct and Option plus Outlook when compared to the untreated control. Injury on June 21, 14 days after EP applications, was greatest with the treatment of Option plus Outlook. Injury with this treatment was greater than from all other treatments except for those where Option was combined with Distinct or Callisto. The yellowing that was observed previously was no longer visible on June 21. However, stunting was still visible in certain plots where Option had been applied. Corn injury was no longer detectable by June 30 and no further injury evaluations were taken.

Corn yields ranged from a low of 66 bu/acre with the untreated control to a high of 85 bu/acre with two applications of Roundup UltraMax (Table 2). Corn yields in this trial were significantly less than those typically obtained at the Malheur Experiment Station. This trial was established approximately 2-3 weeks later than what is typical for corn trials on station. Optimum conditions were not present during pollination and the ears did not fully fill. Reduced yield may be attributed to extremely hot daytime temperatures (>100°F) and low relative humidity during pollen shed and silking, resulting in poor kernel set. The only treatments to yield significantly ($P = 0.10$) greater than the untreated control were those including Roundup UltraMax, combinations of Clarion plus Distinct, or Accent plus Distinct.

Table 1. Weed control with Option® herbicide applied in field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control				
			Pigweed spp†	C. lambs-quarters‡	H. night-shade‡	Kochia	Barnyard-grass‡
Treatment	Rate	Timing*	7-8	7-8	7-8	7-8	7-8
	lb ai/acre % v/v		%				
Option + MSO + 32% N	0.0328 + 1.0% + 2.5%	EP	95	78 c	98 ab	89	90 de
Option + MSO + 32% N	0.0382 + 1.0% + 2.5%	EP	97	81 c	98 ab	90	92 cde
Option + Distinct + MSO + 32% N	0.0328 + 0.175 + 1.0% + 2.5%	EP	98	98 ab	99 ab	100	97 a-d
Option + Callisto + MSO + 32% N	0.0328 + 0.0468 + 1.0% + 2.5%	EP	98	99 ab	100 ab	98	88 de
Option + Aatrex + MSO + 32% N	0.0328 + 0.75 + 1.0% + 2.5%	EP	98	100 a	100 a	100	94 b-e
Option + Outlook + MSO + 32% N	0.0328 + 0.56 + 1.0% + 2.5%	EP	97	86 c	98 ab	91	96 a-e
Clarion + Distinct + NIS + 32% N	0.0328 + 0.175 + 0.5% + 2.5%	EP	98	96 b	94 b	95	91 de
Accent + Distinct + NIS + 32% N	0.031 + 0.175 + 0.5% + 2.5%	EP	97	98 ab	94 b	99	86 e
Topnotch Option + MSO + 32% N	2.0 0.328 + 1.0% + 2.5%	PRE EP	100	98 ab	100 a	95	99 abc
Topnotch Roundup UltraMax	2.0 0.56	PRE LP	99	98 ab	100 a	100	100 a
Roundup UltraMax Roundup UltraMax	0.56 0.56	EP LP	100	98 ab	100 a	100	99 ab
LSD (0.05)			NS	--	--	6	--

*Application timings were preemergence (PRE) on 5-22-03, early postemergence (EP) applied to corn at the V2 growth stage on 6-7-03, and late postemergence (LP) to corn at the V3 to V4 growth stages on 6-17-03.
†Pigweed species were a mixture of Powell amaranth and redroot pigweed.
‡The ANOVA was performed on arcsine square root percent transformed data. Mean separations are applied to non-transformed data. Within-column values followed by the same letter designation are similar (P = 0.05). The untreated control was not included in the ANOVA for weed control.

Table 2. Injury and yield with Option® herbicide applied in field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Field Corn			
			Injury†		Height‡	Yield§
Treatment	Rate	Timing*	6-14	6-21	6-16	10-7
	lb ai/acre % v/v		---------- % ----------		inches	bu/acre
Untreated control	--	--	--	--	11.7	66
Option + MSO + 32% N	0.0328 + 1.0% + 2.5%	EP	8	5	11.2	75
Option + MSO + 32% N	0.0382 + 1.0% + 2.5%	EP	10	5	11.0	70
Option + Distinct + MSO + 32% N	0.0328 + 0.175 + 1.0% + 2.5%	EP	10	9	10.6	77
Option + Callisto + MSO + 32% N	0.0328 + 0.0468 + 1.0% + 2.5%	EP	9	6	11.2	73
Option + Aatrex + MSO + 32% N	0.0328 + 0.75 + 1.0% + 2.5%	EP	5	5	11.4	75
Option + Outlook + MSO + 32% N	0.0328 + 0.56 + 1.0% + 2.5%	EP	10	11	10.9	77
Clarion + Distinct + NIS + 32% N	0.0328 + 0.175 + 0.5% + 2.5%	EP	4	6	11.3	80
Accent + Distinct + NIS + 32% N	0.031 + 0.175 + 0.5% + 2.5%	EP	0	0	11.4	84
Topnotch Option + MSO + 32% N	2.0 0.328 + 1.0% + 2.5%	PRE EP	5	3	11.4	73
Topnotch Roundup UltraMax	2.0 0.56	PRE LP	0	1	12.0	82
Roundup UltraMax Roundup UltraMax	0.56 0.56	EP LP	0	0	11.9	85
LSD (0.05)			5	5	0.8	NS
LSD (0.10)			--	--	--	12

*Application timings were preemergence (PRE) on 5-22-03, early postemergence (EP) applied to corn at the V2 growth stage on 6-7-03, and late postemergence (LP) to corn at the V3 to V4 growth stages on 6-17-03.
†The untreated control was not included in the ANOVA for percent injury.
‡Height was determined by measuring the distance from the soil surface to the first collar.
§Corn yields were significantly less than those typically obtained at the Malheur Experiment Station. Reduced yield may be attributed to extremely hot daytime temperatures (>100°F) and low relative humidity during pollen shed and silking resulting in poor kernel set.

2003 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. Six early season yellow varieties were planted in March and were harvested and graded in August. Forty-two full season varieties (33 yellow, 8 red, and 1 white) were planted in March, harvested in September 2003, and evaluated in January 2004.

Methods

The onions were grown on a Greenleaf silt loam previously planted to wheat. Soil analysis indicated the need for 100 lb P_2O_5/acre, 150 lb K /acre, 6 lb Mn/acre, 2 lb Cu/acre, and 1 lb B/acre that was broadcast in the fall. In the fall of 2002, the wheat stubble was shredded, and the field was disked, irrigated, ripped, moldboard-plowed, roller-harrowed, fumigated with Telone C-17 at 20 gal/acre, and bedded. A soil sample taken on May 9 showed a pH of 7.4, 1.2 percent organic matter, 11 ppm nitrate-N, 30 ppm P, and 185 ppm K.

A full season trial and an early maturing trial were conducted adjacent to each other. The early maturing trial was planted on March 12 and the full season trial was planted on March 13. Both trials were planted in plots four double rows wide and 27 ft long. The early maturing trial had 6 varieties from 4 companies (Table 1) and the full season trial had 42 varieties from 10 companies (Table 2). The experimental design for both trials was a randomized complete block 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 nine 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 14. On March 28 the field was sprayed with Roundup at 24 oz/acre. Onion emergence started on April 2. On May 13, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 15 through 17, 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 field was sidedressed with 44 lb of N/acre as ammonium sulfate, 56 lb N/acre as urea, and 1 lb of B/acre on May 21. On June 9 the field was sidedressed with 100 lb N/acre as urea.

The onions were managed to avoid yield reductions from weeds, pests, and diseases. Weeds were controlled with an application of Buctril at 0.12 lb ai/acre and Poast at 0.38 lb ai/acre on April 16, and an application of Goal at 0.12 lb ai/acre, Buctril at 0.12 lb ai/acre, Poast at 0.28 lb ai/acre, and Prowl at 0.83 lb ai/acre on May 22, and an application of Goal at 0.12 lb ai/acre, Buctril at 0.12 lb ai/acre, and Poast at 0.28 lb ai/acre on May 28. After lay-by the field was hand weeded as necessary. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

The trial was furrow irrigated when the soil water potential at 8-inch depth reached -20 kPa. Soil water potential was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed in mid-June below the onion row at 8-inch depth. 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 26.

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 of the percentage of onion with tops down and the percent dryness. The early maturing trial was evaluated for maturity on July 30 and the full season trial on August 22.

Onions from the middle two rows in each plot in the early maturity trial were lifted, topped by hand, and bagged on August 12. The onion bags were hauled to a barn on August 15. On August 18 the onions were graded. The onions in the full season trial were lifted on September 12 to field cure. Onions from the middle two rows in each plot of the full season trial were topped by hand and bagged on September 17. The bags were put in storage on October 1. The storage shed was managed to maintain an air temperature of approximately 34°F. Onions from the full season trial were graded out of storage on January 14, 2004.

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 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. The red varieties were evaluated subjectively during grading for exterior thrips damage during storage. The bulbs in each red variety plot were rated for the damage that was apparent on the bulb surface, without removing the outer scales (0 = no damage, 10 = most damage).

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 3.5-4.25 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 <1½ inches, "intermediate double" had diameters from 1½-2¼ inches, and "blowout" had diameters >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 least significant differences at the 5 percent probability level, LSD (0.05).

Results

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 (0.05) value for a characteristic should exist before any variety is considered different from any other variety in that characteristic.

Early Maturity Trial, Six Yellow Varieties

The percentage of "bullet" single centers averaged 6.6 percent and ranged from 1.6 percent for 'XON-0101' and 'Renegade' to 19.1 percent for 'Kodiak' (Table 1). Kodiak was the highest in percentage of "bullet" single centers. The percentage of onions that were functionally single centered averaged 24.8 percent and ranged from 12.8 percent for Renegade to 39.2 percent for Kodiak. Kodiak, 'DPSX 1170' and 'Madero' were among those with the highest percentage of functionally single-centered bulbs.

Total yield averaged 716 cwt/acre and ranged from 536 cwt/acre for DPSX 1170 to 974 cwt/acre for Renegade (Table 3). Renegade and XON-0101 had the highest total yield. Super colossal-size onion yield averaged 25.1 cwt/acre and ranged from 0 cwt/acre for DPSX 1170 to 75.3 cwt/acre for Renegade. Renegade and XON-0101 had the highest yield of super colossal bulbs. Not considering super colossals, colossal-size onion yield averaged 173.5 cwt/acre and ranged from 9.8 cwt/acre for DPSX 1170 to 463.7 cwt/acre for Renegade. Renegade and XON-0101 had the highest colossal bulb yields.

Full Season Trial, 33 Yellow Varieties

The percentage of "bullet" single centers averaged 22.3 percent and ranged from 2 percent for 'Delgado' to 72.7 percent for '6011' (Table 2). Varieties 6011 and 'SR 7004 ON' were among the highest in percentage of onions with "bullet" single centers. Varieties 6011, SR 7004 ON, 'Bandolero', and 'SR 7003 ON' were among the highest in percentage of onions that were functionally single centered.

Marketable yield out of storage in January 2004 averaged 951.2 cwt/acre and ranged from 644.4 cwt/acre for 'Milestone' to 1198.9 cwt/acre for 'Ranchero' (Table 4). Ranchero, 'Santa Fe', 'Granero', '6001', SR 7004 ON, 'Torero', and 6011 were among the varieties with the highest marketable yield. Super colossal-size onion yield averaged 228.3 cwt/acre and ranged from 0 cwt/acre for Milestone to 501 cwt/acre for

'Mesquite'. Mesquite and Ranchero were among the varieties with the highest super colossal yield. The number of bulbs per 50 lb of super colossal onions averaged 32 and ranged from 26.3 for 'Tequila' to 37.5 for 'Sabroso'. Only Sabroso had super colossal counts above the acceptable range (averaged too small, because they are almost all at the small end of the size range) for marketing as super colossals (28-36 count per 50 lb). Tequila, 'T-433', and Ranchero had super colossal counts below the acceptable range (averaged too big) for marketing as super colossal. Not considering super colossals, colossal-size onion yield averaged 402.1 cwt/acre and ranged from 56 cwt/acre for Milestone to 607.6 cwt/acre for Granero. Granero, SR 7004 ON, and 'Vaquero' were among the highest in colossal bulb yields.

Decomposition in storage averaged 4.4 percent and ranged from 1.3 percent for Granero to 17.6 percent for T-433. No. 2 bulbs averaged 43.8 cwt/acre and ranged from 1.4 cwt/acre for Milestone to 135.5 cwt/acre for 'XPH95345". Bolting was not observed in any plot in 2003.

Full Season Trial, Eight Red Varieties
The percentage of "bullet" single centers averaged 11 percent and ranged from 2.7 percent for 'Mercury' to 20 percent for 'Redwing' (Table 2). The percentage of functionally single-centered onions averaged 40.8 percent and ranged from 24 percent for 'Red Zepelin' to 60.7 percent for Redwing.

Marketable yield out of storage in January 2004 averaged 537.7 cwt/acre and ranged from 376.4 cwt/acre for 'Red October' to 730.7 cwt/acre for Redwing (Table 4). Super colossal-size onion yield averaged 4.2 cwt/acre and ranged from 0 cwt/acre for Red Zepelin to 17.3 cwt/acre for 'Red Fortress'. The number of bulbs per 50 lb of super colossal onions averaged 30.5 and ranged from 32.5 for Mercury to 54.2 for 'EXP Red 440'. Not considering super colossals, colossal-size onion yield averaged 86.9 cwt/acre and ranged from 49.1 cwt/acre for Red Zepelin to 135.9 cwt/acre for Redwing. Decomposition in storage averaged 4.4 percent and ranged from 1 percent for Red Fortress to 14.4 percent for Red October.

Subjective evaluation of thrips damage to red onions in storage ranged from 1.6 for Red Fortress to 6.7 for Red October. Red Fortress, EXP Red 440, and Redwing were among the lowest in thrips damage.

Table 1. Onion multiple center rating for early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Seed company	Variety	Blowout	Intermediate double	Small double	Bullet	Functionally single centered "Bullet + small double"
		%				
D. Palmer	DPSX 1170	36	36.8	22.4	4.8	27.2
	Kodiak	33.5	27.3	20.1	19.1	39.2
Sakata	XON-0101	48	33.6	16.8	1.6	18.4
Scottseed	Dawn	50.7	26.9	20	2.4	22.4
Sunseeds	Madero	45.6	25.6	18.4	10.4	28.8
	Renegade	56	31.2	11.2	1.6	12.8
Average		45	30.2	18.2	6.6	24.8
LSD (0.05)		NS	NS	NS	8.2	14.4

Table 2. Onion multiple center rating for long season varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Seed company	Variety	Blowout	Intermediate double	Small double	Bullet	Functionally single centered "Bullet + small double"
		%				
A. Takii	Milestone (T-441)	8.0	25.3	62.0	4.7	66.7
	T-433	57.3	27.3	12.7	2.7	15.3
	T-439	34.7	30.7	30.0	4.7	34.7
Bejo	Daytona	58.9	26.3	12.1	2.7	14.8
	Delgado	40.7	36.0	21.3	2.0	23.3
	Gladstone	32.7	29.3	30.7	7.3	38.0
	Redwing	10.0	29.3	40.7	20.0	60.7
	BGS 167	36.7	19.3	27.3	16.7	44.0
Crookham	Harmony	30.5	28.5	14.4	26.6	41.0
	Sweet Perfection	34.7	27.3	18.0	20.0	38.0
	OLYS97-24	43.3	21.3	18.0	17.3	35.3
	OLYS97-27	48.7	17.3	22.0	12.0	34.0
	XPH95345	50.7	25.3	18.7	5.3	24.0
Dorsing	Harvest Moon	48.0	12.0	20.0	20.0	40.0
	Red October	20.0	24.0	37.3	18.7	56.0
D. Palmer	DPSX 1171	40.0	24.7	24.0	11.3	35.3
	DPSX 1172	46.0	20.0	14.7	19.3	34.0
	Mesquite	45.3	20.0	18.0	16.7	34.7
	Tequila	29.3	20.7	19.3	30.7	50.0
Rispens	Red Fortress	37.3	20.0	24.0	18.7	42.7
	Vivacious Red	50.0	17.3	23.3	9.3	32.7
	EXP Red 440	49.3	17.3	21.3	12.0	33.3
Scottseed	Red Marksman	42.7	23.3	30.7	3.3	34.0
Seedworks	Varsity	14.0	16.7	26.7	42.7	69.3
	4001	14.7	28.7	32.7	24.0	56.7
	6001	40.7	14.0	23.3	22.0	45.3
	6005	14.7	24.0	22.7	38.7	61.3
	6011	2.0	4.7	20.7	72.7	93.3
Seminis	Mercury	31.3	26.0	40.0	2.7	42.7
	Red Zepelin	44.7	31.3	20.7	3.3	24.0
	Sea Hawk	22.7	38.7	32.0	6.7	38.7
	Santa Fe	24.0	32.0	23.3	20.7	44.0
Sunseeds	Granero	16.0	24.0	18.7	41.3	60.0
	Pandero	24.0	18.7	26.7	30.7	57.3
	Ranchero	18.0	30.7	22.7	28.7	51.3
	Sabroso	10.7	14.0	44.0	31.3	75.3
	Torero	30.0	22.7	29.3	18.0	47.3
	Vaquero	16.0	28.0	17.3	38.7	56.0
	SR7003 ON	10.0	10.0	23.3	56.7	80.0
	SR7004 ON	4.7	6.0	28.7	60.7	89.3
	Bandolero	0.0	11.3	31.3	57.3	88.7
	SX7002 ON	6.7	17.3	37.3	38.7	76.0
Average		29.5	22.4	25.8	22.3	48.1
LSD (0.05)		13.6	13.2	10.9	12.4	14.3

Table 3. Performance data for early maturing onion varieties harvested on August 12 and graded on August 18, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Marketable yield by grade						Non-marketable yield				Maturity
Company	Entry name	Total yield	Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Total rot	Sun scald	No. 2s	Small	30-Jul
		--- cwt/acre ---		#/50 lb	--------- cwt/acre ----------				%	-- cwt/acre --			%
D. Palmer	DPSX 1170	536.0	494.8		0.0	9.8	432.2	52.7	1.5	7.2	21.3	4.6	62
	Kodiak	667.2	548.4	33.3	8.2	99.3	421.5	19.4	2.6	20.8	73.8	7.1	13
Sakata	XON-0101	942.0	819.7	29.0	72.1	346.5	393.9	7.3	5.8	36.7	31.2	1.6	53
Scottseed	Dawn	757.1	666.2	30.5	16.4	167.4	468.0	14.5	5.7	23.9	22.1	1.4	56
Sunseeds	Madero	789.2	725.6	29.5	3.5	123.8	586.5	11.8	2.1	5.5	36.1	5.5	49
	Renegade	974.0	859.7	29.7	75.3	463.7	312.1	8.6	2.5	48.1	41.2	0.9	46
Average		715.7	625.7	30.4	25.1	173.5	395.5	31.6	4.9	20.3	34.0	5.7	51
LSD (0.05)		41.4	67.6	15.6	29.6	51.1	56.7	13.5	4.3	28.6	23.1	6.0	6.1

Table 4. 2003 performance data for experimental and commercial onion varieties graded out of storage in January 2004 Malheur Experiment Station, Oregon State University, Ontario, OR.

				Marketable yield by grade						Non-marketable yield						Maturity	
Company	Entry name	Bulb color	Total yield	Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Total rot	Neck rot	Plate rot	Black mold	No. 2s	Small	Aug. 22	Thrips damage*
			--- cwt/acre ---		#/50 lb	------------ cwt/acre ------------				----- % of total yield -----				-- cwt/acre --		%	
A. Takii	Milestone (T-441)	Y	660.5	644.4		0.0	56.0	566.8	21.6	1.8	0.9	0.7	0.3	1.4	2.6	86.0	
	T-433	Y	1289.7	979.5	27.3	324.9	451.2	199.1	4.4	17.6	13.8	3.7	0.1	83.0	0.9	31.0	
	T-439	Y	960.5	890.3	31.0	89.1	381.8	412.8	6.6	4.5	2.9	1.4	0.3	25.7	1.2	75.0	
Bejo	Daytona	Y	868.0	795.9	32.5	13.7	258.9	512.9	10.4	1.4	1.0	0.4	0.0	58.2	2.1	49.0	
	Delgado	Y	933.6	869.4	33.8	15.3	315.5	531.7	6.9	2.1	0.6	1.0	0.5	44.1	1.0	70.0	
	Gladstone	W	773.9	640.6	33.1	33.5	207.2	383.2	16.7	11.0	9.1	1.3	0.6	41.3	3.1	52.0	
	Redwing	R	743.5	730.7	38.4	1.3	135.9	587.4	6.1	1.2	0.7	0.6	0.0	2.4	1.5	58.0	2.6
	BGS 167	Y	925.8	854.5	33.4	23.4	308.0	515.2	7.9	2.1	1.4	0.4	0.3	50.4	2.0	58.0	
Crookham	Harmony	Y	1198.3	1063.6	28.6	422.9	475.8	161.0	3.8	7.0	4.1	1.7	1.3	51.7	0.5	35.5	
	Sweet Perfection	Y	1186.0	1037.1	29.5	343.6	451.2	239.1	3.2	7.2	4.8	1.4	1.0	62.5	1.6	52.0	
	OLYS97-24	Y	1217.8	1043.3	28.7	432.6	437.8	165.9	7.0	5.7	3.9	1.5	0.3	104.2	1.0	27.0	
	OLYS97-27	Y	1201.5	1058.1	28.1	418.8	428.0	207.8	3.5	5.0	3.2	1.2	0.7	81.0	1.8	26.0	
	XPH95345	Y	1021.9	816.6	31.0	125.6	362.2	319.0	9.9	6.8	5.6	0.9	0.3	135.5	0.5	37.0	
Dorsing	Harvest Moon	Y	1083.0	885.4	29.0	371.9	351.7	157.1	4.6	8.9	6.0	2.3	0.5	100.8	1.9	40.0	
	Red October	R	500.5	376.4	34.7	4.4	49.8	308.4	13.8	14.9	11.3	3.6	0.0	48.0	1.6	93.0	6.7
D. Palmer	DPSX 1171	Y	1036.9	863.8	29.4	128.8	355.6	372.1	7.3	8.0	6.0	1.1	0.9	86.7	3.5	56.0	
	DPSX 1172	Y	1018.2	842.5	30.0	148.1	318.2	373.7	2.5	5.5	3.1	1.6	0.9	118.7	2.3	55.0	
	Mesquite	Y	1134.1	982.5	28.7	501.0	354.8	122.0	4.7	3.4	2.0	0.8	0.5	113.4	0.8	12.5	
	Tequila	Y	1064.5	964.3	26.3	407.2	380.2	172.1	4.8	4.6	3.0	1.1	0.5	48.6	2.8	26.5	
Rispens	Red Fortress	R	736.2	573.1	38.4	17.3	115.0	425.5	15.2	1.0	0.5	0.5	0.0	153.7	2.4	42.0	1.6
	Vivacious Red	R	710.6	451.1	45.4	1.1	79.8	351.1	19.0	1.9	1.2	0.7	0.0	241.4	5.7	47.0	3.0
	EXP Red 440	R	753.6	578.2	54.2	2.8	128.5	431.0	15.9	1.1	0.9	0.2	0.0	165.8	1.3	37.0	2.1
Scottseed	Red Marksman	R	529.6	386.7		0.0	18.3	330.5	38.0	8.0	4.2	3.7	0.0	98.1	3.5	81.0	6.0

Table 4. 2003 performance data for experimental and commercial onion varieties graded out of storage in January 2004 Malheur Experiment Station, Oregon State University, Ontario, OR.

				Marketable yield by grade						Non-marketable yield						Maturity	
Company	Entry name	Bulb color	Total yield	Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Total rot	Neck rot	Plate rot	Black mold	No. 2s	Small	Aug. 22	Thrips damage*
			--- cwt/acre ---		#/50 lb	------------ cwt/acre ------------				----- % of total yield -----				-- cwt/acre --		%	
Seedworks	Varsity	Y	854.2	826.4	35.5	39.0	362.7	416.1	8.6	2.2	1.2	1.0	0.0	8.9	0.3	71.0	
	4001	Y	851.0	810.8	34.7	51.1	309.6	443.2	6.9	2.3	0.8	1.3	0.2	17.7	2.6	68.0	
	6001	Y	1178.8	1105.9	28.4	499.9	453.8	146.8	5.4	2.6	1.6	1.0	0.0	40.7	3.3	33.0	
	6005	Y	942.3	888.6	27.7	377.8	405.4	103.4	2.0	3.7	2.2	1.3	0.2	18.2	1.5	41.0	
	6011	Y	1151.2	1089.4	28.9	312.9	532.2	240.9	3.4	3.1	1.3	1.8	0.0	25.1	1.6	53.0	
Seminis	Mercury	R	696.4	624.4	32.5	6.3	118.7	487.2	12.2	5.2	3.5	1.1	0.6	34.0	1.3	81.0	6.5
	Red Zepelin	R	689.4	580.8		0.0	49.1	496.7	35.0	1.8	1.2	0.5	0.0	90.6	4.3	72.0	3.7
	Sea Hawk	Y	786.7	737.2	30.6	8.2	230.8	472.7	25.5	2.6	2.0	0.6	0.0	24.9	4.1	71.0	
	Santa Fe	Y	1247.6	1133.5	28.1	320.8	522.7	285.8	4.2	5.5	3.4	1.4	0.7	43.7	3.0	39.0	
Sunseeds	Granero	Y	1153.5	1130.4	29.6	295.7	607.6	221.3	5.8	1.3	0.4	0.7	0.2	7.8	0.4	48.0	
	Pandero	Y	1133.6	1070.7	29.1	262.5	522.5	280.2	5.6	3.8	1.8	1.1	0.8	21.4	0.7	27.0	
	Ranchero	Y	1264.3	1198.9	27.6	443.3	529.8	222.0	3.8	3.5	2.6	0.8	0.1	20.0	2.8	53.0	
	Sabroso	Y	831.9	809.9	37.5	18.7	283.8	494.9	12.6	1.7	0.6	0.9	0.2	3.0	4.2	68.0	
	Torero	Y	1169.5	1090.1	28.3	384.9	474.4	222.3	8.5	5.2	3.4	0.9	0.9	16.3	2.8	40.0	
	Vaquero	Y	1111.4	1052.0	29.5	263.4	537.7	245.9	4.9	3.9	2.6	0.8	0.4	16.3	2.3	50.0	
	SR7003 ON	Y	1045.1	1020.0	31.0	181.6	525.9	307.3	5.1	2.2	1.2	0.7	0.2	1.7	0.7	46.0	
	SR7004 ON	Y	1125.3	1093.0	31.3	163.4	577.4	349.8	2.3	2.2	1.0	1.0	0.2	6.1	0.6	53.0	
	Bandolero	Y	778.3	752.6	34.0	4.5	260.5	471.3	16.3	2.6	1.3	1.3	0.0	3.6	3.0	71.0	
	SX7002 ON	Y	1051.8	988.0	32.6	137.8	446.6	396.0	7.6	5.3	3.3	1.9	0.2	5.4	3.0	74.0	
Average			966.9	865.0	32.0	180.9	337.4	336.9	9.8	4.6	3.0	1.2	0.3	55.3	2.1	52.5	3.8
LSD (0.05)			115.4	120.1	2.9	64.2	76.3	94.4	9.7	3.0	2.7	1.8	NS	29.0	2.7	7.0	1.4

* Thrips damage: 0 = least damage, 10 = most damage.

PUNGENCY OF SELECTED ONION VARIETIES BEFORE AND AFTER STORAGE

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Introduction

The objective of this trial was to evaluate the pungency of five onion varieties commonly grown in the Treasure Valley.

Methods

Varieties for pungency analysis were selected upon recommendation by the seed companies based on their probability of being mild compared to the other varieties (Table 1). 'Vaquero' was included as the industry standard variety of the Treasure Valley. Onion seed company representatives were contacted for input on probable variety pungency.

The onions were grown on a Greenleaf silt loam previously planted to wheat. Onion seed was planted on March 13, 2003. The procedures for growing the onions can be found in the "2003 Onion Variety Trial" report by Shock et al. (2003). The onions were topped and bagged on September 17 and put into storage on October 1. The storage shed was managed to maintain an air temperature of approximately 34°F.

On October 1, 10 bulbs from each of five plots of each of five varieties were sent to Vidalia Labs International (Collins, GA), by UPS ground, for pyruvate analysis. A second sample of 10 bulbs out of storage from each plot of the five varieties was sent to Vidalia Labs on January 16, 2004.

Bulb pyruvic acid content is related to onion pungency with the units of measurement being micro mols pyruvic acid per gram of fresh weight. Onions with low pungency taste sweet, because the sugar can be tasted. Onion bulbs having a pyruvate concentration of 5.5 or less are considered sweet according to Vidalia Labs sweet onion certification specifications.

Results

Varieties 'T-439', 'SX7002 ON', and '6011' had pyruvate concentration low enough to be considered sweet on October 16 (Table 1). 6011 and Vaquero were among the varieties with the highest sugar content. There was a significant increase in pyruvate between October 16, 2003 and January 26, 2004. The pyruvate of all varieties, except 'Harmony', increased significantly between October 16, 2003 and January 26, 2004. On January 26, none of the varieties had pyruvate low enough to be considered sweet.

Averaged over varieties, sugar content decreased slightly between October 16, 2003 and January 26, 2004.

References

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2003. 2003 Onion Variety Trials. Malheur Experiment Station Annual Report, Oregon State University Agricultural Experiment Station Special Report 1055:36-44.

Table 1. Pyruvate concentration and estimated sugar concentration of selected onion varieties on October 16, 2003 and on January 26, 2004, Malheur Experiment Station, Ontario, OR.

Date	Company	Variety	Pyruvate concentration	Sugars
			µmoles/g FW	% Brix
October 16, 2003	A. Takii	T-439	4.66	8.08
	Crookham	Harmony	6.08	8.88
	Seedworks	6011	4.90	9.04
	Seminis	Santa Fe	5.66	8.80
	Sunseeds	Ranchero	5.60	8.56
		Vaquero	5.62	9.00
		SX7002 ON	4.70	8.56
	Average		5.32	8.70
January 26, 2004	A. Takii	T-439	7.54	7.56
	Crookham	Harmony	6.40	8.72
	Seedworks	6011	8.12	8.56
	Seminis	Santa Fe	8.22	8.28
	Sunseeds	Ranchero	8.34	8.12
		Vaquero	8.90	8.64
		SX7002 ON	7.84	7.48
	Average		7.91	8.19
Average	A. Takii	T-439	6.10	7.82
	Crookham	Harmony	6.24	8.80
	Seedworks	6011	6.51	8.80
	Seminis	Santa Fe	6.94	8.54
	Sunseeds	Ranchero	6.97	8.34
		Vaquero	7.26	8.82
		SX7002 ON	6.27	8.02
Average			6.61	8.45
LSD (0.05) Date			0.08	0.17
LSD (0.05) Variety			0.56	0.35
LSD (0.05) Date X Variety			0.79	NS

ONION PRODUCTION FROM TRANSPLANTS IN THE TREASURE VALLEY

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Introduction

The objective of this trial was to evaluate whether yellow, white, and red onion varieties planted as transplants would have adequate bulb yield and quality when grown in the Treasure Valley.

Methods

The 2003 trial was conducted on an Owyhee silt loam with 1.2 percent organic matter and a pH of 7.4. The field had previously been planted to wheat. In the fall of 2002, the wheat stubble was shredded, and the field was disked, irrigated, ripped, moldboard-plowed, roller-harrowed, fumigated with Telone C-17 at 20 gal/acre, and bedded. Soil analysis indicated the need for 100 lb P_2O_5/acre, 150 lb K /acre, 6 lb Mn/acre, 2 lb Cu/acre, and 1 lb B/acre, which was broadcast in the fall.

Onion seed of 19 varieties was planted in flats with a vaccum seeder at 72 seeds/flat on January 30, 2003. The seed was sowed on a 1-inch layer of Sunshine general purpose potting mix. The seed was then covered with 1 inch of potting mix. The flats were watered immediately after planting and were kept moist until emergence on February 7. On March 18 and 19 the seedlings were transplanted to the field. The seedlings were manually planted in double rows on 22-inch beds. The spacing between plants in each single row was 6 inches, equivalent to 95,000 plants per acre. The seedlings had one to two true leaves at the time of transplanting. The field was furrow irrigated on March 20. Plots of each variety were 20 ft long by four double rows wide arranged in a randomized complete block design with four replicates.

The onions were managed to avoid yield reductions from nutrient and irrigation deficiencies, weeds, pests, and diseases. The field had 100 lb N/acre applied on April 22 as water-run urea during an irrigation. Weeds were controlled with an application of Goal at 0.12 lb ai/acre, Buctril at 0.12 lb ai/acre, Poast at 0.38 lb ai/acre on April 16, and Prowl at 1 lb ai/acre on May 22. After lay-by the field was hand weeded as necessary. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior and Lannate (July 16 and August 4). Warrior was applied at 0.03 lb ai/acre and Lannate was applied at 0.4 lb ai/acre.

The trial was furrow irrigated when the soil water potential at 8-inch depth reached -20 kPa. Soil water potential was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed on June 10 below the onion row at 8-inch depth. Sensors were automatically read three times a day with an AM-400 meter (Mike Hansen Co., East Wenatchee, WA).

On July 9 and again on July 22, 9.5 ft of the middle two rows in each plot were topped and bagged. Decomposed bulbs were not bagged. The onions were put in a barn at room temperature for 3 days. After 3 days the onions were graded. 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 inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and super colossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all super colossal bulbs during grading. Varietal differences were compared using ANOVA and protected least significant differences at the 5 percent probability level, LSD (0.05).

A subjective evaluation of exterior bulb quality (sprouting, bulb shape, softness, and appearance) was made soon after grading for bulbs from all plots. Ten randomly chosen bulbs from each plot from the July 22 harvest were shipped on August 1 via UPS ground to Vidalia Labs International in Collins, GA. The bulb samples were analyzed for pyruvic acid content on August 11. 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.

On August 22 the onion bulbs were rated for single centers. The onions from each plot 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 <1½ inch, "intermediate double" had diameters from 1½ to 2¼ inches, and "blowout" had diameters >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".

Results

Plant establishment was very good. There were no significant differences in plant population between varieties in 2003 (Tables 1 and 2). Plant population averaged 88,000 plants per acre at harvest.

On July 9, total yields ranged from 910 cwt/acre for 'XON-0101' to 523 cwt/acre for 'Everest' (Table 1). Variety XON-0101 had the highest total yield on July 9. The super colossal yields of varieties XON-0101, 'Candy', 'T-803', 'XON-0103', 'Stanza', 'EX6876', and 'Rumba' were among the highest on July 9. Varieties 'Electric', 'Alabaster', Rumba, Stanza, and T-803 were among the best in total exterior bulb quality rating for the July 9 harvest (Table 3).

On July 23, total yields ranged from 1,186 cwt/acre for XON-0101 to 170 cwt/acre for Everest (Table 2). Varieties XON-0101 and 'Renegade' had the highest super colossal yields on July 23. Total exterior bulb quality rating for the July 23 harvest ranged from 5 for Rumba to 12 for 'Mesquite' (Table 3).

'Cometa' had the highest percentage of "bullet" single-centered bulbs (Table 4). Cometa and 'Ranchero' had the highest percentage of functionally single-centered bulbs.

Varieties Renegade, Rumba, Electric, Stanza, 'Golden Spike', and 'Dawn' had bulb pyruvate concentrations low enough (< 5.5) to be classified as sweet onions (Table 4). Renegade had the lowest pyruvate concentration.

Transplanted onions were more productive in 2003 than in 2002 (Table 5). Plant populations were lower in 2002, possibly because of very cold weather immediately after transplanting. Varieties Candy and Renegade were among the highest yielding of marketable bulbs and super colossal bulbs in both 2002 and 2003. The pyruvate concentration of Renegade was among the lowest in 2002 (Table 6) and was the lowest in 2003.

Discussion

Growing onions for transplant produced early high yields. Onion quality was adequate for marketing some of the varieties and lines tested. The costs and returns of transplanting for early harvest were not thoroughly examined, so the economic viability of the practice is unknown. Promising varieties such as Renegade might require special handling for successful harvest and packing. The ideal date to start seedlings in the greenhouse was not determined. An earlier date in January might be beneficial.

Vidalia Labs suggested that onions be shipped overnight as soon as harvest was completed, so that bulb pyruvate would not increase between harvest and analysis. Instead we chose to have the bulbs evaluated 2 weeks after harvest after shipping by ground, a realistic time interval between bulb harvest and delivery to a retail outlet or end user.

Table 1. Performance data for experimental and commercial onion varieties grown from transplants and harvested on July 9, 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

			Total	Marketable yield by grade							Plant
		Bulb	yield	Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small	population
Company	Variety	color	--- cwt/acre ---		#/50 lb	------------------ cwt/acre ------------------					plants/acre
American Takii	T-803	Y	819.4	817.5	40	49.4	203.9	553.9	10.3	2.0	89,613
Bejo	Electric	R	574.0	573.6	0	0.0	11.0	513.8	48.8	0.4	82,274
	Stanza	Y	811.2	809.5	34	40.8	316.0	440.3	12.4	1.7	84,652
Crookham	XPH97H27	Y	638.4	632.7	52	14.8	38.3	559.1	15.9	4.7	88,993
D. Palmer	Mesquite	Y	579.3	573.0	46	16.9	23.5	480.4	52.2	6.2	89,303
	Tequila	Y	557.5	553.0	44	3.5	7.1	496.2	46.2	4.5	86,822
Sakata	XON-0101	Y	910.3	905.5	46	63.9	391.3	442.1	8.1	4.9	91,784
	XON-0103	Y	765.6	765.4	54	48.4	212.9	496.8	7.3	0.1	87,442
Shamrock	Dawn F1	Y	797.7	797.7	43	26.5	246.3	514.1	10.9	0.0	86,202
Seminis	Candy	Y	833.3	830.5	45	57.9	312.1	457.1	3.4	2.8	87,132
	Golden Spike	Y	740.3	738.2	54	29.2	92.0	589.9	27.1	2.2	92,714
	Santa Fe	Y	663.3	661.9	73	2.8	73.0	561.2	24.9	1.4	88,476
	EX 6876	Y	781.9	780.5	44	35.1	210.5	530.4	4.4	1.4	87,753
Sunseeds	Alabaster	W	667.2	664.4	55	5.9	99.1	547.1	12.2	2.9	83,411
	Cometa	W	552.5	538.8	151	1.0	15.3	476.4	46.1	13.6	87,132
	Ranchero	Y	622.3	614.5	56	8.3	48.4	513.1	44.6	7.8	90,233
	Renegade	Y	744.4	741.4	51	29.8	228.5	474.8	8.2	3.1	85,272
	Rumba	R	660.4	654.7	47	34.6	63.4	510.1	46.8	5.7	90,543
US Agriseeds	Everest	W	523.2	513.4	0	0.0	13.4	461.4	38.7	9.8	83,928
Average			697.0	693.0	49.3	24.7	137.2	506.2	24.7	4.0	87,562
LSD (0.05)			70.7	72.3	13	33.4	77.0	83.9	18.4	5.9	ns

Table 2. Performance data for experimental and commercial onion varieties grown from transplants and harvested on July 22, 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

		Total	Marketable yield by grade								Plant
		yield	Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small	Rot	population
Company	Variety	--- cwt/acre ---		#/50 lb	---------------------- cwt/acre ----------------------						plants/acre
American Takii	T-803	909.8	908.4	31	50.8	355.7	490.5	11.3	0.0	1.4	91,669
Bejo	Electric	645.5	639.7	0	0.0	69.5	543.4	26.8	2.6	3.2	91,018
	Stanza	1,007.7	1,004.7	30	190.7	511.6	298.9	3.5	1.1	1.9	86,517
Crookham	XPH97H27	871.5	867.0	29	47.2	354.6	457.1	8.1	2.3	2.2	94,176
D. Palmer	Mesquite	762.2	756.0	29	51.5	295.8	398.7	10.1	1.4	4.8	91,627
	Tequila	835.2	828.1	36	20.9	325.2	471.0	10.9	4.3	2.8	91,836
Sakata	XON-0101	1,186.5	1,183.8	30	347.4	629.9	201.6	4.9	1.0	1.7	91,780
	XON-0103	1,089.0	1,087.8	31	255.9	511.9	315.8	4.2	0.0	1.2	88,393
Shamrock	Dawn F1	1,016.1	1,012.4	29	98.7	497.3	408.0	8.5	1.9	1.8	91,998
Seminis	Candy	1,112.6	1,109.1	30	200.3	565.1	339.5	4.1	1.4	2.1	92,920
	Golden Spike	966.4	962.7	32	93.7	433.6	430.2	5.2	2.4	1.3	91,540
	Santa Fe	865.6	863.0	33	109.7	463.4	285.1	4.9	0.1	2.5	78,218
	EX 6876	985.8	980.1	32	200.2	517.6	258.8	3.5	2.9	2.8	86,213
Sunseeds	Alabaster	771.4	763.2	30	17.2	251.2	480.9	14.0	4.7	3.5	88,973
	Cometa	806.9	802.1	34	35.5	281.8	470.8	13.9	1.9	2.9	91,844
	Ranchero	944.9	942.4	32	70.7	459.3	400.3	12.1	0.2	2.3	92,072
	Renegade	1,027.2	1,023.5	30	269.8	504.8	239.8	9.2	1.0	2.6	89,833
	Rumba	853.9	845.0	30	16.1	319.9	501.5	7.5	8.2	0.7	87,193
US Agriseeds	Everest	169.5	158.3	0	0.0	12.1	134.5	11.7	0.0	11.3	77,467
Average		885.7	880.9	28	109.3	387.4	375.1	9.2	2.0	3.0	89,226
LSD (0.05)		120.7	122.0	3	88.8	120.1	113.7	ns	ns	2.6	ns

Table 3. Subjective rating of exterior bulb quality: 0-10, 1 = least and 10 = most for sprouting, torpedo shape, and softness; 1 = best and 10 = worst for appearance; 1 = best and 10 = worst for total subjective rating; Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	July 9 harvest					July 22 harvest				
Variety	Sprouting	Torpedo shape	Softness	Appear.	Total	Sprouting	Torpedo shape	Softness	Appear.	Total
T-803	1.0	4.0	2.0	2.8	9.8	1.0	2.5	1.3	1.8	6.5
Electric	1.0	2.0	1.0	2.0	6.0	1.0	1.0	1.3	2.0	5.3
Stanza	1.0	2.8	2.8	2.5	9.0	1.0	1.5	1.3	1.5	5.3
XPH97H27	5.5	6.8	5.0	6.3	23.5	2.5	3.3	1.7	3.3	11.0
Mesquite	6.5	7.3	5.8	7.0	26.5	3.3	3.5	2.0	3.5	12.3
Tequila	5.3	5.8	5.0	6.0	22.0	2.5	3.0	1.8	3.0	10.3
XON-0101	1.3	3.5	2.5	3.0	10.3	1.0	2.0	1.5	1.5	6.0
XON-0103	2.8	5.5	4.5	4.8	17.5	1.3	3.3	1.8	2.5	8.8
Dawn F1	2.0	3.5	2.0	2.8	10.3	1.5	2.5	1.5	2.0	7.5
Candy	1.0	3.0	5.5	3.8	13.3	1.0	1.3	2.5	1.0	5.8
Golden Spike	2.3	5.3	4.8	4.8	17.0	1.0	3.0	1.3	2.3	7.5
Santa Fe	4.3	4.7	5.7	4.7	19.3	2.7	2.7	2.3	3.0	10.7
EX 6876	2.0	4.0	3.3	3.5	12.8	1.3	2.0	2.0	1.5	6.8
Alabaster	1.3	3.0	2.0	2.3	8.5	1.3	2.0	1.0	2.0	6.3
Cometa	2.5	5.0	3.5	4.0	15.0	1.3	2.3	1.3	2.5	7.3
Ranchero	5.0	6.0	4.5	5.3	20.8	1.3	2.5	2.0	2.3	8.0
Renegade	1.0	3.3	3.5	3.3	11.0	1.0	2.0	2.3	2.0	7.3
Rumba	1.0	2.7	2.3	2.7	8.7	1.0	1.3	1.0	1.7	5.0
Everest	1.0	3.0	1.7	3.7	9.3	1.0	1.7	1.3	5.7	9.7
Average	2.5	4.3	3.5	3.9	14.2	1.5	2.3	1.6	2.4	7.7
LSD (0.05)	1.5	1.6	1.5	1.4	4.3	0.9	1.2	ns	1.2	2.5

Table 4. Pyruvate concentration on August 11, 2003 in bulbs from July 22 harvest, and multiple center rating, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Entry name	Pyruvate concentration	"Blowout"	"Intermediate double"	"Small double"	"Bullet"	Functionally single centered "small double + bullet"
		µmoles/g FW	%				
American Takii	T-803	5.7	5.0	36.0	55.0	4.0	59.0
Bejo	Electric	5.0	70.7	24.0	4.0	1.3	5.3
	Stanza	5.3	59.0	28.0	12.0	1.0	13.0
Crookham	XPH97H27	5.8	27.0	33.0	21.0	19.0	40.0
D. Palmer	Mesquite		24.0	48.0	11.0	17.0	28.0
	Tequila		15.0	33.0	17.0	35.0	52.0
Sakata	XON-0101	5.9	27.0	39.0	33.0	1.0	34.0
	XON-0103	5.7	31.0	41.0	17.0	11.0	28.0
Shamrock	Dawn F1	5.4	34.0	34.0	29.0	3.0	32.0
Seminis	Candy	6.0	18.0	47.0	28.0	7.0	35.0
	Golden Spike	5.3	22.0	22.0	38.0	18.0	56.0
	Santa Fe	6.0	10.7	26.7	28.0	34.7	62.7
	EX 6876		17.0	39.0	26.0	18.0	44.0
Sunseeds	Alabaster	6.1	27.0	44.0	28.0	1.0	29.0
	Cometa	5.6	2.0	2.0	11.0	85.0	96.0
	Ranchero	5.7	6.0	12.0	47.0	35.0	82.0
	Renegade	3.9	17.0	51.0	28.0	4.0	32.0
	Rumba	4.8	25.3	36.0	32.0	6.7	38.7
US Agriseeds	Everest		38.7	21.3	29.3	10.7	40.0
Average		5.5	25.1	32.5	26.0	16.4	42.5
LSD (0.05)		0.6	14.1	19.2	16.4	9.4	14.6

Table 5. Performance data for experimental and commercial onion varieties grown from transplants and harvested on July 23, 2002 and July 22, 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	Total yield	Marketable yield by grade Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small	Rot	Plant population
	--- cwt/acre ---		#/50 lb	---------------------- cwt/acre			----------------------			plants/acre
2002										
XPH97H27	748.5	719.9	33.0	74.2	286.8	320.7	38.2	28.6		68,310
Candy	982.1	973.8	25.7	251.9	424.4	293.8	3.7	8.3		76,230
Santa Fe	794.2	794.2	30.4	196.7	322.6	222.2	52.6	0.0		63,360
Alabaster	549.9	549.9	0.0	0.0	186.2	352.8	10.9	0.0		73,920
Cometa	709.5	677.6	35.7	55.7	201.7	368.3	52.0	31.9		66,330
Ranchero	921.4	921.4	29.1	102.4	327.9	417.2	74.0	0.0		79,200
Renegade	962.5	955.5	27.3	234.0	422.4	285.5	13.5	7.0		72,270
Rumba	742.2	582.2	23.4	42.3	241.7	424.4	33.8	0.0		73,260
Average	801.3	771.8	29.2	136.8	301.7	335.6	34.8	9.5		71,610
LSD (0.05) Variety	ns	ns	16.2	117.3	ns	173.0	48.2	ns		ns
2003										
XPH97H27	871.5	867.0	29.0	47.2	354.6	457.1	8.1	2.3	2.2	94,176
Candy	1,112.6	1,109.1	30.0	200.3	565.1	339.5	4.1	1.4	2.1	92,920
Santa Fe	865.6	863.0	33.0	109.7	463.4	285.1	4.9	0.1	2.5	78,218
Alabaster	771.4	763.2	30.0	17.2	251.2	480.9	14.0	4.7	3.5	88,973
Cometa	806.9	802.1	34.0	35.5	281.8	470.8	13.9	1.9	2.9	91,844
Ranchero	944.9	942.4	32.0	70.7	459.3	400.3	12.1	0.2	2.3	92,072
Renegade	1,027.2	1,023.5	30.0	269.8	504.8	239.8	9.2	1.0	2.6	89,833
Rumba	853.9	845.0	30.0	16.1	319.9	501.5	7.5	8.2	0.7	87,193
Average	906.8	901.9	30.9	95.8	400.0	396.9	9.2	2.5	2.3	89,403
LSD (0.05) Variety	120.7	122.0	3.0	88.8	120.1	113.7	ns	ns	2.6	ns
LSD (0.05) Year	84.1	82.0	4.3	ns	54.9	ns	12.3	ns		8,149

Table 6. Bulb pyruvate concentration on August 7, 2002 in bulbs from July 23, 2002 harvest and multiple center rating, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Pyruvate concentration	Onion multiple center rating "Blowout"	"Intermediate double"	"Small double"	"Bullet"	Functionally single centered "small double + bullet"
		μmoles/g FW	----------------------------		%		----------------------------
Petoseed	Candy	6.3	9.7	32.7	31.4	26.1	57.6
Sunseeds	SR4000ON	7.1	1.8	9.1	52.1	37.1	89.1
	Renegade	5.4	7.3	34.4	20.8	37.5	58.3
	Ranchero	6.2	0.0	0.0	0.0	100.0	100.0
	Alabaster	7.2	3.0	41.1	47.8	8.0	55.8
	La Nina	7.9	1.6	23.1	33.0	42.3	75.3
	SRO-1403	5.9	0.0	3.6	15.5	81.0	96.4
	Cometa	5.4	0.0	0.0	0.0	100.0	100.0
	Rumba	4.7	2.3	35.7	38.9	23.1	62.0
Average		6.2	2.9	20.0	26.6	50.6	77.2
LSD (0.05)		1.1	9.2	14.9	14.8	14.0	17.3

EFFECT OF SHORT-DURATION WATER STRESS ON ONION SINGLE CENTEREDNESS AND TRANSLUCENT SCALE

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Introduction

In earlier trials we have shown that onion yield and grade are very responsive to soil water (Shock et al. 1998b, 2000). Using a high-frequency automated drip-irrigation system, the soil water potential at 8-inch depth that resulted in maximum onion yield, grade, and quality after storage was determined to be -20 kPa. Short term water stress, caused by irrigation errors, could result in internal bulb defects such as multiple centers and translucent scale. This trial tested the effects of short-duration water stress at different times during the season on onion single centeredness and translucent scale.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. Onion (cv. 'Vaquero', Sunseeds, Morgan Hill, CA) 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 17, 2003. The two rows in 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 6-inch depth between the two double onion rows on March 28. 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. Onion emergence started on April 7. The trial was irrigated on April 14 with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart.

The experimental design was a randomized complete block with five replicates. There were five treatments that consisted of four timings of short-duration water stress and an unstressed check. The water stress was applied by turning the water off to all plots in a treatment until the average soil water potential at 8-inch depth for the treatment reached -60 kPa; at this point, the water to all plots in that treatment was turned on again. Each treatment was stressed once during the season. The four timings for the stress treatments were: four-leaf stage (water off June 2, water back on June 10), early six-leaf stage (water off June 16, water back on June 21), late six-leaf stage (water off June 26, water back on July 2) , and eight-leaf stage (water off July 7, water back on July 11).

Soil water potential was measured in each plot with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors were calibrated to SWP (Shock et al. 1998a). The GMS were connected to the datalogger with three multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the soil water potential every hour. The irrigations were controlled by the datalogger using a relay driver (A21 REL, Campbell Scientific, Logan, UT) connected to a solenoid valve. Irrigation decisions were made every 12 hours by the datalogger: if the average soil water potential at 8-inch depth in the unstressed treatment plots was -20 kPa or less the field was irrigated for 4 hours. The pressure in the drip lines was maintained at 10 psi by a pressure regulator. Irrigations were terminated on September 2.

Onion tissue was sampled for nutrient content on June 4 and 19. The roots from four onion plants in each check plot were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, ID. The onions in all treatments were fertilized according to the nutrient analyses. Fertilizer was applied through the drip tape: ammonium sulfate at 25 lb N/acre on May 30, urea ammonium nitrate solution at 25 lb N/acre on June 5, June 16, and June 25, and zinc chelate at 0.25 lb Zn/acre and copper chelate at 0.2 lb Cu/acre on June 25.

Roundup at 24 oz/acre was sprayed on March 28. The field had Prowl (1lb ai/acre) broadcast on April 21 for postemergence weed control. Approximately 0.4 inch of water was applied through the minisprinkler system on April 21 to incorporate the Prowl. The field had Buctril at 0.12 lb ai/acre and Poast at 0.4 lb ai/acre applied on April 28. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

On September 11 the onions were lifted to field cure. On September 17, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. On December 11 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), double 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 (2¼-3 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.

After grading, 50 bulbs ranging in diameter from 3.5 to 4.25 inches from each plot were rated for single centers and translucent scale. 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 <1½ inch, "intermediate double" had diameters from 1½-2¼ inches, and "blowout" had diameters >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." The number and location of translucent scales in each bulb was also recorded.

Results and Discussion

The soil water potential at 8-inch depth during the stress treatments reached values lower than the planned -60 kPa (Fig. 1). Irrigations for the plots being stressed were restarted as soon as the soil water potential reached -60 kPa. However, because the drip tape was located 11 inches from the soil moisture sensors, there was a short delay between the onset of irrigation and when the wetting front reached the sensors, when the soil moisture sensors began responding to the irrigations.

Water stress at the four-leaf (early June) and at the six-leaf (mid-June) stages resulted in fewer bullet single-centered and functionally single-centered onions than the unstressed check (Table 1). Water stress at the later stages did not affect onion single-centeredness. Water stress at the four-leaf stage resulted in higher percentage of blowout multiple centered onions. Water stress did not affect translucent scale. The level of translucent scale was very low, with all of the treatments having less than 1 percent of bulbs with translucent scales. In contrast to a previous study (Hegde 1986), the short-duration water stress in this trial did not affect onion yield or grade. Onion yield and size were reduced by short-duration water stress to -85 kPa, with the onions otherwise irrigated at -45 kPa (Hegde 1986). In the study by Hegde, the soil water potential at which the onions were irrigated was drier (-45 kPa) than in this study (-20 kPa) and the irrigation frequency was much lower, possibly causing the difference in results. The average onion yields in this trial were: 860 cwt/acre total yield, 837 cwt/acre marketable yield, 8 cwt/acre super colossal yield, 155 cwt/acre colossal yield, and 652 cwt/acre jumbo yield.

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Table 1. Onion multiple-center rating response to timing of water stress, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Water stress timing	Blowout	Intermediate double	Small double	Bullet	Functionally single centered "Bullet + small double"
	%				
Check, no stress	2.5	14.0	14	69.5	83.5
4-leaf stage, early June	10.5	20.0	17	52.5	69.5
6-leaf stage, mid-June	4.5	26.0	15.5	54.0	69.5
6-leaf stage, late June	1.5	12.0	21.5	65.0	86.5
8-leaf stage, early July	3.5	18.5	16.0	62.0	78.0
LSD (0.05)	3.7	7.9	NS	10.9	8.5

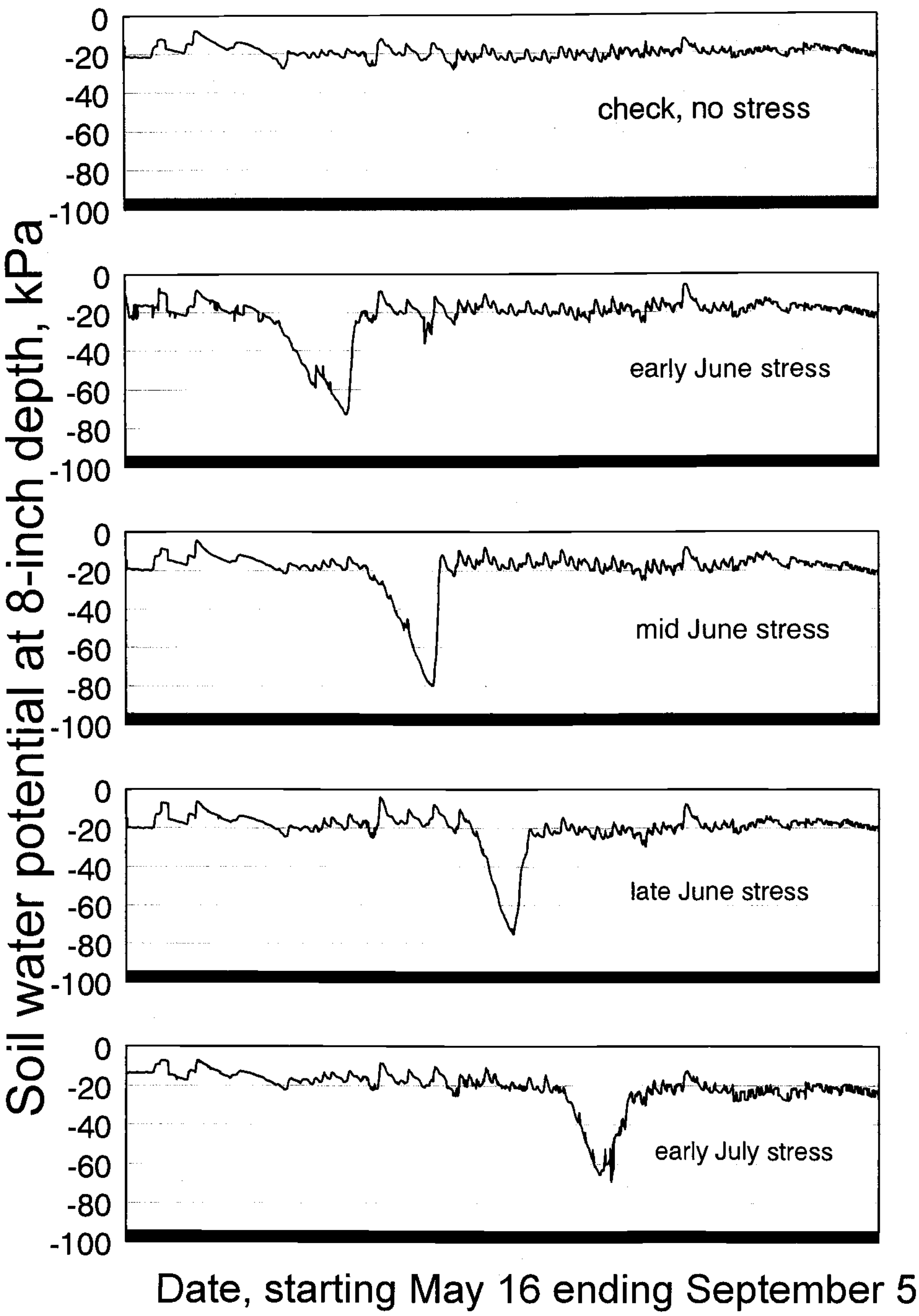

Figure 1. Soil water potential for onions irrigated at -20 kPa with an automated drip irrigation system and submitted to short-duration water stress, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

IRRIGATION FREQUENCY, DRIP TAPE FLOW RATE, AND ONION PERFORMANCE

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Introduction

Onion production with subsurface drip irrigation has proven at the Malheur Experiment Station to be highly productive on sites that are difficult to irrigate. In 1997 and 1998 onions were submitted to five soil water potential treatments using an automated, high frequency irrigation system (Shock et al. 2000a). The soil water potential was maintained relatively constant by applying 0.06 inch of water up to eight times a day, depending on soil water potential readings. The soil water potential at 8-inch depth that resulted in maximum onion yield, grade, and quality after storage was determined to be -20 kPa. An irrigation frequency of up to eight times a day in small increments is not feasible on a commercial scale. Would reducing the irrigation frequency result in lower water use efficiencies and lower onion yield and quality?

The drip tape that has been used at the Malheur Experiment Station has a flow rate of 0.22 gal/min/100 ft of tape. A reduced flow rate could theoretically result in an improved soil wetting pattern and less water lost to deep percolation. An improved soil wetting pattern could result in the onions on the outside row of a double row receiving more uniform soil moisture. New “ultra low flow” drip irrigation tapes with reduced emitter flow rates are being introduced by drip tape manufacturers. This trial tested four irrigation frequencies and two drip tape flow rates for their effect on onion yield and quality.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. Onion (cv. ‘Vaquero’, Sunseeds, Morgan Hill, CA) 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 17, 2003. The rows in 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 on March 28. The distance between the tape and the double row was 11 inches. The drip tape had emitters spaced 12 inches apart and either of two flow rates: low flow (0.22 gal/min/100 ft) and ultra low flow (0.11 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. Onion emergence started on April 7. The trial was irrigated on April 14 with a minisprinkler system (R10 Turbo

Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals, which were spaced 30 ft apart.

Onion tissue was sampled for nutrient content on June 19. The roots from 25 onion plants taken from plot border rows representative of the field were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, Idaho. The onions in all treatments were fertilized according to the nutrient analyses (Table 1). Fertilizer was applied through the drip tape: ammonium sulfate at 25 lb N/acre on May 30, urea ammonium nitrate solution at 25 lb N/acre on June 5, 16, and 25, and zinc chelate at 0.25 lb Zn/acre and copper chelate at 0.2 lb Cu/acre on June 25.

Roundup at 24 oz/acre was sprayed on March 28. The field had Prowl (1lb ai/acre) broadcast on April 21 for postemergence weed control. Approximately 0.4 inch of water was applied through the minisprinkler system on April 21 to incorporate the Prowl. The field had Buctril at 0.12 lb ai/acre and Poast at 0.4 lb ai/acre applied on April 28. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

The experimental design was a randomized complete block with four replicates. The onions were submitted to eight treatments consisting of a combination of two drip tape flow rates and four daily irrigation frequency/duration treatments (Table 2). The onions in each plot (four double rows by 50 ft) were submitted to one irrigation frequency and one tape flow rate. The irrigation frequencies were the daily time interval by which the datalogger (CR10, Campbell Scientific, Logan, UT) checked the sensors and made irrigation decisions. Each plot was irrigated independently when the average soil water potential at 8-inch depth in the plot reached -20 kPa. The irrigation durations for each treatment were adjusted so that when irrigated the maximum number of times, all treatments had the capacity to deliver a maximum of 0.48 inch of water per day.

Soil water potential was measured in each plot with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors were calibrated to SWP (Shock et al. 1998a). The GMS were connected to the datalogger via five multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the soil water potential every 3 hours. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, UT) connected to solenoid valves in each plot. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The amount of water applied to each plot was recorded daily at 8:00 a.m. from a water meter installed between the solenoid valve and the drip tape. The automated drip irrigation system was started on May 22. Irrigations were terminated on September 2.

Onion evapotranspiration (Et_c) was calculated with a modified Penman equation (Wright 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station. Onion Et_c was estimated and recorded from crop emergence on April 7 until the final irrigation.

On September 11 the onions were lifted to field cure. On September 17, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. Onions were graded on December 11.

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 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.

Results

In the analysis of variance, the year effect was significant for total marketable and jumbo onion yields, both being higher in 2002. The yield of the larger bulb size classes was limited in these trials by the high plant population (Shock et al. 2004). While the yields are above the county average, they are in the range achieved by growers using drip irrigation.

There was no interaction between emitter type or irrigation frequency and year, so the results are analyzed and discussed as the average over the 2 years. Averaged over irrigation frequencies, the drip tape with 0.13 gal/hour emitters had significantly higher total yield, marketable yield, and colossal onion yield than the tape with 0.07 gal/hour emitters (Table 2). Averaged over emitter type, the once per day irrigation frequency (0.48 inch of water applied per irrigation) had among the highest total and marketable onion yields. Averaged over emitter type, the once per day irrigation frequency resulted in the highest colossal onion yield.

There was no significant difference in average soil water potential between treatments (Table 2). The standard deviation of the soil water potential increased with decreasing irrigation frequency, reflecting the higher amplitude of soil water potential oscillation around the criteria of -20 kPa (Table 2, Figs. 1 and 2). There was no significant difference in total water applied between treatments, with, on average, 32 and 28 inches applied in 2002 and 2003, respectively. Onion Et_c from emergence to the last irrigation totaled 30.2 and 32 inches in 2002 and 2003, respectively. The total amount of water applied includes 2 and 0.52 inches of water applied with the minisprinkler system after emergence, and 0.84 and 1.28 inches of precipitation, in 2002 and 2003, respectively. Water applications to all treatments closely followed Et_c during the season (Figs. 3 and 4).

Discussion

An explanation for the increased bulb size with the lowest irrigation frequency could be that, since the lowest irrigation frequencies had the highest amplitude of soil water potential oscillation, the onions might have responded to the soil becoming wetter during irrigations than with the lower irrigation frequencies. Our past research has shown that onions will respond to irrigation criteria higher than -20 kPa with increased bulb size (Shock et al. 1998b, Shock et al. 2000b). An irrigation criteria higher than -20 kPa is not recommended on silt loam soils, because of the unpredictability of onion storage quality, which in some years can be low with irrigation criteria higher than -20 kPa.

The results of this study suggest that the drip tape with 0.066 gal/hour emitters should not be recommended for onion production in the Treasure Valley, since onion yield and size were lower and there were no apparent irrigation benefits.

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Table 1. Onion root nutrient concentrations on June 19, 2003. Malheur Experiment Station, Oregon State University, Ontario, OR.

Nutrient	Sufficiency range*	Analysis
NO_3 (ppm)	6,200	4,251
P (%)	0.32 - 0.70	0.59
K (%)	2.7 - 7.0	4.95
S (%)	0.24 - 1.4	0.61
Ca (%)	0.4 - 1.6	1.69
Mg (%)	0.3 - 0.6	0.41
Zn (ppm)	32 - 100	27
Mn (ppm)	35 - 100	91
Cu (ppm)	8 - 30	8
Fe (ppm)	60 - 250	448
B (ppm)	19 - 80	27

*supplied by Western Labs, Parma, ID.

Table 2. Effect of irrigation frequency and drip tape emitter flow rate on onion yield and size, Malheur Experiment Station, Oregon State University, Ontario, OR.

Emitter flow rate gal/h	Irrigation frequency h	Irrigation duration h	Water applied Per irrigation (inch)	Water applied Total (inch)	Avg soil water potential (kPa)	Total yield (cwt/acre)	Marketable yield Total (cwt/acre)	Marketable yield Super colossal (cwt/acre)	Marketable yield Colossal (cwt/acre)	Marketable yield Jumbo (cwt/acre)	Marketable yield Medium (cwt/acre)
2002											
0.13	3	1	0.06	32.7	-20.3 ± 3.1	1,042	1,028	6	239	764	20
0.13	6	2	0.12	32.2	-19.9 ± 3.4	985	970	11	192	738	30
0.13	12	4	0.24	32.6	-20.3 ± 3.5	1,041	1,028	9	192	800	28
0.13	24	8	0.48	31.5	-18.8 ± 4.1	1,052	1,028	16	287	708	16
Avg				32.3	-19.8	1,030	1,014	10	227	753	24
0.066	3	2	0.06	32.6	-19.8 ± 2.9	969	952	13	185	736	18
0.066	6	4	0.12	31.2	-21.2 ± 3.9	994	972	3	190	751	28
0.066	12	8	0.24	32.9	-19.8 ± 4.2	977	958	10	178	746	24
0.066	24	16	0.48	31.5	-19.9 ± 5.4	1,041	1,025	11	213	778	23
Avg				32.0	-20.2	995	977	9	192	753	23
Avg over tape types	3		0.06	32.7	-20.0	1,005	990	9	212	750	19
	6		0.12	31.8	-20.4	989	971	8	191	744	29
	12		0.24	32.7	-20.1	1,009	993	10	185	773	26
	24		0.48	31.5	-19.4	1,047	1,027	14	256	738	19
2003											
0.13	3	1	0.06	28.5	-18.0 ± 2.7	861	846	17	164	649	17
0.13	6	2	0.12	28.0	-19.4 ± 3.0	880	846	9	211	610	16
0.13	12	4	0.24	27.7	-18.9 ± 3.3	902	894	6	194	677	18
0.13	24	8	0.48	29.2	-17.4 ± 4.5	947	925	26	269	615	15
Avg				28.4	-18.4	897	878	14	209	637	17
0.066	3	2	0.06	26.9	-18.9 ± 2.8	849	834	2	138	673	20
0.066	6	4	0.12	28.8	-18.9 ± 2.4	805	786	16	150	599	22
0.066	12	8	0.24	24.9	-19.6 ± 3.3	940	901	5	186	692	18
0.066	24	16	0.48	31.1	-18.7 ± 4.1	882	859	13	197	630	19
Avg				27.9	-19.0	869	845	9	168	649	20
Avg over tape types	3		0.06	28.0	-18.5	855	840	10	151	661	18
	6		0.12	28.3	-19.2	842	816	12	180	605	19
	12		0.24	26.8	-19.2	921	897	6	190	684	18
	24		0.48	29.9	-18.1	914	892	19	233	622	17
2002-2003											
0.13	3	1	0.06	29.9	-18.8	952	937	11	201	706	18
0.13	6	2	0.12	29.8	-19.6	932	908	10	201	674	23
0.13	12	4	0.24	29.8	-19.5	972	961	7	193	738	23
0.13	24	8	0.48	30.0	-17.9	1,000	976	21	278	662	16
Avg				29.9	-18.9	964	946	12	218	695	20
0.066	3	2	0.06	29.8	-19.2	909	893	8	162	705	19
0.066	6	4	0.12	30.0	-19.6	886	866	10	167	664	24
0.066	12	8	0.24	28.9	-19.7	958	930	8	182	719	21
0.066	24	16	0.48	31.3	-19.1	950	930	12	204	693	21
Avg				30.0	-19.4	926	905	9	179	695	21
Avg over tape types	3		0.06	29.8	-19.0	930	915	9	181	705	19
	6		0.12	29.9	-19.6	911	889	10	185	669	24
	12		0.24	29.5	-19.6	965	945	8	187	729	22
	24		0.48	30.5	-18.5	976	955	17	244	676	18
LSD (0.05) Emitter				NS	NS	36	34	NS	4	NS	NS
LSD (0.05) Water applied				NS	NS	50	48	9	50	44	1
LSD (0.05) Emitter X Water applied				NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Emitter X Water appl. X Year				NS	NS	NS	NS	NS	NS	NS	NS

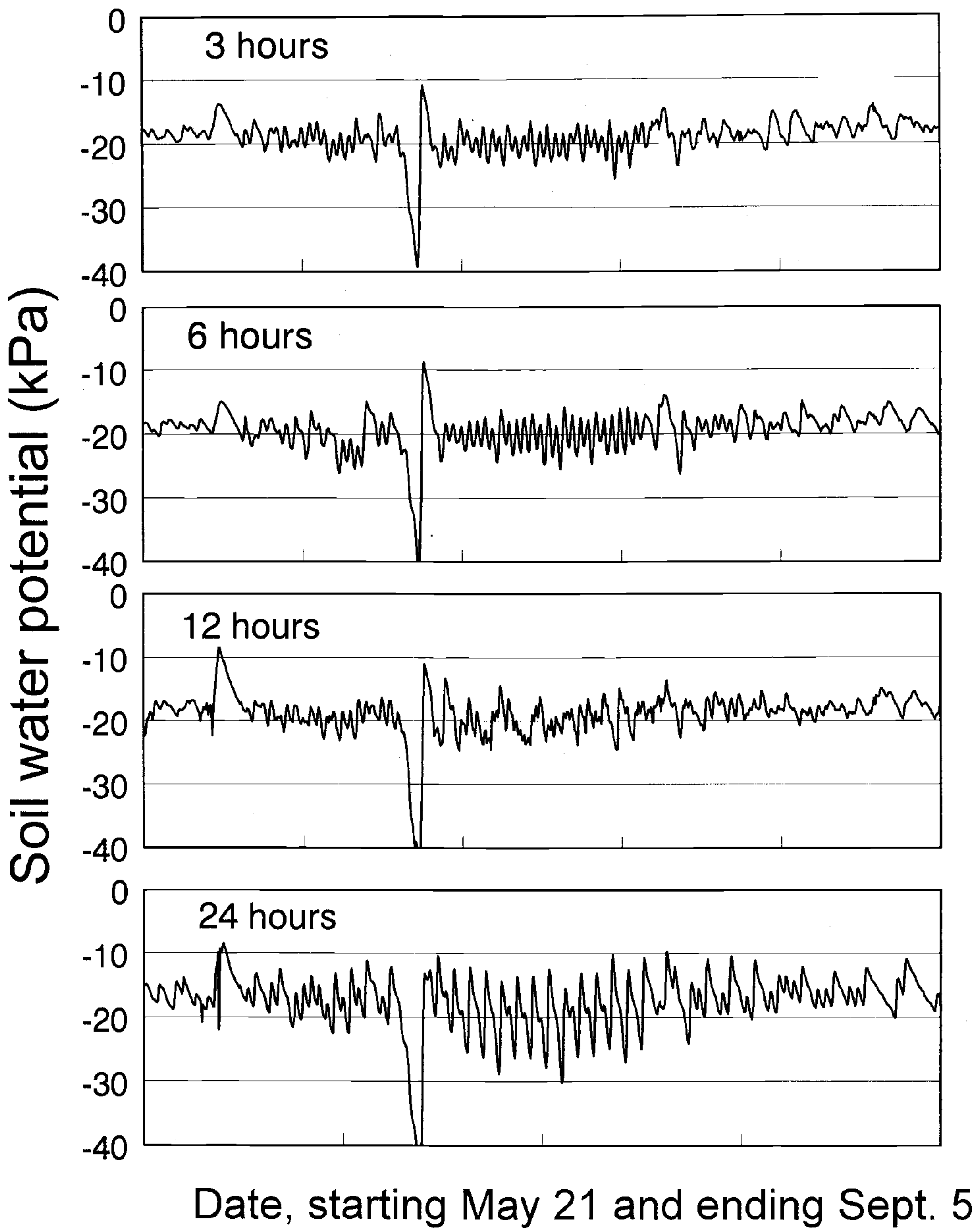

Figure 1. Soil water potential over time for drip-irrigated onion using a tape flow rate of 0.22 gal/min/100 ft and four irrigation frequencies (time interval used by datalogger for checking sensors and making irrigation decisions). Soil water potential is the average of 16 sensors. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

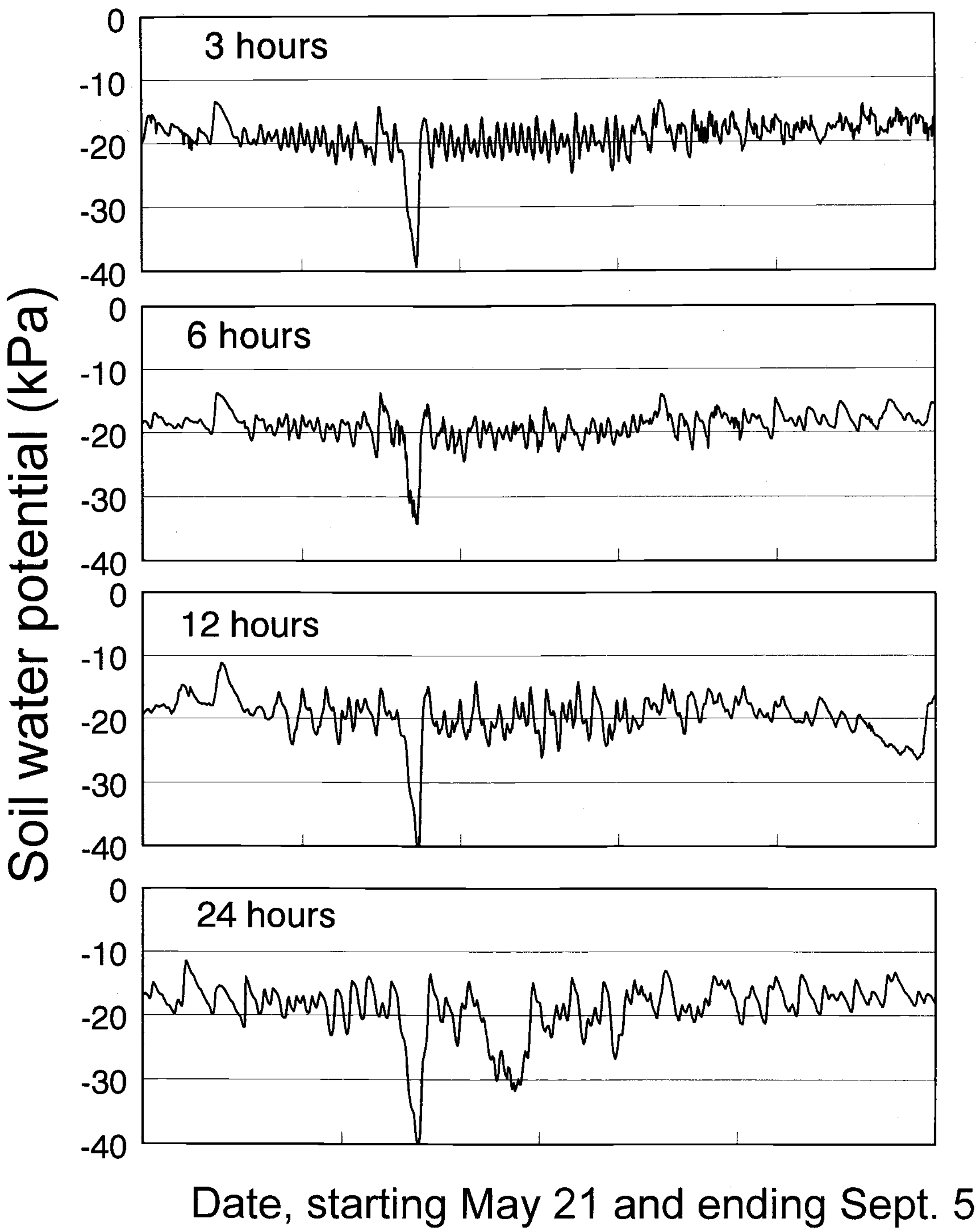

Figure 2. Soil water potential over time for drip-irrigated onion using a tape flow rate of 0.11 gal/min/100 ft and four irrigation frequencies (time interval used by datalogger for checking sensors and making irrigation decisions). Soil water potential is the average of 16 sensors. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

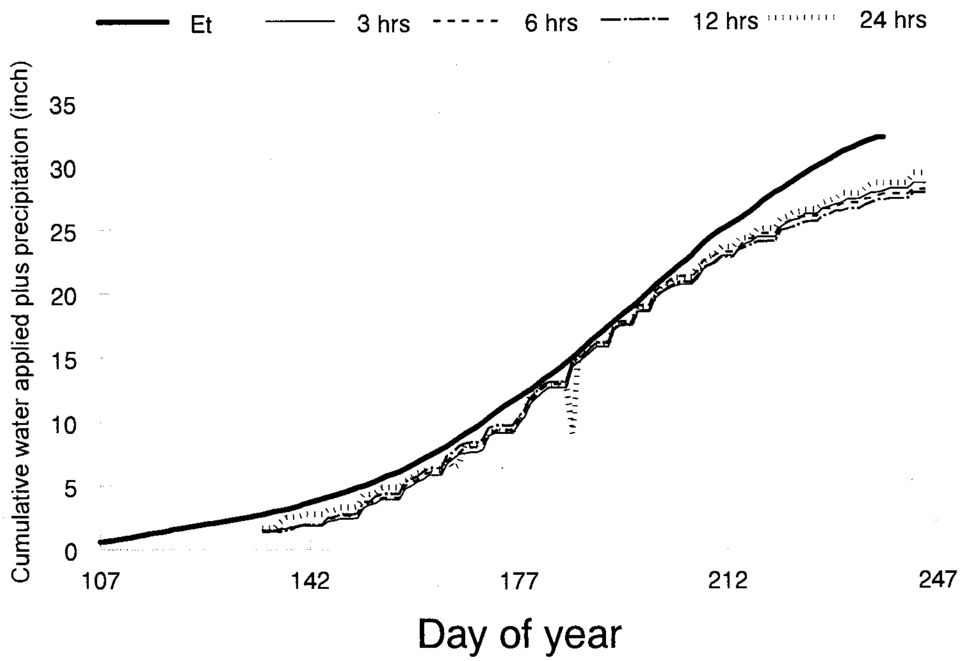

Figure 3. Cumulative water applied and Et_c over time for drip-irrigated onion using a tape flow rate of 0.22 gal/min/100 ft and four irrigation frequencies. Water applied is the average of four plots. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

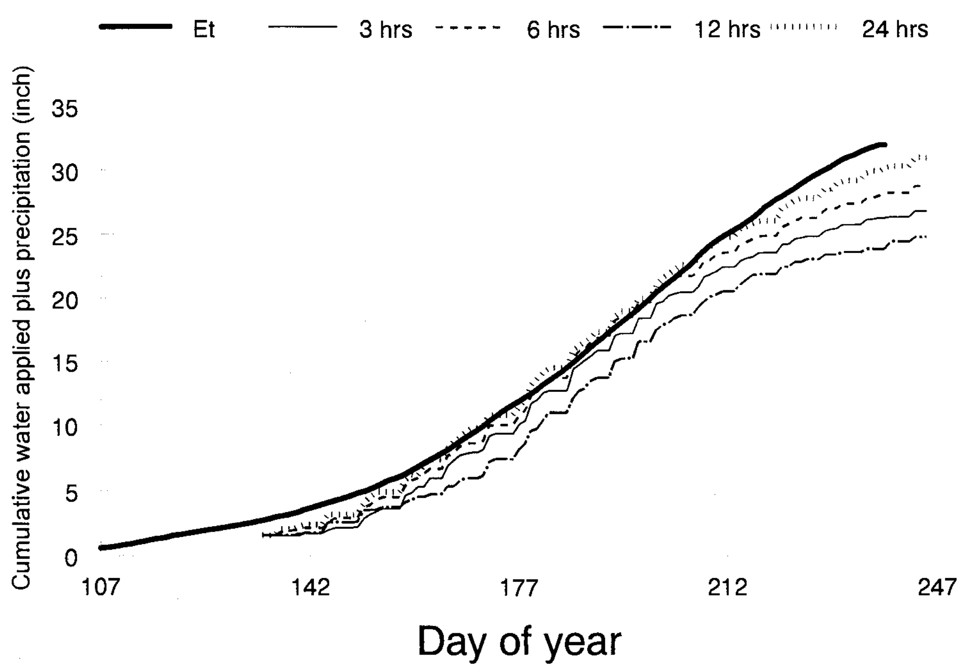

Figure 4. Cumulative water applied and Et_c over time for drip-irrigated onion using a tape flow rate of 0.11 gal/min/100 ft and four irrigation frequencies. Water applied is the average of four plots. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

EFFECT OF PHOSPHITE FERTILIZER FORMULATIONS ON ONION YIELD AND QUALITY

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Introduction

Biagro Western (Visalia, CA) manufactures formulations of phosphite fertilizer. They claim that phosphorus (P) in the form of phosphite (PO_3) is to be more easily absorbed by plants than P in the form of phosphate (PO_4). This trial tested three phosphite fertilizer formulations for their effect on onion plant P content, and onion yield and grade.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. In the fall of 2002, the wheat stubble was shredded, and the field was disked, irrigated, ripped, moldboard-plowed, roller-harrowed, fumigated with Telone C-17 at 20 gal/acre, and bedded. Soil analysis indicated the need for 100 lb P_2O_5/acre, 150 lb K /acre, 6 lb Mn/acre, 2 lb Cu/acre, and 1 lb B/acre, which was broadcast in the fall. A soil sample taken on May 9 showed a pH of 7.7, 1.4 percent organic matter, 0.2 percent lime, 20 ppm nitrate-N, 29 ppm P (Olsen test, sodium bicarbonate extractant), and 216 ppm K.

Onion (cv. 'Vaquero', Sunseeds, Morgan Hill, CA) was planted in two double rows, spaced 22 inches apart (center of double row to center of double row) in 44-inch beds on March 17, 2003. The two rows in 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 6-inch depth between the two double onion rows on March 28. 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. Onion emergence started on April 7. The trial was irrigated on April 14 with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart.

The experimental design was a randomized complete block with five replicates. There were four treatments: an untreated check and three fertilizer formulations. The fertilizer formulations were manufactured by Biagro Western and were Magnum Nutri-phite (2-40-16) foliar (3 pints/acre/application), Sulfone Nutri-phite (5-20-15-14) foliar (3 lb/acre/application), and P Soil Hi-Grade (0-60-0) drip injected (2 quarts/acre/application). Each fertilizer treatment was applied three times as follows: first application: bulb at 0.5 inch (June 10); second application: 3 weeks after first application (July 1); third application: 6 weeks after first application (July 17). The two foliar applied formulations were applied at 40 gal/acre with a backpack sprayer with four 8004 nozzles at 30 PSI. The drip-injected formulation was applied through the drip tape at an injection rate of 2.5 percent using a Dosmatic A30 injector (Dosmatic USA, Carrolton, TX). All treatments including the check received standard fertilizer applications based on soil and tissue analyses.

Onion tissue was sampled for nutrient content on June 4 and 19. The roots from four onion plants in each check plot were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, Idaho. The onions in all treatments were fertilized according to the nutrient analyses. Onion root P concentration for the check treatment was 0.40 and 0.59 percent on June 4 and 19, respectively. Fertilizer was applied through the drip tape: ammonium sulfate at 25 lb N/acre on May 30; urea ammonium nitrate solution at 25 lb N/acre on June 5, 16, and 25; and zinc chelate at 0.25 lb Zn/acre and copper chelate at 0.2 lb Cu/acre on June 25.

Onion tissue was also sampled from all treatments for comparison of P contents on July 3, July 19, and August 8. Five onion plants from outside the harvest area from each plot of each treatment were combined to make one sample per treatment. Each sample was separated into roots, bulbs, and leaves. The roots and leaves were weighed, dried in a forced-air oven at 150°F for 4 days and weighed. The bulbs were weighed and shredded. A subsample of the shredded bulbs was weighed, dried in a forced-air oven at 150°F for 4 days, and weighed. The dried roots, bulbs, and leaves were ground and analyzed for total P content.

The field was irrigated automatically twice per day based on soil water potential readings. Soil water potential was measured with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row in each of four adjacent plots. Sensors were calibrated to SWP (Shock et al. 1998). The GMS were connected to a datalogger with three multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the soil water potential every hour. The irrigations were controlled by the datalogger using a relay driver (A21 REL, Campbell Scientific, Logan, UT) connected to a solenoid valve. Irrigation decisions were made every 12 hours by the datalogger: if the average soil water potential at 8-inch depth was -20 kPa or less the field was irrigated for 4 hours. The pressure in the drip lines was maintained at 10 psi by a pressure regulator. Irrigations were terminated on September 2.

Roundup at 24 oz/acre was sprayed on March 28. The field had Prowl (1lb ai/acre) broadcast on April 21 for postemergence weed control. Approximately 0.4 inch of water was applied through the minisprinkler system on April 21 to incorporate the Prowl. The field had Buctril at 0.12 lb ai/acre and Poast at 0.4 lb ai/acre applied on April 28. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

On September 11 the onions were lifted to field cure. On September 17, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. On December 11 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), double 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 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.

After grading, 50 bulbs ranging in diameter from 3.5 to 4.25 inches from each plot were rated for single centers and translucent scale. 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 <1½ inch, "intermediate double" had diameters from 1½ to 2¼ inches, and "blowout" had diameters >2 ¼ inch 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 number and location of translucent scales in each bulb was also recorded.

Results and Discussion

The automated drip-irrigation system maintained the soil water potential close to -20 kPa during the season (Fig. 1). The onions treated with the three phosphite fertilizer formulations had increased levels of bulb P on the first two sampling dates (Table 1). Definitive conclusions on differences in tissue P levels between treatments cannot be made due to a lack of tissue sample replication.

There was no significant difference in onion yield or grade between the phosphite fertilizer formulations and the check (Table 2). There was no significant difference in onion single centeredness between the phosphite fertilizer formulations and the check (Table 3).

The May 9 soil test showed 29 ppm P. According to the "Nutrient Management Guide for Onions in the Pacific Northwest" (Sullivan et al. 2001), P fertilizer would not have been necessary. Although limited data exist to interpret onion tissue P, Sullivan et al. (2001) suggests a sufficiency range from 0.2 to 0.35 percent root P. Western Labs uses a sufficiency range for onion root P of 0.32 to 0.7 percent. Root P for the check treatment onions was 0.40 percent on June 4 and 0.59 percent on June 19.

To increase the probability of onion response to the phosphite fertilizers, this trial should have been conducted in a field without fall-applied P, and preferably on a soil more prone to P deficiencies, such as a Nyssa silt loam. In addition, onions are more prone to P deficiency early in the season when the soils are colder, which hinders the uptake of P by the roots. Despite the preexisting limitations of the field used in this trial, the manufacturer opted for the site and for the late applications.

References

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

Sullivan, D.M., B.D. Brown, C.C. Shock, D.A. Horneck, R.G. Stevens, G.Q. Pelter, and E.B.G. Feibert. 2001. Nutrient Management for onions in the Pacific Northwest. Pacific Northwest Extension Publication PNW 546. 26p.

Table 1. Onion tissue phosphorus levels (percent dry weight) for onions treated with three phosphite fertilizer formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	July 3			July 19			August 8		
Treatment	Roots	Bulbs	Leaves	Roots	Bulbs	Leaves	Roots	Bulbs	Leaves
Check	0.66	0.35	0.44	0.42	0.52	0.31	0.49	0.48	0.19
Magnum Nutri-Phite	0.66	0.59	0.46	0.47	0.76	0.35	0.58	0.51	0.27
Sulfone Nutri-Phite	0.61	0.57	0.41	0.56	0.61	0.35	0.42	0.45	0.23
P Soil Hi-Grade	0.65	0.57	0.45	0.49	0.50	0.36	0.56	0.48	0.24

Table 2. Onion yield and grade response to three phosphite fertilizer formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Total	Marketable yield by grade					Non-marketable yield		
Treatment	yield	Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Rot	No. 2s	Small
	---------------------------- cwt/acre ----------------------------						%	-- cwt/acre --	
Check	837.6	815.2	9.7	152.3	632.6	20.6	2.1	2.3	5.4
Magnum Nutri-Phite	778.3	754.3	5.6	128.9	597.5	22.3	2.5	1.2	4.2
Sulfone Nutri-Phite	871.0	849.6	13.0	167.6	650.2	18.8	2.2	3.1	2.3
P Soil Hi-Grade	839.5	810.3	7.0	163.4	620.8	19.1	3.1	3.5	3.8
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Single-center rating for onions treated with three phosphite fertilizer formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Blowout	Intermediate double	Small double	Bullet	Functionally single centered "Bullet + small double"
	%				
Check	2.5	14	14	69.5	83.5
Magnum Nutri-Phite	4.4	17.2	18.8	59.6	78.4
Sulfone Nutri-Phite	2.8	13.2	17.6	66.4	84
P Soil Hi-Grade	6.4	15.6	18.8	59.2	78
LSD (0.05)	NS	NS	NS	NS	NS

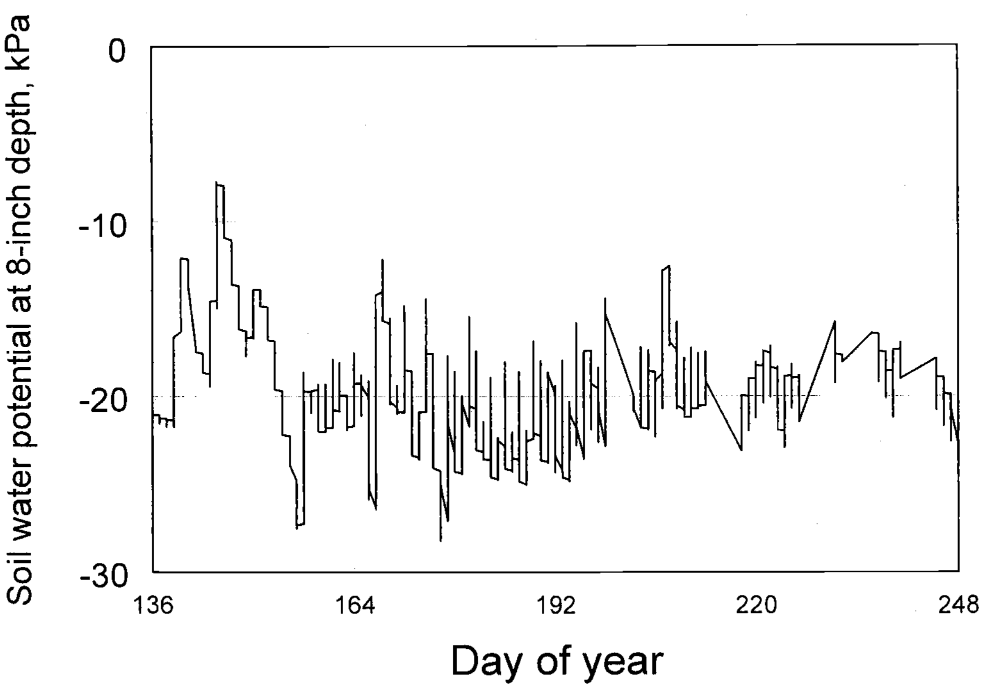

Figure 1. Soil water potential at 8-inch depth for onions irrigated with an automated subsurface drip-irrigation system, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

EFFECT OF A MYCORRHIZAE FORMULATION ON ONION YIELD AND QUALITY

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Introduction

Onion growers routinely fumigate onion fields in the fall prior to planting. Fumigation is highly detrimental to mycorrhizal fungi colonizing onion roots. Onions growing in fumigated fields may suffer from P deficiency due to inadequate mycorrhizal colonization. Application of mycorrhizae to the soil could overcome the loss due to fumigation. This trial tested onion yield and grade response to an application of mycorrhizae to previously fumigated soil.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. In the fall of 2002, the wheat stubble was shredded, and the field was disked, irrigated, ripped, moldboard-plowed, roller-harrowed, fumigated with Telone C-17 at 20 gal/acre, and bedded. Soil analysis indicated the need for 100 lb P_2O_5/acre, 150 lb K /acre, 6 lb Mn/acre, 2 lb Cu/acre, and 1 lb B/acre, which was broadcast in the fall. A soil sample taken on May 9 showed a pH of 7.7, 1.4 percent organic matter, 20 ppm nitrate-N, 29 ppm P, and 216 ppm K.

Onion (cv. 'Vaquero', Sunseeds, Morgan Hill, CA) 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 17, 2003. The single onion rows in 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 6-inch depth between the two double onion rows on March 28. 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/min100 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. Onion emergence started on April 7. The trial was irrigated on April 14 with a minisprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) for even stand establishment. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals that were spaced 30 ft apart.

The experimental design was a randomized complete block with five replicates. There were two treatments: an untreated check and a liquid mycorrhizae formulation (LP9).

The LP9 was manufactured by Western Labs Inc. (Parma, ID). The LP9 was applied in a furrow on both sides of each onion double row on May 24. The trench was filled and the field was drip-irrigated manually for 4 hours. Both treatments received standard fertilizer applications based on soil and tissue analyses.

Onion tissue was sampled for nutrient content on June 4 and 19. The roots from four onion plants in each check plot were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, Idaho. The onions in all treatments were fertilized according to the nutrient analyses. Fertilizer was applied through the drip tape: ammonium sulfate at 25 lb N/acre on May 30, urea ammonium nitrate solution at 25 lb N/acre on June 5, 16, and 25, and zinc chelate at 0.25 lb Zn/acre and copper chelate at 0.2 lb Cu/acre on June 25.

The field was irrigated automatically twice per day based on soil water potential readings. Soil water potential was measured with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) installed at 8-inch depth in the center of the double row in each of four adjacent plots. Sensors were calibrated to SWP (Shock et al. 1998). The GMS were connected to a datalogger with three multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger read the sensors and recorded the soil water potential every hour. The irrigations were controlled by the datalogger using a relay driver (A21 REL, Campbell Scientific, Logan, UT) connected to a solenoid valve. Irrigation decisions were made every 12 hours by the datalogger: if the average soil water potential at 8-inch depth was -20 kPa or less the field was irrigated for 4 hours. The pressure in the drip lines was maintained at 10 psi by a pressure regulator. Irrigations were terminated on September 2.

Roundup at 24 oz/acre was sprayed on March 28. The field had Prowl (1lb ai/acre) broadcast on April 21 for postemergence weed control. Approximately 0.4 inch of water was applied through the minisprinkler system on April 21 to incorporate the Prowl. The field had Buctril at 0.12 lb ai/acre and Poast at 0.4 lb ai/acre applied on April 28. Thrips were controlled with one aerial application of Warrior on June 5 and two aerial applications of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 16 and August 4.

On September 11 the onions were lifted to field cure. On September 17, onions in the central 40 ft of the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. On December 11 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), double 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 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.

Results

There was no significant difference in onion yield or grade between the mycorrhizae treatment and the check (Table 1).

Discussion

Mycorrhizae can be beneficial for plant phosphate uptake. Plant phosphate uptake is particularly slow in early spring when the soil is cold, and in soils with low phosphate. The late application timing and good soil phosphate status worked against benefits from the mycorrhizae treatment being shown in this trial.

References

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

Table 1. Onion yield and grade response to a mycorrhizae formulation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Total	Marketable yield by grade					Nonmarketable yield		
Treatment	yield	Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Rot	No. 2s	Small
	cwt/acre						%	cwt/acre	
Check	837.6	815.2	9.7	152.3	632.6	20.6	2.1	2.3	5.4
LP9	826.7	801.9	8.0	153.3	619.8	20.9	2.3	3.4	5.3
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

TREATMENT OF ONION BULBS WITH "SURROUND" TO REDUCE TEMPERATURE AND BULB SUNSCALD

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Introduction

Onion prices generally decrease starting in September when harvest intensifies. Harvesting earlier from overwintered, transplanted, or normally planted full season onions could increase profits, but mechanized early harvest runs the risk of increased losses to sunscald. Sunscald occurs when the side of the bulb exposed to afternoon sun becomes excessively hot. Sunscald results in a flattened and shrunken area on the bulb surface. The 59-year-average maximum air temperature at the Malheur Experiment Station is 91, 90, and 80°F for July, August, and September, respectively. Maximum air temperatures in July and August often exceed 100°F, which can result in very high unprotected bulb temperatures and result in sunscald. "Surround" (Engelhard Corp., Iselin, NJ) is a product made from kaolinite clay and works by forming a white coating on surfaces, thus reflecting solar radiation. "Surround" is a wettable powder that is labeled for reduction of sunscald in fruits and vegetables. Application of "Surround" after onions are lifted could reduce sunscald and make early mechanized harvests more feasible.

Methods

The trial was conducted in two fields.

Procedures for Growing Onions in Field 1

The onions were grown with subsurface drip irrigation at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. Onion (cv. 'Vaquero', Sunseeds, Morgan Hill, CA) was planted on March 17, 2003. The procedures can be found in the article "Effect of Short Duration Water Stress on Onion Single Centeredness and Translucent Scale" found in this report (Shock et al. 2004a).

Procedures for Growing Onions in Field 2

The onions were grown with furrow irrigation on a Greenleaf silt loam previously planted to wheat. Onion seed ('Vaquero' Sunseeds, Parma, ID) was planted on March 17, 2003. The procedures can be found in the article "2003 Onion Variety Trials" found in this report (Shock et al. 2004b).

Procedures for Surround Treatments
Four rows of onions in each field were lifted on August 11. The lifted onions were divided into plots 25 ft long. The experimental designs were randomized complete blocks with four replicates in each field. There were seven treatments: treatment 1 was untreated, treatment 2 received one "Surround" application after lifting, treatment 3 received a "Surround" application after lifting and windrowing, and treatment 4 was treated after windrowing (Table 1). Treatments 5-7 were the same as treatments 2-4, except that a different formulation of "Surround" was used. The "Surround" formulation (type 2) used for treatments 5-7 was made to be more light reflecting than type 1. The "Surround" was applied after lifting on August 11 with a ground sprayer and a boom with 9 nozzles spaced 10 inches apart. The "Surround" was applied at 50 lb/acre in 112 gallons of water per acre with 8004 nozzles at 40 psi.

Prior to the "Surround" application temperature probes were installed in bulbs at 0.5-cm depth. The temperature probes in the monitored bulbs were positioned so that they faced to the south-southeast and placed in a position receiving direct sun. Three replicates in the drip-irrigated field and two replicates in the furrow-irrigated field each had one bulb monitored for temperature. The temperature probes were read hourly by a datalogger (Hobo datalogger, Onset Computer Corp., Bourne, MA).

On August 14 the temperature probes and probed onions were removed and the onions were topped and windrowed by hand. After windrowing the temperature probes were reinserted in different onions as before. The onion windrow was sprayed with "Surround" using a ground sprayer with 3 nozzles spaced 10 inches apart. Application rates and specifications were the same as the initial "Surround" application. Since only the windrow was sprayed (one-third of the field), only 17 lb of "Surround" were actually used per acre of onions.

The onions were bagged on August 21 and placed into storage. On December 11 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), bulbs with sunscald damage, double 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 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 by weighing and counting all supercolossal bulbs during grading.

To reduce the influence on the statistical analysis of the variability in onion yield and size between plots, the data for each field were normalized in relation to the average total yield for that field. Normalized data were subjected to analysis of variance.

Results and Discussion

The highest air temperature reached after lifting of the onions and before topping and windrowing was 93°F (Table 2). The highest bulb temperature reached after lifting of the onions and before topping and windrowing was 123°F. Following the application of "Surround" after lifting, average maximum bulb temperatures were reduced 4-5°F compared to the untreated bulbs. There was no difference in maximum bulb temperature between "Surround" types, except on August 11, when only "Surround" type 2 reduced maximum bulb temperature.

The highest air temperature reached after topping and windrowing was 99°F (Table 3). The highest bulb temperature reached after topping and windrowing was 121°F. For the onions treated with "Surround" after topping and windrowing, average maximum bulb temperatures were reduced by 2-4°F compared to the untreated check. There was a trend for "Surround" type 2 to reduce bulb temperatures more than "Surround" type 1, but the difference was only significant on August 15, when "Surround" type 1 did not reduce bulb temperatures compared to the check.

The furrow-irrigated field (field 2) had higher marketable yield, and yield of onions with sunscald and rot than the drip-irrigated field (field 1, Table 4). In the furrow-irrigated field, one or two applications of "Surround" type 1 and application of "Surround" type 2 before and after windrowing or only after windrowing, resulted in significantly higher marketable onion yield (Table 4). Averaged over the two fields, one or two applications of "Surround" type 1 and application of "Surround" type 2 before and after windrowing or only after windrowing resulted in significantly higher marketable onion yield. In the furrow-irrigated field, one or two applications of either type of "Surround" resulted in lower bulb rot. Averaged over the two fields, one or two applications of "Surround" type 1 and application of "Surround" type 2 before and after windrowing or only before windrowing resulted in lower yield of onions with sunscald. Averaged over the two fields, two applications of "Surround" type 1 or type 2, and application of "Surround" type 2 after windrowing resulted in lower bulb rot.

References

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2004a. Effects of short-duration water stress on onion single centeredness and translucent scale. Malheur Experiment Station Annual Report, Oregon State University Agricultural Experiment Station Special Report 1055:53-56.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2004b. 2003 onion variety trials. Malheur Experiment Station Annual Report, Oregon State University Agricultural Experiment Station Special Report 1055:36-44.

Table 1. Treatments applied to onions to evaluate two types of "Surround". "Surround" type 2 is a new formulation designed to be more reflective of sunlight. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Surround type	Post lifting Surround application	Post topping and windrowing Surround application
1	none	No	No
2	1	Yes	No
3	1	Yes	Yes
4	1	No	Yes
5	2	Yes	No
6	2	Yes	Yes
7	2	No	Yes

Table 2. Maximum daily air temperature and maximum bulb temperature (°F) at 0.5-cm depth for onions treated with two types of "Surround" after lifting. "Surround" type 2 is a new formulation designed to be more reflective of sunlight. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Date	Maximum air temperature	Solar radiation	Surround type			LSD (0.05)
			none	1	2	
11 Aug	93	7259	120.6	118.1	114.9	(3.3)*
12 Aug	92	7226	119.9	115.2	113.5	2.3
13 Aug	93	7245	123.0	118.5	118.2	2.6
Average			121.2	117.0	116.7	(2.8)*

*significant at the 0.10 level.

Table 3. Maximum daily air temperature, solar radiation, and maximum bulb temperature (°F) at 0.5-cm depth for onions treated with two types of "Surround" after topping and windrowing. "Surround" type 2 is a new formulation designed to be more reflective of sunlight. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Date	Maximum air temperature	Solar radiation	Surround type			LSD (0.05)
			none	1	2	
14 Aug	96	6446	119.1	116.9	116.8	1.5
15 Aug	99	5345	115.0	113.8	112.8	1.7
16 Aug	90	7262	112.6	113.5	109.8	NS
17 Aug	91	7114	117.2	118.2	112.7	NS
18 Aug	94	6898	118.6	na	116.2	NS
19 Aug	98	6593	121.1	na	118.7	NS
20 Aug	93	6969	118.5	na	112.8	3.2
Average			117.3	114.6	113.8	1.3

Table 4. Onion yield and grade response to application of two types of "Surround" in a drip-irrigated field (field 1) and in a furrow-irrigated field (field 2). "Surround" type 2 is a new formulation designed to be more reflective of sunlight. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Type	1st applic.	2nd applic.	Marketable yield		Non-marketable yield			
					Small	Doubles	Scald	Rot
			cwt/acre	%	---------------- cwt/acre ----------------			
Field 1								
none	No	No	580.6	94.8	4.1	0.9	12.6	13.9
Type 1	Yes	No	581.5	95.0	6.3	0.4	8.2	15.8
Type 1	Yes	Yes	587.9	96.0	4.7	0.9	6.4	12.3
Type 1	No	Yes	557.3	91.0	6.2	0.4	7.8	40.5
Type 2	Yes	No	564.2	92.2	5.7	0.6	14.9	26.8
Type 2	Yes	Yes	590.0	96.4	5.8	0.5	5.8	10.1
Type 2	No	Yes	580.0	94.7	6.3	1.0	5.4	19.5
average			577.4	94.3	5.6	0.7	8.7	19.8
Field 2								
none	No	No	540.4	74.4	2.8	2.9	89.7	90.8
Type 1	Yes	No	610.4	84.0	3.6	2.6	51.4	58.6
Type 1	Yes	Yes	628.5	86.5	2.6	1.3	58.4	32.8
Type 1	No	Yes	621.5	85.5	2.3	6.0	66.1	33.2
Type 2	Yes	No	584.0	80.4	4.0	0.6	88.4	49.6
Type 2	Yes	Yes	614.8	84.6	3.2	3.3	72.6	32.6
Type 2	No	Yes	614.5	84.6	2.9	1.4	67.6	40.2
average			602.0	82.9	3.0	2.6	70.6	48.3
Field 1, Field 2 average								
none	No	No	560.5	84.6	3.5	1.9	51.1	52.3
Type 1	Yes	No	596.0	89.5	4.9	1.5	29.8	37.2
Type 1	Yes	Yes	608.2	91.3	3.7	1.1	32.4	22.6
Type 1	No	Yes	589.4	88.3	4.2	3.2	37.0	36.9
Type 2	Yes	No	574.1	86.3	4.8	0.6	51.6	38.2
Type 2	Yes	Yes	602.4	90.5	4.5	1.9	39.2	21.4
Type 2	No	Yes	597.3	89.7	4.6	1.2	36.5	29.8
LSD (0.05) Trt			23.5	3.5	NS	NS	(14.2)*	(21.3)*
LSD (0.05) Field			12.8	1.9	1.5	1.7	(7.7)*	(10.8)*
LSD (0.05) Trt X Fld			33.9	5.1	NS	NS	NS	(28.5)*

*significant at the 0.10 level.

PRELIMINARY OBSERVATIONS ON THE EFFECT OF ONION BULB TEMPERATURE AND HANDLING ON BRUISING

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Introduction

There is some evidence that onion handling after harvest can bruise bulbs and cause symptoms similar in appearance to translucent scale. Several shippers have suggested that the effect of handling on bruise can be influenced by bulb temperature during handling and by length of time after handling before the onions are checked. This trial tested the effect of handling four onion varieties at two temperatures on bruise.

Methods

Trial 1

Prior to evaluating variety susceptibility to bruise, a preliminary test of the effect of drop height on bruise was conducted. Fifteen onions from mixed varieties were each dropped on their sides onto a concrete floor from heights of 0.8 m (2 ft, 7 inches), 1 m (3 ft, 4 inches), 1.2 m (3 ft, 11 inches), or 1.4 m (4 ft, 7 inches). The onions were cut equatorially and rated for damage. During rating it was noted that the damage was in part of the bulb and had the appearance of either translucent or watery, mushy rings. The damaged or bruised area had the form of a triangle (Fig. 1) which extended from the surface to the center of the bulb. The bruise damage was different from typical translucent scale in that the scales were only translucent in the bruised area.

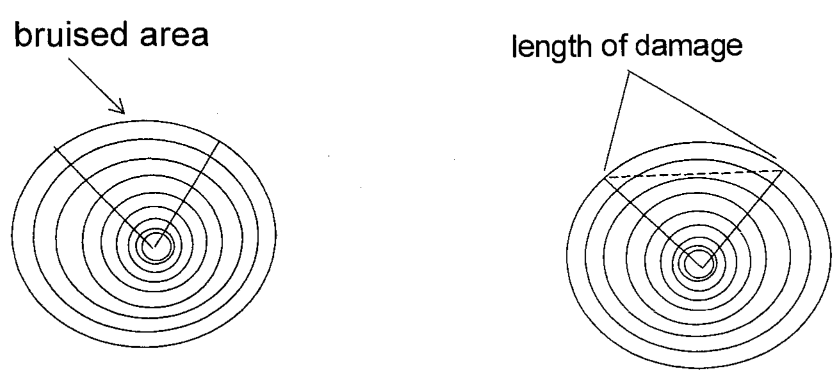

Figure 1. Diagram of onion bulb damage or bruising resulting from a drop from a height of 1 m (3 ft, 4 inches).

All drop heights resulted in bulb damage (Table 1). The lowest drop height of 0.8 m (2 ft, 7 inches) resulted in damage that was less pronounced.

Table 1. Number of onions out of 15 with visible damage or translucent scale after being dropped on a concrete floor from different heights.

Drop height		
meters	(feet, inches)	Onions with damage
0.0	0	0 of 15
0.8	2'7"	10* of 15
1.0	3'4"	8 of 15
1.2	3'11"	10 of 15
1.4	4'7"	11 of 15

*damage was less pronounced.

Trial 2

Onions of four varieties were placed in nylon mesh bags (24 bags per variety). Given the availability of bulbs, there were 31 bulbs/bag of 'Delgado' (Bejo Seeds), 34 bulbs/bag of 'Granero', 23 bulbs/bag of 'Vaquero', and 28 bulbs/bag of 'Bandolero' (all three Sunseeds). On January 23, 2004 the bags were placed in two coolers: one at 32°F and one at 38°F. On January 26 and 27, the bags were removed a few at a time from the coolers and were either not handled or handled by dropping all bulbs in each bag on their sides onto a concrete floor from a height of 1 m (3 ft, 4 inches). After the handling treatments half of the bags were put in a cooler at 38°F and the bulbs in the other half of the bags were immediately cut equatorially and rated for bruising. Three days after dropping, the bags stored in the cooler were rated for bruising. Each treatment was replicated three times (three bags) for each variety (Table 2).

Table 2. Treatments applied to four onion varieties.

Treatment	Pre-treatment storage	Handling treatment	Post-treatment storage
1	32°F	Drop	no storage
2			storage at 38°F
3		No Drop	no storage
4			storage at 38°F
5	38°F	Drop	no storage
6			storage at 38°F
7		No Drop	no storage
8			storage at 38°F

The number and location of the bruised or watery rings was recorded. The length of the bruised area (Fig. 1) was also recorded.

Results

The varieties tested here did not differ significantly in their tendency to bruise with dropping. Bruising from dropping for all varieties, except Bandolero, was significantly higher after storage for 3 days than immediately after dropping (Table 3). The bruised rings became more translucent after storage, making the damage more pronounced and detectable. Averaged over all varieties and over the two temperatures, 66 percent and 80 percent of the dropped bulbs showed bruising before and after short-term storage, respectively.

Averaged over varieties and handling treatments, bulbs that were at 32°F when dropped showed a higher percentage of bruised bulbs than bulbs that were at 38°F. Averaged over the two temperatures and over varieties, the percentage of rings that showed bruising was lower after 3 days of storage than immediately after dropping. Averaged over temperature, handling, and variety, the length of the bruise was lower after 2 days of storage than immediately after dropping.

Discussion

Clearly onions are very sensitive to bruise injury during handling. This bruising could contribute to undesirable bulb quality at arrival for retail sales or processing.

It would be desirable to know the maximum drop onions can withstand and still recover from that injury. The full range of variability in variety susceptibility to bruising injury is not known. Observations were made only on four varieties in this preliminary trial. We did not evaluate the effects of post-bruising temperature on bulb recovery or fully explore the recovery time necessary for bruising injury to disappear.

Table 3. Effect of pre-handling temperature, handling, and time after handling on onion bulb bruising, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Pre-treatment storage temperature	Handling treatment	Bruised bulbs Before storage	Bruised bulbs After storage	Bruised bulbs Avg.	Affected rings in bruised bulbs Before storage	Affected rings in bruised bulbs After storage	Affected rings in bruised bulbs Avg.	Length of damage in bruised bulbs Before storage	Length of damage in bruised bulbs After storage
	°F		--------- % ---------			--------- % ---------			-------- cm --------	
Delgado	32	Drop	64.5	89.3	76.9	99.1	92.3	95.7	5.64	5.64
		No drop	2.2	2.2	2.2	66.7	24.4	45.6	2.33	1.00
	38	Drop	65.6	75.3	70.5	99.7	91.1	95.4	5.77	5.72
		No drop	2.2	0.0	1.1	31.7	0.0	15.9	1.50	0.00
	Average	Drop	65.0	82.3	73.7	99.4	91.7	95.6	5.71	5.68
		No Drop	2.2	1.1	1.7	49.2	12.2	30.7	1.92	0.50
Overall variety average			33.6	41.7	37.7	74.3	52.0	63.2	3.81	3.09
Granero	32	Drop	66.7	87.3	77.0	99.9	85.2	92.6	6.22	5.95
		No drop	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
	38	Drop	71.6	79.4	75.5	94.7	84.2	89.5	5.89	5.38
		No drop	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
	Average	Drop	69.2	83.3	76.3	97.3	84.7	91.0	6.05	5.67
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
Overall variety average			34.6	41.7	38.2	48.6	42.4	45.5	3.03	2.83
Vaquero	32	Drop	79.7	95.7	87.7	99.6	84.1	91.9	6.07	5.80
		No drop	5.8	1.5	3.7	66.7	2.2	34.5	4.33	2.33
	38	Drop	62.3	91.3	76.8	98.4	71.9	85.2	6.61	5.73
		No drop	2.9	2.9	2.9	66.7	2.3	34.5	3.67	1.83
	Average	Drop	71.0	93.5	82.3	99.0	78.0	88.5	6.34	5.76
		No Drop	4.3	2.2	3.3	66.7	2.3	34.5	4.00	2.08
Overall variety average			37.7	47.9	42.8	82.8	40.1	61.5	5.17	3.92
Bandolero	32	Drop	60.7	60.7	60.7	99.4	74.6	87.0	5.74	5.15
		No drop	2.4	4.8	3.6	66.7	34.5	50.6	1.67	3.17
	38	Drop	56.0	64.3	60.2	99.2	75.9	87.6	5.59	5.02
		No drop	1.2	1.2	1.2	33.3	14.3	23.8	1.67	1.67
	Average	Drop	58.4	62.5	60.5	99.3	75.3	87.3	5.67	5.09
		No Drop	1.8	3.0	2.4	50.0	24.4	37.2	1.67	2.42
Overall variety average			30.1	32.8	31.5	74.7	49.8	62.3	3.67	3.75
Over all averages	32	Drop	67.9	83.3	75.6	99.5	84.0	91.8	5.92	5.63
		No drop	2.6	2.1	2.4	50.0	15.3	32.7	2.08	1.63
	38	Drop	63.9	77.6	70.8	98.0	80.8	89.4	5.96	5.46
		No drop	1.6	1.0	1.3	32.9	4.2	18.6	1.71	0.88
	Average	Drop	65.9	80.4	73.2	98.8	82.4	90.6	5.94	5.55
		No drop	2.1	1.6	1.9	41.5	9.7	25.6	1.90	1.25
	32	Average	35.3	42.7	39.0	74.8	49.7	62.3	4.00	3.63
	38	Average	32.7	39.3	36.0	65.5	42.5	54.0	3.84	3.17
		Average	34.0	41.0	37.5	70.2	46.1	58.1	3.92	3.40
LSD	Temperature				2.3			NS		NS
	Handling				NS			NS		0.50
	Time				2.3			8.6		0.50
	Variety				NS			NS		0.70
	Handling X Time				3.2			NS		NS
	Handling X Variety				NS			NS		1.00
	Time X Variety				NS			24.2		NS
	Temp. X Time X Variety				6.4			NS		NS
	Handling X Time X Variety				6.4			NS		NS

WEED CONTROL IN ONION WITH POSTEMERGENCE HERBICIDES

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Introduction

Weed control is essential for the production of marketable onions. Weed control in onions is difficult compared to many crops because of the lack of a complete crop canopy and limited herbicide options. Valor (flumioxazin) and Nortron (ethofumesate) are two experimental herbicides that have been evaluated for use in onions in past research trials. Trials were conducted this year to determine the benefits of using these experimental herbicides in postemergence herbicide combinations and compare performance to registered herbicide combinations.

Methods

General Procedures

Trials were conducted at the Malheur Experiment Station to evaluate experimental and registered herbicides for weed control and onion tolerance. Trials were conducted under furrow irrigation. On March 28, onions (cv. 'Vaquero', Sunseeds, Parma, ID) were planted at a 3.7-inch spacing in double rows on 22-inch beds. Plots were four rows wide and 27 ft long and arranged in a randomized complete block design with four replications. Lorsban was applied in a 6-inch band over each row at 3.7 oz/1,000 ft of row. Onions were sidedressed with 117 lb N, 72 lb P, 111 lb sulfate, 114 lb S, 6 lb Zn, and 1 lb B/acre on June 3. Registered insecticides and fungicides were applied for thrips and downy mildew control.

Herbicide treatments were applied with a CO_2-pressurized backpack sprayer. Preemergence applications and postemergence grass herbicides were applied at 20 gal/acre at 30 psi and postemergence treatments were applied at 40 gal/acre at 30 psi. All plots were treated with a preemergence application of Roundup (glyphosate) at 0.75 lb ai/acre plus Prowl (pendimethalin) at 1.0 lb ai/acre on April 11 and a postemergence application of Poast (sethoxydim) at 0.29 lb ai/acre plus crop oil concentrate (COC) (1.0% v/v) on June 6. Weed control and onion injury were evaluated throughout the season. Onions were harvested September 17 and 18 and graded by size on September 23-25.

Data were analyzed using analysis of variance and means were separated using a protected least significant difference (LSD) at the 5 percent level (0.05).

Postemergence Valor Combinations

Valor and Goal (oxyflurofen) were applied in combinations with Buctril (bromoxynil) to evaluate weed control and onion tolerance. Buctril, Goal, and Valor were evaluated at two rates. Comparisons of Goal or Valor with Buctril included several combinations of herbicides and rates. Additional treatments included a split application of Valor applied to two-leaf and again to three-leaf onions, and a comparison of Buctril plus Valor treatments following preemergence applications of Roundup, Prowl, and Dacthal (DCPA).

Addition of Nortron to Postemergence Treatments

This trial was conducted to determine if the addition of Nortron to postemergence herbicide applications would improve weed control. Each treatment was applied without Nortron or with Nortron added to the two-leaf and three-leaf applications at either 0.25 or 0.5 lb ai/acre. One treatment evaluated Outlook (dimethenamid-P) applied in the two-leaf application and Nortron applied in the three-leaf application.

Results and Discussion

Preemergence herbicides worked fairly well due to rainfall events in April. Adequate rainfall also ensured that weeds were actively growing when postemergence treatments were applied.

Postemergence Valor Combinations

On June 30, treatments with Buctril alone applied to two-leaf onions had among the least onion injury, while combinations of Buctril with either Goal or Valor had among the greatest injury (Table 1). By July 14, no onion injury was observed. On August 14, pigweed control was improved by the addition of Valor (0.094 lb ai/acre) to Buctril at the low rate (0.125 lb ai/acre) (Table 1). The lower rate of Valor (0.063 lb ai/acre) did not significantly increase pigweed control when added to the low rate of Buctril. Similar trends were apparent for Goal where pigweed control was improved by the high rate (0.25 lb ai/acre) but not the low rate (0.125 lb ai/acre) when added to the low rate of Buctril. Valor (0.094 lb ai/acre) added to Buctril (0.25 lb ai/acre) increased pigweed control, while the addition of Goal at any rate did not significantly improve the control achieved with Buctril at the high rate alone. All treatments provided 88 percent or greater common lambsquarters control. When Buctril was applied at 0.125 lb ai/acre, the addition of Valor significantly increased hairy nightshade control. Hairy nightshade control was increased with the addition of the high rate of Goal, but not the low rate. The addition of Valor or Goal to Buctril (0.25 lb ai/acre) did not provide a significant increase in hairy nightshade control. Buctril (0.125 lb ai/acre) applied alone at the two-leaf onion timing produced more medium onions than any other treatment. Onion yields were related to weed control, with treatments providing less weed control having among the lowest yields and treatments providing the highest weed control producing among the greatest yields. The addition of Valor or Goal to Buctril tended to increase pigweed and hairy nightshade control and resulted in improved yields.

Addition of Nortron to Postemergence Treatments

Nortron or Outlook did not increase onion injury when added to any of the postemergence treatments (Table 2). The addition of Nortron (0.25 lb ai/acre) to Buctril applied to two-leaf onions significantly improved pigweed control. The addition of Nortron at the higher rate (0.5 lb ai/acre) improved both pigweed and hairy nightshade control. The higher Nortron rate improved hairy nightshade control compared to the lower rate. The addition of Goal with Buctril at the two-leaf application improved pigweed control compared to Buctril alone. The addition of Nortron (0.25 and 0.5 lb ai/acre) to Buctril plus Goal applied at the two-leaf application did not affect pigweed control, but significantly improved hairy nightshade control. Common lambsquarters control was 99 percent or greater with all treatments. There were few differences among treatments for onion yield; the treatment with Buctril alone applied at two-leaf onions had among the lowest super colossal yield (Table 3). This research suggests that the addition of Nortron to postemergence herbicide applications may improve weed control without injuring onions. The registration of Nortron for use in onions depends on the residue package submitted by the IR-4 program being reviewed by the U.S. Environmental Protection Agency.

Table 1. Onion injury, weed control, and yield from Goal or Valor combinations with Buctril, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Injury	Weed control†			Onion yield					
Treatment	Rate	Timing*	6-30	Pigweed	Common lambsquarters	Hairy nightshade	Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	%				cwt/acre					
Untreated	--	--	0	0	0	0	12	0	0	0	0	0
Hand-Weeded	--	--	0	95	98	96	3	17	610	413	76	1116
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	1	81	100	47	5	57	657	302	34	1051
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.25 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	4	83	100	79	4	12	665	352	47	1076
Roundup + Prowl Buctril + Valor Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	5	86	99	90	3	16	683	298	46	1043
Roundup + Prowl Buctril + Valor Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	11	97	99	91	5	12	639	408	81	1140
Roundup + Prowl Buctril + Valor Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	8	92	100	92	4	20	601	443	60	1124
Roundup + Prowl Buctril + Valor Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	9	98	100	92	3	13	579	428	81	1100
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 4-leaf	1	86	100	63	3	20	619	345	51	1035

Table 1. *(continued)* Onion injury, weed control, and yield from Goal or Valor combinations with Buctril, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Injury	Weed control†			Onion yield					
Treatment	Rate	Timing*	5-24	Pigweed	Common lambsquarters	Hairy nightshade	Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
Roundup + Prowl	0.75 + 1.0	PRE	6	92	98	91	3	9	648	455	71	1183
Buctril + Goal	0.125 + 0.25	2-leaf										
Buctril + Goal	0.25 + 0.125	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl	0.75 + 1.0	PRE	8	90	100	91	5	9	619	461	81	1170
Buctril + Goal	0.25 + 0.125	2-leaf										
Buctril + Goal	0.25 + 0.125	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl	0.75 + 1.0	PRE	11	88	100	88	5	13	621	433	104	1170
Buctril + Goal	0.25 + 0.25	2-leaf										
Buctril + Goal	0.25 + 0.125	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl	0.75 + 1.0	PRE	11	93	100	98	3	13	680	376	70	1139
Buctril + Valor	0.125 + 0.047	2-leaf										
Buctril + Valor	0.25 + 0.047	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl + Dacthal	0.75 + 0.6 + 7.5	PRE	6	99	99	99	4	9	567	513	105	1194
Buctril + Valor	0.25 + 0.094	2-leaf										
Buctril + Goal	0.25 + 0.125	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl + Dacthal	0.75 + 0.6 + 7.5	PRE	6	99	100	97	4	9	605	489	96	1200
Buctril + Valor	0.125 + 0.094	2-leaf										
Buctril + Goal	0.25 + 0.125	3-leaf										
Goal	0.25	4-leaf										
Roundup + Prowl + Dacthal	0.75 + 0.6 + 7.5	PRE	12	98	97	98	3	11	607	451	94	1163
Buctril + Valor	0.125 + 0.094	2-leaf										
Buctril + Goal	0.125 + 0.125	3-leaf										
Goal	0.25	4-leaf										
LSD (0.05)			6	10	3	19	4	24	93	114	41	115

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.
†Weed control ratings were taken August 14. Pigweed is a combination of redroot pigweed and Powell amaranth.

Table 2. Onion injury and weed control in response to adding Nortron to postemergence applications of Buctril and Goal, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

				Weed control				
			Injury	Pigweed		Common lambsquarters	Hairy nightshade	
Treatment	Rate	Timing*	6-30	6-30	8-14	8-14	6-30	8-14
	lb ai/acre	Leaf		%				
Untreated	--	--	-	-	-	-	-	-
Roundup + Prowl	0.75 + 1.0	PRE	10	97	88	100	94	83
Buctril	0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	11	100	95	99	97	82
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	10	99	94	100	98	81
Buctril + Nortron	0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	11	100	96	100	99	93
Buctril + Nortron	0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	10	100	94	100	98	92
Buctril + Goal + Nortron	0.125 + 0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	10	100	99	100	100	97
Buctril + Goal + Nortron	0.125 + 0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	10	100	98	100	100	99
Buctril + Goal + Outlook	0.125 + 0.125 + 0.84	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
LSD (0.05)			NS	2	5	NS	4	9

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.

Table 3. Onion yield in response to adding Nortron to postemergence applications of Buctril and Goal, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Rate	Timing*	Onion yield†					
			Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	13	0	0	0	0	0
Roundup + Prowl	0.75 + 1.0	PRE	6	21	715	410	32	1178
Buctril	0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	4	10	713	419	116	1257
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	5	15	710	469	61	1255
Buctril + Nortron	0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	7	15	655	511	65	1247
Buctril + Nortron	0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	5	7	670	526	94	1298
Buctril + Goal + Nortron	0.125 + 0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	5	11	707	423	79	1221
Buctril + Goal + Nortron	0.125 + 0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	5	18	665	474	95	1252
Buctril + Goal + Outlook	0.125 + 0.125 + 0.84	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	4-leaf						
LSD (0.05)			7	14	104	147	45	112

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.
†Onions were harvested September 17 and 18.

PREEMERGENCE HERBICIDES FOR WEED CONTROL IN ONION

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Introduction

Weed control is essential for the production of marketable onions. Only a few herbicides are registered for preemergence application in onion. Effective preemergence herbicides can control weeds as they germinate and reduce the size and number of weeds that are present when onions are large enough to tolerate postemergence herbicide applications. This research evaluated registered and experimental herbicides for preemergence weed control in onion.

Methods

General Procedures

Trials were conducted at the Malheur Experiment Station under furrow irrigation. On March 28, onions (cv. 'Vaquero', Sunseeds, Parma, ID) were planted at a 3.7-inch spacing in double rows on 22-inch beds. Plots were four rows wide and 27 ft long and arranged in a randomized complete block design with four replicates. Lorsban was applied in a 6-inch band over each row at 3.7 oz/1,000 ft of row. Onions were sidedressed with 117 lb N, 72 lb P, 111 lb Sulfate, 114 lb S, 6 lb Zn, and 1 lb B/acre on June 3. Registered insecticides and fungicides were applied for thrips and downy mildew control.

Herbicide treatments were applied with a CO_2-pressurized backpack sprayer. Preemergence applications were applied at 20 gal/acre at 30 psi and postemergence treatments were applied at 40 gal/acre at 30 psi. All plots received Poast (sethoxydim) at 0.29 lb ai/acre plus crop oil concentrate (COC) (1.0% v/v) applied postemergence at 20 gal/acre and 30 psi on June 6. Weed control and onion injury were evaluated throughout the season. Onions were harvested September 17 and 18 and graded by size on September 23-25.

Data were analyzed using analysis of variance and means were separated using a protected least significant difference (LSD) at the 5 percent level (0.05).

Preemergence Dacthal and Prowl

Preemergence-applied Prowl (pendimethalin) was compared to Dacthal (DCPA) 75 WP (a dry formulation) and Dacthal 6F (a liquid formulation). Combinations of Prowl plus Dacthal in two different ratios were also compared. Postemergence applications following preemergence Prowl and Dacthal combinations were similar with the exception of a comparison of Buctril (bromoxynil) plus Goal (oxyflurofen) to Buctril plus Valor (flumioxazin) applied to two-leaf onions.

Comparison of Preemergence Prowl, Nortron, and Outlook
Preemergence applications of Prowl, Nortron (ethofumesate), and Outlook (dimethenamid-P) in combination with Roundup (glyphosate) were evaluated for weed control and onion tolerance. Each product was evaluated at two rates. Combinations of Prowl with Nortron or Outlook were also evaluated. Preemergence treatments with soil-active herbicides were compared to plots where only Roundup was applied preemergence.

Results and Discussion

Preemergence Dacthal and Prowl
Preemergence Prowl gave greater than 89 percent control of all weed species and was more effective on nightshade than Dacthal alone (Table 1). There were no differences in weed control efficacy between the two Dacthal formulations. Certain combinations of Prowl plus Dacthal increased pigweed control compared to Dacthal alone but were not more effective than Prowl alone. Plots treated with Dacthal alone had reduced colossal, super colossal, and marketable onion yields compared to plots treated with Prowl alone or in combination with Dacthal (Table 2). The reduced yields were caused by weed competition.

Comparison of Preemergence Prowl, Nortron, and Outlook
Preemergence treatments were effective because of timely rain. No onion injury was observed from preemergence treatments (Table 3). Preemergence Prowl was most effective in controlling pigweed and hairy nightshade compared to Outlook or Nortron. Prowl significantly improved common lambsquarters control compared to Roundup alone. High rates of Outlook and Nortron gave lambsquarters control similar to Prowl but were not greater than Roundup alone or lower rates of Outlook or Nortron. Outlook did not increase hairy nightshade control compared to Roundup alone. Nortron increased nightshade control 45-60 percent and Prowl increased control 75-83 percent compared to Roundup alone. In past trials at the Malheur Experiment Station, Prowl has been much weaker on hairy nightshade. Preemergence Outlook did not increase marketable onion yields compared to Roundup alone (Table 4). In general, both Nortron and Prowl increased marketable onion yields compared to Outlook or Roundup alone.

Table 1. Onion injury and weed control in response to preemergence Dacthal and Prowl and different postemergence herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

				Weed control					
			Injury	Pigweed[†]		Common lambsquarters		Hairy nightshade	
Treatment	Rate	Timing*	6-30	6-30	8-14	6-30	8-14	6-30	8-14
	lb ai/acre	Leaf	%						
Untreated	--	--	-	-	-	-	-	-	-
Roundup + Prowl	0.75 + 1.0	PRE	5	100	90	100	100	99	89
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Dacthal 75 WP	0.75 + 7.5	PRE	5	94	83	98	90	78	45
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Dacthal 6F	0.75 + 7.5	PRE	5	98	81	99	92	78	54
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Prowl + Dacthal	0.75 + 0.75 + 5.6	PRE	5	100	90	100	100	93	90
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Prowl + Dacthal	0.75 + 0.6 + 3.8	PRE	5	100	97	100	100	95	84
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Prowl + Dacthal	0.75 + 0.75 + 5.6	PRE	5	100	97	100	99	100	97
Buctril + Valor	0.125 + 0.063	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Prowl + Dacthal	0.75 + 0.6 + 3.8	PRE	6	100	95	100	100	98	96
Buctril + Valor	0.125 + 0.063	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
LSD (0.05)			NS	4	9	2	9	5	22

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.

[†]Pigweed is a combination of redroot pigweed and Powell amaranth

Table 2. Onion yield in response to preemergence Dacthal and Prowl and different postemergence herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Onion yield					
Treatment	Rate	Timing*	Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	14	0	0	0	0	14
Roundup + Prowl	0.75 + 1.0	PRE	4	10	651	551	106	1322
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Dacthal 75 WP	0.75 + 7.5	PRE	8	22	763	254	23	1070
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Dacthal 6F	0.75 + 7.5	PRE	6	22	794	272	22	1116
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl + Dacthal	0.75 + 0.75 + 5.6	PRE	5	12	704	497	125	1343
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl + Dacthal	0.75 + 0.6 + 3.8	PRE	3	14	740	463	59	1279
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl + Dacthal	0.75 + 0.75 + 5.6	PRE	0	14	622	521	94	1253
Buctril + Valor	0.125 + 0.063	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Prowl + Dacthal	0.75 + 0.6 + 3.8	PRE	1	15	674	555	82	1326
Buctril + Valor	0.125 + 0.063	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
LSD (0.05)			5	14	106	138	63	123

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.

Table 3. Onion injury and weed control in response to preemergence Outlook, Nortron, and Prowl, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

				Weed control					
			Injury	Pigweed†		Common lambsquarters		Hairy nightshade	
Treatment	Rate	Timing*	6-30	6-30	8-14	6-30	8-14	6-30	8-14
	lb ai/acre	Leaf	%						
Untreated	--	--	-	-	-	-	-	-	-
Roundup	0.75	PRE	10	80	71	86	88	65	18
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	4-leaf							
Roundup + Outlook	0.75 + 0.66	PRE	10	86	74	89	88	77	37
POST Program	same	2, 3, 4-leaf							
Roundup + Outlook	0.75 + 0.84	PRE	10	89	80	86	96	75	14
POST Program	same	2, 3, 4-leaf							
Roundup + Nortron	0.75 + 1.0	PRE	10	85	80	91	88	84	63
POST Program	same	2, 3, 4-leaf							
Roundup + Nortron	0.75 + 2.0	PRE	10	91	76	98	98	95	78
POST Program	same	2, 3, 4-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	10	100	96	100	100	99	93
POST Program	same	2, 3, 4-leaf							
Roundup + Prowl	0.75 + 1.5	PRE	10	100	99	100	100	100	100
POST Program	same	2, 3, 4-leaf							
Roundup + Prowl + Nortron	0.75 + 1.0 + 1.0	PRE	10	100	98	100	100	100	100
POST Program	same	2, 3, 4-leaf							
Roundup + Prowl + Outlook	0.75 + 1.0 + 0.84	PRE	10	100	98	100	100	100	99
POST Program	same	2, 3, 4-leaf							
LSD (0.05)			NS	5	8	4	11	6	22

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.
†Pigweed is a combination of redroot pigweed and Powell amaranth

Table 4. Onion yield in response to preemergence Outlook, Nortron, and Prowl, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Onion yield					
Treatment	Rate	Timing*	Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	16	0	0	0	0	16
Roundup	0.75	PRE	15	88	624	85	3	815
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	4-leaf						
Roundup + Outlook	0.75 + 0.66	PRE	9	62	706	187	12	976
POST Program	same	2, 3, 4-leaf						
Roundup + Outlook	0.75 + 0.84	PRE	6	50	697	151	6	910
POST Program	same	2, 3, 4-leaf						
Roundup + Nortron	0.75 + 1.0	PRE	4	151	772	243	16	1188
POST Program	same	2, 3, 4-leaf						
Roundup + Nortron	0.75 + 2.0	PRE	5	48	675	348	41	1117
POST Program	same	2, 3, 4-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	7	21	734	372	68	1201
POST Program	same	2, 3, 4-leaf						
Roundup + Prowl	0.75 + 1.5	PRE	5	15	794	351	55	1221
POST Program	same	2, 3, 4-leaf						
Roundup + Prowl + Nortron	0.75 + 1.0 + 1.0	PRE	3	13	799	368	35	1218
POST Program	same	2, 3, 4-leaf						
Roundup + Prowl + Outlook	0.75 + 1.0 + 0.84	PRE	4	18	806	381	53	1262
POST Program	same	2, 3, 4-leaf						
LSD (0.05)			7	129	193	170	47	192

*Preemergence (PRE) treatment applied on April 11, two-leaf (2-leaf) on May 16, three-leaf (3-leaf) on May 27, and four-leaf (4-leaf) on June 9.

YELLOW NUTSEDGE COMPETITION IN DRY BULB ONION PRODUCTION

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Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in eastern Oregon and southwestern Idaho. Yield losses of up to 87 and 89 percent for agronomic and horticultural crops, respectively, have been attributed to yellow nutsedge competition (Keeley 1987). Yellow nutsedge is problematic in many crops, especially those that are short in stature such as onion. Because of its short stature and relatively small leaf area, much of the available sunlight reaches the soil surface and is not intercepted by the onion canopy. Yellow nutsedge has a C_4 photosynthetic pathway and therefore responds well to conditions of high light intensity that exist in onion production. Keeley and Thulen (1978) used several artificial shading regimes to determine that the number of yellow nutsedge shoots, tubers, and total dry matter increased in direct proportion to increasing amounts of light. In the same trial it was determined that the time required for 95 percent canopy interception of photosynthetically active radiation in onion took considerably longer within the drill rows and was less overall in the furrows when compared to several other crops having faster developing and more complete canopies (Keeley and Thullen 1978). In addition to high light conditions, management practices including frequent irrigation and high nitrogen fertilization required to maximize onion yield also stimulate yellow nutsedge growth (Keeling et al. 1990).

Chemical options for yellow nutsedge control are limited. Of the products currently registered only Dual Magnum (s-metolachlor) and Vapam (metham sodium) have activity on yellow nutsedge. Dual Magnum can be applied postemergence to two-leaf or larger onions while Vapam is applied typically in the fall prior to onion planting the following spring.

The objective of this trial was to determine the effect of yellow nutsedge competition on onion yield in several commercial fields.

Methods

Five commercial onion fields were sampled between August 19 and 29. At each location paired samples consisting of 5-ft sections of row inside and immediately adjacent to a yellow nutsedge patch were harvested. Onion varieties and management practices varied among locations. At each field location six paired samples were taken each from a different yellow nutsedge patch. Onion bulbs and yellow nutsedge shoots were harvested from the sample area. Onions were graded according to diameter: small (<2.25 inches), medium (2.25-3.0 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and super colossal (>4.25 inches) in order to evaluate total onion yield loss and yield loss by market class due to yellow nutsedge competition. Bulb counts were taken for each market class. Yellow nutsedge shoot numbers and biomass were recorded. Paired samples were compared using a *t* test at the 0.05 level for onion yield (cwt/acre) and at 0.10 for onion bulb counts (number/acre).

Results and Discussion

Yellow nutsedge shoot densities at the different locations ranged from 28 to 67 shoots/ft^2. Yellow nutsedge shoot dry weight biomass from the sampled patches ranged from 0.27 to 0.98 ton/acre (data not shown). On average, small onion bulbs (number/acre) increased by 43 percent, medium bulbs were unchanged, jumbo decreased by 44 percent, colossal decreased by 72 percent, and marketable (i.e., medium, jumbo, and colossal) bulbs decreased by 34 percent from yellow nutsedge competition. Location 2 had the highest density of yellow nutsedge, resulting in a 61 percent decrease in marketable onion bulbs from yellow nutsedge competition (Table1).

Small onion yields (cwt/acre) were significantly ($P \leq 0.05$) greater with yellow nutsedge competition at only one of the five locations (Table 2). Yellow nutsedge competition did not influence medium onion yields at any of the five locations. Jumbo onion yields were significantly ($P \leq 0.05$) less with yellow nutsedge competition at locations 1, 2, and 5, resulting in yield losses from 53 to 67 percent. Colossal onion yield trended lower with yellow nutsedge competition at all locations but was only statistically less when averaged over all locations. Marketable onion yields were 23 to 64 percent less with yellow nutsedge competition than without. This trial was previously conducted in 1998 with similar results. In 1998, when averaged across five locations, yellow nutsedge competition increased small onion yields, did not influence medium onion yields, and decreased jumbo and colossal onion yields.

References

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Keeley, P. E., and R. J. Thulen. 1978. Light requirements of yellow nutsedge *(Cyperus esculentus)* and light interception by crops. Weed Sci. 26:10-16.

Keeling, J.W., D.A. Bender, and J. R. Abernathy. 1990. Yellow nutsedge *(Cyperus esculentus)* management in transplanted onions *(Allium cepa)*. Weed Technol. 4:68-70.

Table 1. Onion bulbs by grade and total marketable bulbs with and without yellow nutsedge competition from five commercial fields near Ontario, OR, 2003.

Location	Yellow nutsedge density	Onion yield*									
		Small		Medium		Jumbo		Colossal		Marketable[†]	
		-YNS	+YNS	-YNS	+YNS	-YNS	+YNS	-YNS	+YNS	-YNS	+YNS
	no/ft^2	------ no/acre ------		------ no/acre ------		------ no/acre ------		------ no/acre ------		------ no/acre ------	
1	39	10,296	42,768*	24,568	29,320	81,592	26,944*	3,184	0	109,296	56,216*
2	67	6,320	808	9,504	5,560	49,896	17,440*	3,184	1,568	62,584	24,568*
3	40	4,752	4,752	19,008	12,688	79,976	65,720	6,320	3,184	106,112	81,592*
4	28	11,880	17,440	36,448	26,136	91,856	64,960*	5,560	808	133,864	91,856*
5	47	19,816	27,704	45,144	57,832*	49,896	24,568*	1,568	0	96,608	82,352
Average	44	10,597	18,675*	26,944	26,279	70,662	39,917*	3,944	1,092*	101,693	67,336*

*Values marked with an asterisk represent significant differences between paired samples at the 0.10 level. Without yellow nutsedge = -YNS, with yellow nutsedge = +YNS.
[†]Marketable onion counts consisted of medium, jumbo, and colossal bulbs.

Table 2. Onion yield by grade and total marketable yield with and without yellow nutsedge competition from five commercial fields near Ontario, OR, 2003.

Location	Yellow nutsedge density	Onion yield*									
		Small		Medium		Jumbo		Colossal		Marketable[†]	
		-YNS	+YNS	-YNS	+YNS	-YNS	+YNS	-YNS	+YNS	-YNS	+YNS
	no/ft^2	------ cwt/acre ------		------ cwt/acre ------		------ cwt/acre ------		------ cwt/acre ------		------ cwt/acre ------	
1	39	9	33.3*	39	48	275.1	84.1*	16.6	0	331.2	132.1*
2	67	5.7	0.9	17.1	8.6	173.9	57.5*	18.5	10.4	209.6	76.5*
3	40	5.2	5.2	31.4	22.3	267.1	220.5	41.3	21.9	345.9	264.7*
4	28	12.4	15.7	65.1	45.6	288.4	202	35.6	5.2	389.2	252.8*
5	47	21.9	26.6	79.8	94.6	145.4	68.4*	9.5	0	234.7	162.5*
Average	44	10.9	16.1	46.6	43.7	229.9	126.4*	24.2	7.6*	302.2	177.7*

*Values marked with an asterisk represent significant differences between paired samples at the 0.05 level. Without yellow nutsedge = -YNS, with yellow nutsedge = +YNS.
[†]Marketable onion yield consisted of medium, jumbo, and colossal yields.

INSECTICIDE TRIALS FOR ONION THRIPS (*THRIPS TABACI*) CONTROL

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Introduction

During the past 3 years alternative insecticides have demonstrated superior control of onion thrips when compared to conventional insecticides. Alternative insecticides in this trial are azadirachtin (Aza Direct and Ecozin), neem tree (*Azadirachia indica*, A Juss.) extracts, and spinosad (Success), a bacterial fermentation product. Neither product has been particularly effective in short-term screening trials but when applied throughout the season to plots with added straw mulch they have been very effective in controlling thrips and increasing yields. These insecticides are relatively safe to beneficial predators, thus allowing predator populations to increase while suppressing thrips populations.

Research in 2002 suggested the possibility that increasing the time interval between spraying with conventional insecticides might give similar or better control than more frequent applications. Conventional insecticides are the currently registered products in the synthetic pyrethriod (Warrior, Mustang), organo-phosphate (parathion, malathion, Guthion, Diazinon) and carbamate (Lannate, Vydate) classes.

Materials and Methods

A block of onion 36.7 ft wide by 600 ft in length was planted to onion (cv. 'Vaquero', Sunseeds, Parma, ID) on March 14, 2003. The onions were planted as two double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 154,000 seeds per acre. Lorsban 15G was applied in a 6-inch band over each double row at planting at a rate of 3.7 oz/1,000 ft of row for onion maggot control. Water was applied by furrow irrigation. The plots were 7.3 ft wide (2 beds) by 50 ft long and were replicated four times.

There were 12 treatments as outlined in Table 1. The application dates for each treatment are shown in Table 2. A new insecticide, 1785, is being evaluated for the FMC Corporation.

Insecticide applications were made with a CO_2-pressurized plot sprayer with four nozzles spaced 19 inches apart. All treatments were made with water as a carrier at 42.6 gal/acre. Thrips counts were made weekly through the growing season by counting the total number of thrips on 20 plants.

The onion bulbs were harvested by hand on September 23 and graded on October 14 and 15. The plot area harvested was 30 ft of the center two double rows.

Results and Discussion

The season average thrips population is shown in Table 3. The product 1785 was not effective at any rate or timing. The best treatments were Success alone or Success in combination with Aza Direct. Weekly applications of Success were better than split applications of Success and Aza Direct rotated every other week.

The effect of thrips on yield is shown in Table 4. Aza Direct applied alone throughout the growing season had a negative impact on yield. The best yields were combinations of Aza Direct plus Success applied weekly or Success applied alone on a weekly basis. The conventional insecticide treatment using Warrior, Warrior Plus, Lannate, or Warrior Plus MSR were applied at 3-week intervals. When applied at these intervals these treatments were no better than the untreated check.

An examination of each treatment yield compared to the season-long thrips populations of each treatment gives an indication of where the economic threshold is located. Figure 1 shows the average season-long thrips population in each of the different treatments, listed from most effective to least effective. Each point on the graph represents the average season-long thrips population of the treatment along with its corresponding yield for each treatment. Figure 2 shows the relationship of thrips population to total yield. Figure 3 shows the same trend for thrips population versus colossal plus super colossal yields. There is a strong trend for decreasing yields of premium-sized bulbs as season-long thrips populations go above an average of seven thrips per plant. The economic threshold has been suggested to be 15-25 thrips per plant but these data would suggest that this number is around 6-8 thrips per plant on a seasonal basis.

Conclusions

Success appears to be an important part of an alternative thrips control program. Weekly applications of Success alone or Aza Direct with Success were better than alternating with other products.

There is a strong suggestion that the economic threshold level for season-long thrips populations may be as low as 8-10 thrips per plant rather than the 15-25 level previously reported.

Table 1. Insecticides evaluated for onion thrips control, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment no.	Insecticides applied	Formulated product	Treatment interval
		Rate/Acre	
1	1785 50DF	2.848 oz	21 day
2	1785 50DF	2.144 oz	14 day
3	1785 50DF	1.728 oz	7 day
4	1785 50DF Aza Direct Success	1.728 oz 20.0 oz 10.0 oz	7 day with all products.
5	Aza Direct Success	20.0 oz 10.0 oz	7 day with both products
6	1785 50DF Aza Direct Success	2.848 oz 20.0 oz 10.0 oz	7 day rotating each product (3-week rotation)
7	Aza Direct Success	20.0 oz 10.0 oz	7 day rotating each product (2-week rotation)
8	Aza Direct Success	20.0 oz 10.0 oz	7 day with both products
9	Warrior Warrior & Lannate Warrior & MSR	3.84 oz 3.84 oz + 3.0 pt 3.84 oz + 2.0 pt	21 day rotating each combination
10	Untreated Check	---------------	------------------
11	Aza Direct	20.0 oz	7 day
12	Success	10.0 oz	7 day

Table 2. Application dates of insecticide treatments for onion thrips, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment no.	Insecticides applied	Treatment interval	Date 6/3	 6/14	 6/25	 7/3	 7/11	 7/25
1	1785 50DF	21 day	X			X		
2	1785 50DF	14 day	X		X		X	
3	1785 50DF	7 day	X	X	X	X	X	
4	1785 50DF Aza Direct Success	7 day all products tank mixed	X	X	X	X	X	X
5	Aza Direct Success	7 day both products tank mixed	X	X	X	X	X	X
6	1785 50DF Aza Direct Success	7 day rotating each product (3 week rotation)	X	 X	 X	X	 X	 X
7	Aza Direct Success	7 day rotating each product (2 week rotation)	X	 X	X	 X	X	 X
8	Aza Direct Success	7 day both products tank mixed	X	X	X	X	X	X
9	Warrior Warrior & Lannate	21 day rotating each combination	X			 X		
10	Untreated Check	------------------						
11	Aza Direct	7 day	X	X	X	X	X	X
12	Success	7 day	X	X	X	X	X	X

Table 3. Average thrips population during 2003 growing season with different insecticide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

No.	Treatment	Average
1.	1785 50DF	10.8
2.	1785 50DF	11.1
3.	1785 50DF	12.5
4.	1785 50DF Aza Direct Success	7.6
5.	Aza Direct Success	8.0
6.	1785 50DF Aza Direct Success	10.3
7.	Aza Direct Success	9.5
8.	Aza Direct Success	9.2
9.	Warrior Warrior & Lannate	10.7
10.	Untreated Check	10.9
11.	Aza Direct	10.6
12.	Success	6.9
	LSD (0.05)	1.4

Table 4. Effects of different thrips treatments on onion yield and quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Medium	Jumbo	Colossal	Super colossal	Colossal + super colossal	Total yield
	cwt/acre					
1785 50DF	11.7	426.6	529.2	156.7	686.0	1,124.2
1785 50DF	12.3	450.4	514.3	136.4	650.7	1,113.4
1785 50DF	11.9	463.0	461.3	122.3	583.6	1,058.6
1785 50DF Aza Direct Success	11.4	365.1	534.3	270.3	804.6	1,181.1
Aza Direct Success	7.7	357.8	574.5	255.2	829.7	1,195.2
1785 50DF Aza Direct Success	8.1	356.7	547.6	207.8	755.3	1,120.1
Aza Direct Success	5.7	383.8	500.4	204.7	705.2	1,094.7
Aza Direct Success	5.7	389.6	576.2	213.1	789.3	1,184.7
Warrior Warrior & Lannate	10.6	409.9	517.7	214.8	732.6	1,153.0
Untreated check	13.2	457.3	464.5	171.4	635.9	1,106.4
Aza Direct	7.8	489.6	473.0	90.6	563.6	1,061.0
Success	5.0	319.2	616.2	232.0	848.2	1,172.4
LSD (0.05)	5.1	82.3	86.6	68.7	126.3	89.3

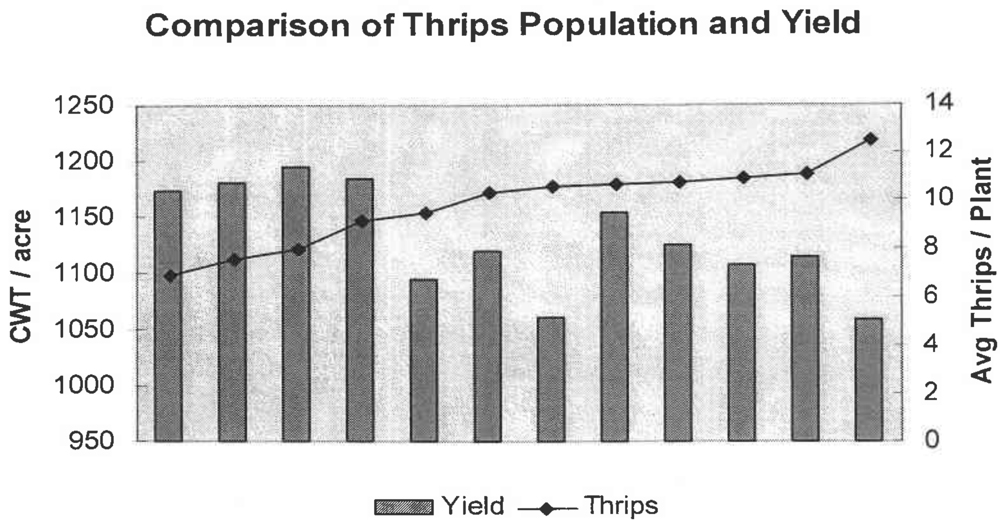

Figure 1. The relationship between season-long thrips population and yield on Vaquero onions. Each point on the line graph represents the average thrips population of 1 of 12 treatments, sorted from most to least effective. Each bar represents the yield associated with each treatment on the line graph. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

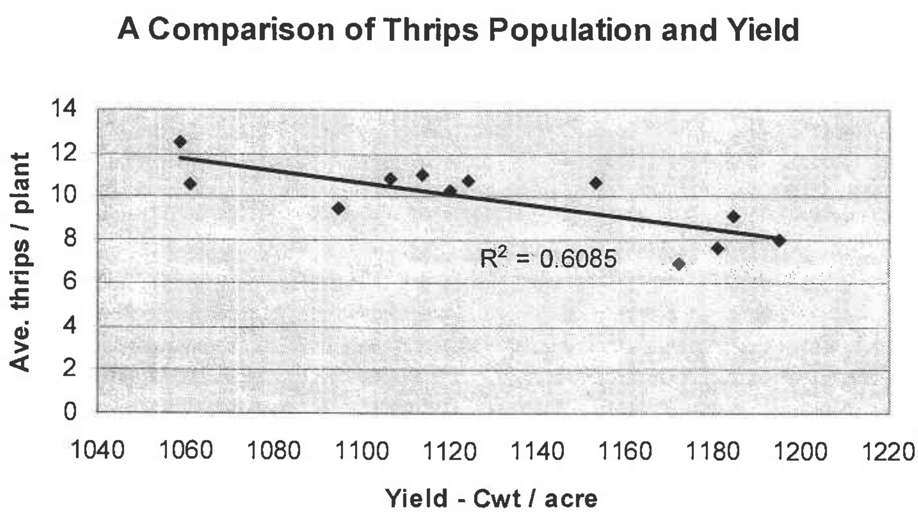

Figure 2. The relationship between season-long average thrips counts and yield on Vaquero onions. Corresponding points on the graph represent the average season-long thrips population and total yield for 1 of 12 treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

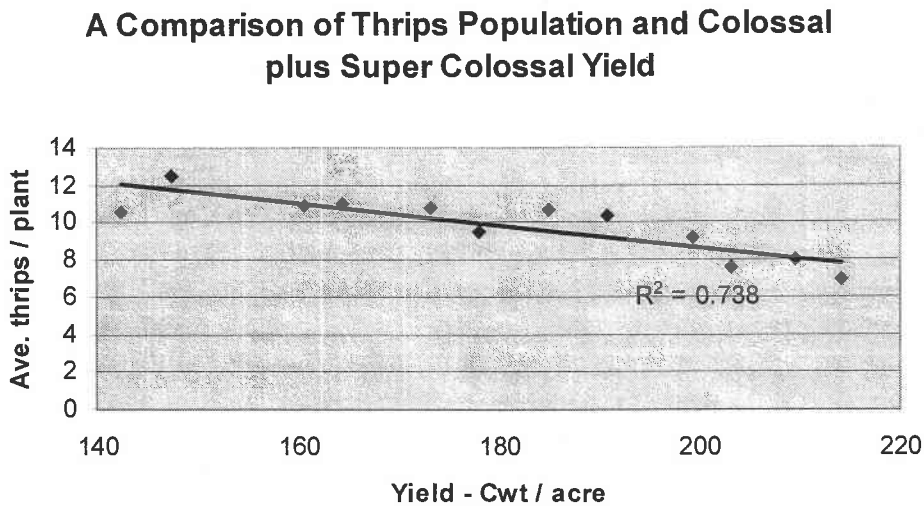

Figure 3. The relationship between season-long average thrips counts and yield on Vaquero onions. Corresponding points on the graph represent the average season-long thrips population and total yield for 1 of 12 treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

ALTERNATIVE METHODS FOR CONTROLLING ONION THRIPS – EFFECTS OF THRIPS ON TWO VARIETIES OF STORED RED ONIONS

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Introduction

Red onion has been grown in the Treasure Valley production region for many years. The quality of red onions coming out of the valley is generally very high, but the past 3 years have seen some quality problems related to thrips damage in storage. Thrips damage on red onion bulbs has been reported from most production areas of the world and is a relatively new problem, having developed over the past 6-10 years. Many ideas have circulated about why this problem has recently arisen. One theory is that widespread use of synthetic pyrethroid insecticides, which are toxic to predatory insects, has reduced the availability of late season predators to prey on thrips. Over the past 3 years, an alternative approach to controlling onion thrips has been developed at the Malheur Experiment Station. This program consists of straw mulch for predator habitat plus the use of soft insecticides to suppress thrips while leaving predators to feed on the residual thrips population. This program has been very successful in controlling thrips and increasing bulb size and yield. In 2003, a trial was established to investigate the effects of an alternative program on two red onion varieties in storage.

Materials and Methods

A 1.5-acre field was planted to the onion varieties 'Flamenco' and 'Redwing' (cv. Flamenco, Sunseeds, Parma, ID; Redwing, Bejo Seeds, Oceano, CA) in a split-plot design on March 14, 2003. The onions were planted as two double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 154,000 seeds per 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. Irrigation was by furrow. The field was divided into plots 36.7 ft wide by 100 ft long. There were three treatments with six replications.

The three treatments were a grower standard treatment, an untreated check, and the alternative treatment. The grower standard treatment included four applications of Warrior (lambda-cyhalothrin); Metasystox-R (oxydemeton-methyl) and Lannate (methomyl) applied through the growing season. The untreated check did not receive any treatments for thrips control. The alternative treatment included straw mulch applied to the center of the bed plus Success (spinosad), and Aza Direct (azadirachtin) applied five times during the growing season.

Insecticide treatments were applied according to the treatment schedule during the growing season. All insecticides were applied in water at 30.9 gal/acre. Straw was applied only between the irrigation furrows on top of the beds to avoid confounding irrigation effects with thrips effects. The straw was applied on May 1, 2003 at rate of 1,080 lb/acre.

The onions were harvested on September 23. They were put in burlap bags and placed in a temporary storage at ambient temperature for 30 days. This time period was to allow any thrips on the bulbs to actively feed on the bulbs, so that relative injury could be evaluated. After 30 days, the onions were placed into cooled storage and the temperature kept as close to 38°F as possible. The onions were peeled and the top fleshy layers subjectively evaluated for thrips injury. Fifteen bulbs from each plot were evaluated; the results are shown in Table 1.

Results

There was a trend towards lower injury in both varieties with the alternative thrips control program compared to either the standard spray program or the untreated check. Redwing also had significantly less thrips injury than Flamenco. Redwing had tighter wrapper skins than Flamenco, which probably accounts for the varietal differences.

Conclusion

Redwing had less thrips injury than Flamenco, probably due to tighter wrapper skins. Varietal characteristics such as more wrapper skins, and tighter wrapper skins will help reduce thrips injury. The alternative approach to controlling thrips also reduced thrips injury.

Table 1. Thrips injury (0 = no injury, 10 = severe injury), on two stored red onion varieties, Malheur Experiment Station Oregon State University, Ontario, OR, 2003.

Treatment	Redwing	Flamenco
Alternative	1	1.3
Standard	1.3	1.6
Untreated Check	1.5	2.1
LSD (.05)	0.3	ns

Varietal differences	
Redwing	1.27
Flamenco	1.68
LSD (.05)	0.39

VARIETAL RESPONSE TO AN ALTERNATIVE APPROACH FOR CONTROLLING ONION THRIPS (*THRIPS TABACI*) IN SPANISH ONIONS

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Introduction

Onion is a major economic crop in the Treasure Valley region of eastern Oregon and western Idaho. Annually about 20,000 acres of onion is grown in the valley. Spanish hybrids typically are grown for their large size, high yield, and mild flavor.

The principal onion pest in this region is the onion thrips. Thrips cause yield reduction by feeding on the epidermal cells of the plant, and can reduce total yields from 4 to 27 percent, depending on the onion variety, but can reduce yields of colossal sized bulbs from 27 to 73 percent. The larger sized colossal bulbs are difficult to grow and demand a premium in the marketplace. Growers typically spray three to six times per season to control onion thrips. Treatments include the use of synthetic pyrethroid, organophosphate, and carbamate insecticides. The ability of these products to control thrips has decreased from over 90 percent control in 1995 to less than 70 percent control in 2000. Onion growers are applying insecticides more frequently in order to keep thrips populations low.

New biological insecticides with low toxicity to beneficial predators have been developed, including neem tree (*Azadirachta indica* A. Juss.) extracts (azadirachtin) and bacterial fermentation products (spinosad). Both of these materials have previously been evaluated for thrips control and have performed poorly compared to conventional insecticides. Studies during the past 2 years have shown that applications of spinosad and azadirachtin coupled with straw mulch are superior to conventional insecticide programs for controlling onion thrips on the onion variety 'Vaquero' (Jensen et al. 2002, 2003a, 2003b). Vaquero was used in the study because of its vigorous growth characteristics and resistance to thrips injury compared to slower growing varieties. The objective of this study was to test this program on varieties that were highly susceptible to thrips injury.

Materials and Methods

A 1.5-acre field was planted to the onion varieties Vaquero, 'Flamenco', and 'Redwing' (cv. Vaquero, Flamenco, Sunseeds, Parma, ID; Redwing, Bejo Seeds, Oceano, CA) in a split-plot design on March 14, 2003. Vaquero is a yellow variety while Redwing and

Flamenco are red varieties. Red varieties are generally assumed to be more attractive to thrips than yellow varieties. The onion varieties were planted as two double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 154,000 seeds per acre. Lorsban 15G was applied in a 6-inch band over each row at planting at a rate of 3.7 oz / 1,000 ft of row for onion maggot control. Water was applied by furrow irrigation. The field was divided into plots 36.7 ft wide by 100 ft long. There were three treatments with six replications.

The three treatments were a grower standard treatment, an untreated check, and the alternative treatment. The grower standard treatment included Warrior (lambda-cyhalothrin), MSR (oxydemeton-methyl) and Lannate (methomyl). The untreated check did not receive any treatments for thrips control. The alternative treatment included straw mulch applied to the center of the bed plus Success (spinosad), and Aza Direct (azadirachtin).

Insecticide treatments were applied as needed during the growing season (Table 1). All insecticides were sprayed in water at 30.9 gal/acre. Straw was applied only between the irrigation furrows on top of the beds to avoid confounding irrigation effects with thrips effects. The straw was applied on May 1, 2003 at rate of 1,080 lb/acre.

Thrips populations were monitored only in Vaquero. They were sampled by two methods. The first was by visually counting the number of thrips on 20 plants. The second method was by cutting 10 plants at ground level and inserting the plants into a Berlese funnel. Turpentine was used in the Berlese funnel to dislodge the thrips from the plant, where they would then fall into a jar containing 90 percent isopropyl alcohol. The collected thrips were then counted through a binocular microscope. Thrips populations were monitored weekly through the growing season.

The predator populations were monitored using pitfall traps that contained ethylene glycol. They were evaluated three times per week. The Berlese funnel was also used to monitor predators foraging on the plants. The onions were harvested on September 23 and graded on October 14 and 15.

Results and Discussion

Thrips pressure was light during the growing season compared to previous seasons. The 2003 treatments are compared in Figure 1. The alternative program had significantly lower average thrips population (10 percent level) than either the standard treatment or the untreated check (Fig. 2). There were significantly fewer predators in the standard treatment compared to either the untreated check or the alternative treatment (Fig. 3). No visual damage to the foliage was observed with the variety Vaquero. Flamenco showed severe foliage damage from thrips feeding. The visual thrips damage to Redwing appeared intermediate to Vaquero and Flamenco. Flamenco is less vigorous than Redwing and more thrips damage would be expected.

There were no yield differences among any of the treatments with Vaquero (Table 2). There was less thrips damage in Vaquero in 2003, which may have been due to the year, or the red varieties may have been more attractive to the thrips than the yellow onions. No attempt was made to monitor thrips populations in each variety.

Redwing had a significant increase in colossal sized bulbs with the alternative treatment (Table 3) compared to either the standard or untreated check and a significant increase in total yield compared to the untreated check. There was a trend, though not significant, towards higher overall yields compared to the standard treatment.

Flamenco responded to the alternative treatments with significantly less medium yield and higher jumbo and colossal yield compared to the untreated check. There was a trend towards higher total yield and larger bulb size compared to the standard treatment but this was only significant in the colossal size class (Table 4). Predator populations (Fig. 1) were significantly higher in the alternative and untreated check treatments than in the standard treatment. The predator population consisted mostly of spiders, big-eyed bugs, minute pirate bugs, damsel bugs, lacewings and lady bird beetles.

Conclusion

There are obviously conditions when thrips pressure is light enough to preclude having to control them on certain varieties, as was the case with Vaquero. This may be due to the year or more likely to the close proximity of the red varieties, which were more attractive to thrips. There were no economic advantages to controlling thrips on Vaquero in 2003 in this trial. Both Redwing and Flamenco responded favorably to the alternative treatments, producing better yield and quality than the standard insecticide program or the untreated check.

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Jensen, L., B. Simko, C. Shock and L. Saunders 2002. Alternative methods for controlling onion thrips (*Thrips Tabaci*) in Spanish onions. Pages 65-72 *in* Proc. 2002 Allium Res. National Conf.

Jensen, L., C. Shock, B. Simko and L. Saunders 2003b. Straw mulch and insecticide to control onion thrips (Thrips Tabaci) in dry bulb onions. Pages 19-30 *in* Proc. Pacific Northwest Veg. Assoc. 17th Ann. Meeting.

Table 1. Application data for the alternative onion thrips trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Standard insecticide treatment			Alternative insecticide treatment		
Application date	Insecticides applied	Rate/acre	Application date	Insecticides applied	Rate/acre
Jun 7	Warrior	3.84 oz	Jun 7	Aza Direct	20.0 oz
Jun 25	Warrior	3.84 oz		Success	10.0 oz
	Lannate	3.0 pt	Jun 14	Aza Direct	20.0 oz
Jul 7	Warrior	3.84 oz		Success	10.0 oz
	Meta Systox R	2.0 pt	Jul 3	Aza Direct	20.0 oz
Jul 25	Warrior	3.84 oz		Success	10.0 oz
	Lannate	3.0 pt	Jul 11	Aza Direct	20.0 oz
				Success	10.0 oz
			Jul 29	Aza Direct	20.0 oz
				Success	10.0 oz

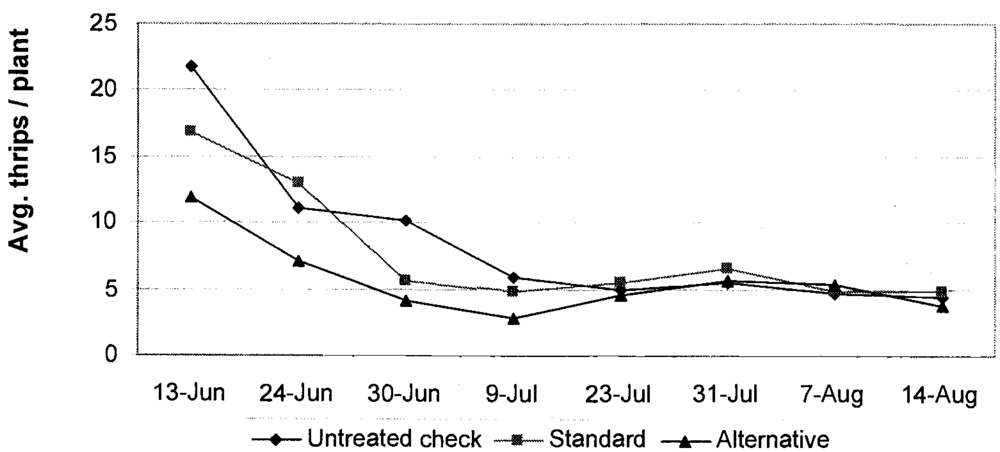

Figure 1. Thrips populations with different treatments in an alternative thrips control program, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

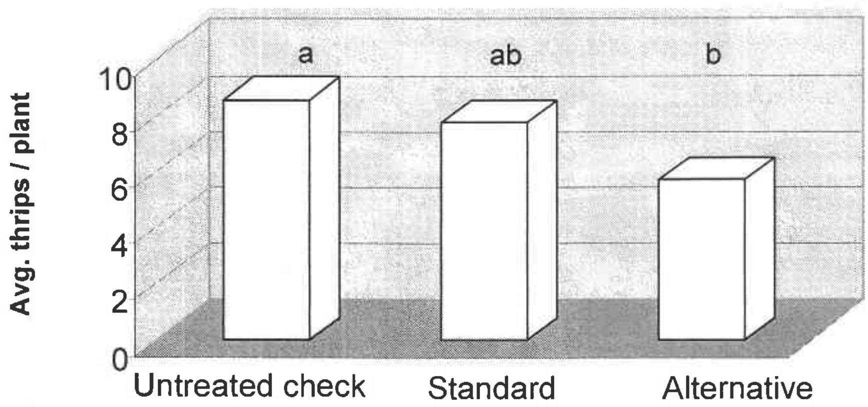

Figure 2. Average season-long thrips populations in an alternative thrips control program, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

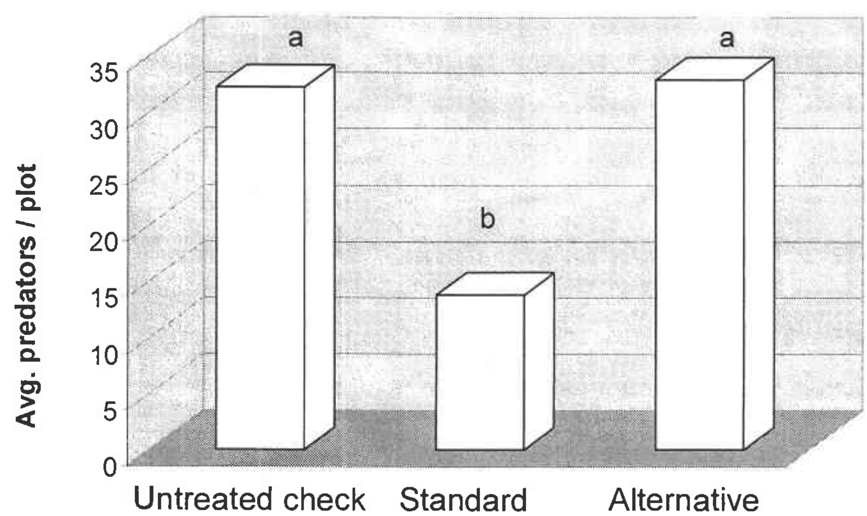

Figure 3. Predator populations in the alternative thrips trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 2. Yield and grade of Vaquero onion with different strategies for controlling onion thrips, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Medium	Jumbo	Colossal	Super colossal	Total yield
	----------	----------	cwt/acre	----------	----------
Untreated check	9.7	459.7	464.1	124.0	1,057.5
Standard	9.8	451.0	489.6	140.9	1,091.3
Alternative	10.9	446.1	484.2	145.2	1,086.4
LSD (0.05)	NS	NS	NS	NS	NS

Table 3. Yield and grade of Redwing onion with different strategies for controlling onion thrips, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Medium	Jumbo	Colossal	Super colossal	Total yield
	----------	----------	cwt/acre	----------	----------
Untreated check	12.0	726.4	107.4	4.0	849.8
Standard	14.2	724.2	174.3	2.2	914.9
Alternative	11.6	701.2	240.2	6.9	959.9
LSD (0.05)	NS	NS	62.2	NS	56.3

Table 4. Yield and grade of Flamenco onions with different strategies for controlling onion thrips, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Medium	Jumbo	Colossal	Super colossal	Total yield
	----------	----------	cwt/acre	----------	----------
Untreated check	9.4	121.5	380.5	1.0	512.4
Standard	6.9	107.1	442.3	9.2	565.5
Alternative	7.7	94.0	486.1	19.1	606.9
LSD (0.05)	NS	16.9	55.5	7.8	51.8

PERFORMANCE OF HYBRID POPLAR CLONES ON AN ALKALINE SOIL

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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 sawlogs have increased in the Treasure Valley.

Some hybrid poplar clones are susceptible to nutrient deficiencies in alkaline soils, leading to poor growth. Clone trials planted in 1995 in Malheur County demonstrated that clone OP-367 (hybrid of *Populus deltoides* x *P. nigra*) was the only clone performing well on alkaline soils. 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. Poplar growers need updated information on the vigor and adaptability of new clones to alkaline soils.

Materials and Methods

The trial was conducted on a Nyssa silt loam with a pH of 8.4 and 1.3 percent organic matter. The field was planted to wheat in the fall of 2002. On March 28, 2003, the wheat was sprayed with Roundup (glyphosate) at 1.5 lb ai/acre. Based on a soil analysis, on April 9, 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 5 replicates. Tree rows were spaced 5 ft apart and trees were spaced 5 ft apart within the row. Each plot consisted of four trees, two rows wide and two trees long. Goal herbicide (oxyfluorfen) at 2 lb ai/acre was sprayed on April 11. The field was irrigated with 0.6 inch of water on April 11.

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. Emitters have a flow rate of 0.5 gal/hour. The field was irrigated when the soil water potential 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 maintained the soil water potential above -25 kPa until around mid-July, when the irrigation rate was increased to 1 inch per irrigation. The increased irrigation rate was not effective in maintaining the soil water potential above -25 kPa, so starting in mid-August the field was irrigated 5-7 times per week until the last irrigation on September 30. Soil water potential was measured with six Watermark soil moisture sensors model 200SS (Irrometer Company, 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) on July 11 indicated 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.

The heights and diameter at breast height (DBH, 4.5 ft from ground) of all trees in each plot were measured on October 6, 2003. Stem volumes (excluding bark and including stump and top) were calculated for each tree using an equation developed for poplars that uses tree height and DBH (Browne 1962). 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).

Results and Discussion

Starting around mid-July, the soil water potential did not remain above the target of -25 kPa (Fig. 1). The increased irrigation frequency in mid-August raised the soil water potential, but was not successful in maintaining it above the target. A total of 19.2 inches of water were applied during the season to the whole field (Fig. 2). Greater tree growth and wood volume would have been obtained if the intended soil water potential had been maintained, which would have required a higher amount of water to be applied.

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.

Height on October 6 ranged from 7.36 ft for clone 50-184 to 10.90 ft for clone 59-289 (Table 2). Diameter at breast height on October 6 ranged from 0.45 inch for 50-184 to 0.73 inch for clone 59-289. Wood volume on October 6 ranged from 5.84 inches^3 for clone 50-184 to 22.34 inches^3 for clone 59-289. Tree heights for clones 59-289, 184-401, 309-74, 195-529, NM-6, 57-276, OP-367, 15-29, and 56-273 were among the highest. Tree volumes for clones 59-289, 184-401, 309-74, 57-276, 195-529, NM-6, 15-29, OP-367, 56-273, and 50-197 were among the highest.

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 Div., Victoria, B.C.

Table 1. Analysis of leaf samples (first fully expanded leaf from clone OP-367) on July 11, 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

Nutrient	Sufficiency range*	Analysis
N (%)	3 - 3.5	4.02
P (%)	0.3 - 0.4	0.45
K (%)	1.7 - 2.1	5.88
S (%)	0.3 - 0.4	0.22
Ca (%)	0.8 - 1.2	0.9
Mg (%)	0.15 - 0.25	0.29
Zn (ppm)	15 - 25	36
Mn (ppm)	70 - 110	81
Cu (ppm)	3 - 5	12
Fe (ppm)	65 - 95	256
B (ppm)	35 - 45	17

* supplied by Western Labs, Parma, ID.

Table 2. Height, diameter at breast height (DBH), and wood volume on October 6, 2003 of hybrid poplar clones planted on April 10, 2003 at the Malheur Experiment Station, Oregon State University, Ontario, OR.

Clone	Cross	Height	DBH	Wood volume
		ft	inch	$inch^3$/tree
15-29	P. trichocarpa X P. deltoides	9.82	0.63	16.69
50-184	P. trichocarpa X P. deltoides	7.36	0.45	5.84
50-197	P. trichocarpa X P. deltoides	9.46	0.64	15.03
52-225	P. trichocarpa X P. deltoides	8.86	0.58	11.66
55-260	P. trichocarpa X P. deltoides	9.36	0.54	11.74
56-273	P. trichocarpa X P. deltoides	9.71	0.63	15.39
57-276	P. trichocarpa X P. deltoides	10.19	0.68	18.75
58-280	P. trichocarpa X P. deltoides	8.74	0.60	12.01
59-289	P. trichocarpa X P. deltoides	10.90	0.73	22.34
184-401	P. trichocarpa X P. deltoides	10.78	0.71	21.00
184-411	P. trichocarpa X P. deltoides	8.85	0.56	12.41
195-529	P. trichocarpa X P. deltoides	10.41	0.67	18.69
309-74	P. trichocarpa X P. nigra	10.48	0.65	20.26
311-93	P. trichocarpa X P. nigra	8.72	0.46	7.87
NM-6	P. nigra X P. maximowiczii	10.34	0.64	17.32
DTAC-7	P. trichocarpa X P. deltoides	7.94	0.46	8.32
OP-367	P. deltoides X P. nigra	9.95	0.63	15.84
PC1	P. deltoides X P. nigra	9.18	0.53	10.36
PC2	P. trichocarpa X P. deltoides	9.21	0.59	12.47
49-177	P. trichocarpa X P. deltoides	8.57	0.49	8.77
Clint1	native poplar, Malheur County, OR	8.47	0.46	9.36
Clint2	native poplar, Malheur County, OR	8.81	0.51	10.32
Clint3	native poplar, Malheur County, OR	9.00	0.55	11.55
DN-34	P. deltoides X P. nigra	8.01	0.51	8.87
LSD (0.05)		1.29	0.14	7.78

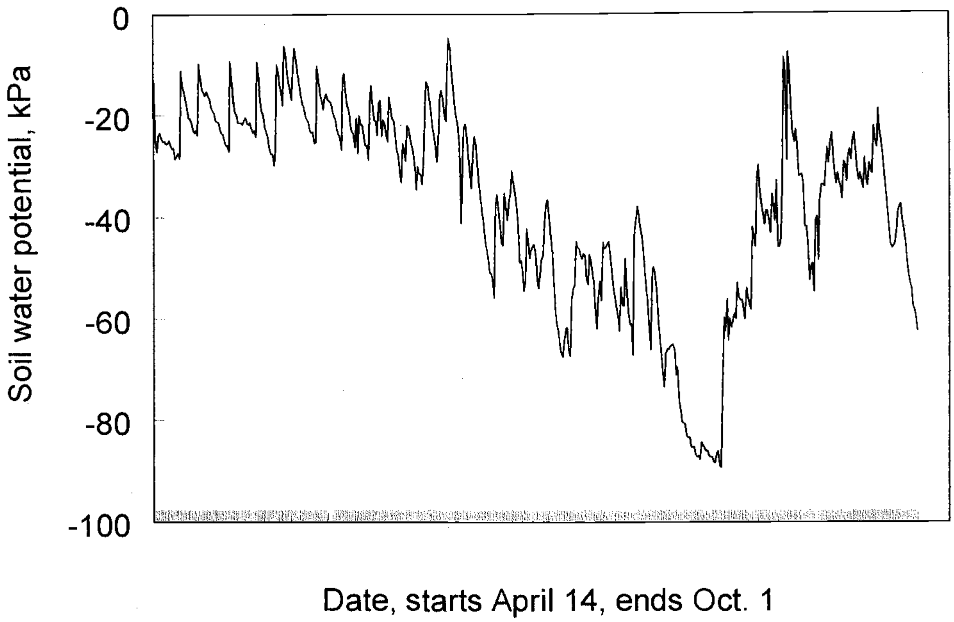

Figure 1. Soil water potential at 8-inch depth for poplar clones irrigated with a drip irrigation system with two emitters per tree, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

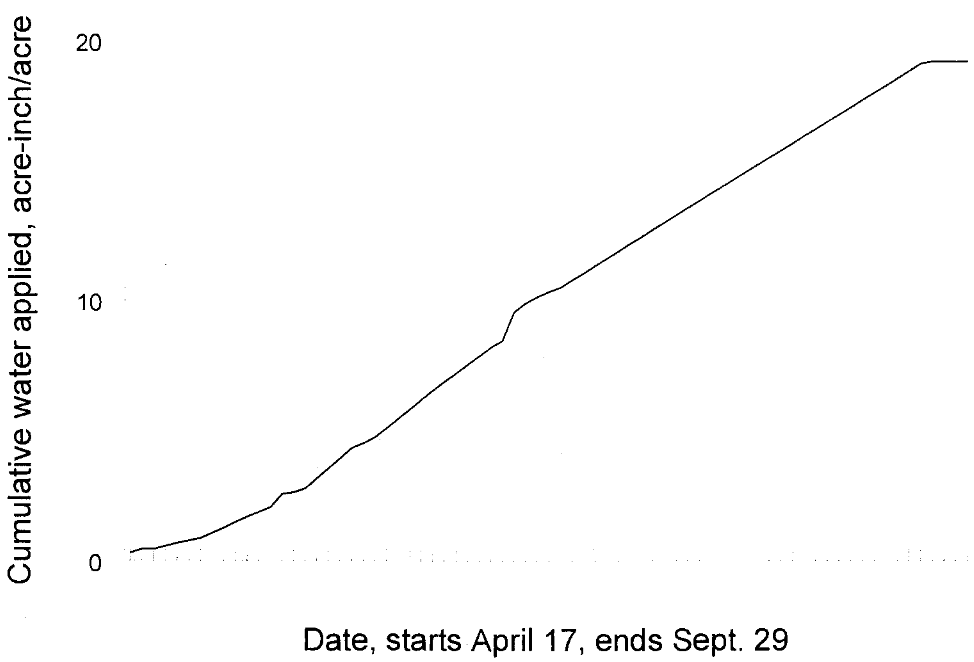

Figure 2. Cumulative water applied to poplar clones irrigated with a drip irrigation system with two emitters per tree, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION 2003 TRIAL

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Summary

Hybrid poplar (cultivar OP-367), planted for sawlog production in April 1997 at the Malheur Experiment Station, received five irrigation treatments in 2000-2003. Irrigation treatments consisted of three water application rates using microsprinklers and two water application rates using drip tape. Irrigation scheduling was by soil water potential at 8-inch depth with a threshold for initiating irrigations at -50 kPa in 2000-2002, and at -25 kPa in 2003. Reducing the water application rate reduced the annual growth in diameter at breast height (DBH) and stem volume for the microsprinkler-irrigated treatments. There was no significant difference between the microsprinkler-irrigated 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 higher tree growth than microsprinkler irrigation.

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. Growers in Malheur County have made experimental plantings of hybrid poplars for saw logs and peeler logs. Clone trials in Malheur County have demonstrated that the clone OP-367 (hybrid of *Populus deltoides* x *P. nigra*) performs well on alkaline soils for at least 7 years. Other clones have higher productivity on soils with nearly neutral pH.

Hybrid poplars are known to have high growth rates (Larcher 1969) and 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). The results showed that tree growth was not reduced by scheduling irrigations when the soil water potential reached -50 kPa. Irrigating at -25 kPa necessitated 38 irrigations for 3-year-old trees, compared to 26 irrigations when trees were irrigated at -50 kPa. Based on these results it was 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. It was decided that 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 in the seventh year 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 1997 and to alfalfa before 1995. 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 nine 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 the rate of 0.14 inches/hour at 25 psi and a radius of 14 ft. The poplar field was used for irrigation management research (Shock et al. 2002) and groundcover research (Feibert et al. 2000) from 1997 through 1999.

Procedures Common to all Treatments

In March 2000 the field was divided into 20 plots, each of which was 6 tree rows wide and 7 trees long. The plots each were assigned one of five treatments arranged in a randomized complete block design and replicated four times (Table 1). The microsprinkler irrigation treatments used the existing irrigation system. For the drip-irrigation treatments, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row in early May 2000. The plots with two 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 monitored daily by water meters in each plot.

Soil water potential (SWP) was measured in each plot by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors model 200SS, Irrometer Co., Riverside, CA); two at 8-inch depth, two at 20-inch depth, and two 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.). 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 (Table 2). From 2000 through 2002, all plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth for treatment one reached -50 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth for the respective treatment reached -50 kPa. Irrigation treatments were terminated on September 30 each year.

Soil water content was measured with a neutron probe. Two access tubes were installed in each plot along the middle tree row on each side of the fourth tree between the sprinklers and the tree. Soil water content readings were made twice weekly at the same depths as the GMS. The neutron probe was calibrated by taking soil samples and probe readings at 8-, 20-, and 32-inch depth during installation of the access tubes. The soil water content was determined gravimetrically 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. Coefficients of determination (r^2) for the regression equations were 0.89, 0.88, and 0.81 at $P = 0.001$ for the 8-, 20-, and 32-inch depths, respectively.

2000 Procedures

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

On May 19 the trees received 50 lb 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, 0.6 lb copper, 0.4 lb iron, 5 lb magnesium, 0.25 lb zinc, and 3 lb phosphorus. 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 S/acre, and 14 lb Zn/acre (urea, monoammonium phosphate, zinc sulfate and elemental sulfur) were broadcast. The ground between the tree rows was lightly disked on April 12. On April 13, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.8 inch of water to incorporate the Prowl.

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

2002 Procedures

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

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

2003 Procedures

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

Starting in 2003 the irrigation criterion was changed to -25 kPa and the water applied at each irrigation was reduced accordingly (Table 2). All plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth for treatment one reached -25 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth for 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.

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 for 2003 were calculated as the difference in the respective parameter between October 2003 and October 2002.

Results and Discussion

The microsprinkler-irrigated treatment with 1 inch of water applied at each irrigation consumed 47 acre-inch/acre of water in 47 irrigations (Table 1). The drip treatment with 1 inch of water applied with 2 tapes consumed 52 acre-inch/acre applied in 35 irrigations. The drip treatment with 0.5 inch of water applied with 1 tape consumed 29 acre-inch/acre in 35 irrigations.

In November 2003 (seventh year), trees in the wettest sprinkler-irrigated treatment averaged 57 ft in height, 8.3-inch DBH, and 1,697 ft^3/acre of stem volume (Table 2). In November 2003, trees in the treatment drip-irrigated with 2 drip tapes per tree row averaged 64 ft in height, 8.5-inch DBH, and 2,090 ft^3/acre of stem volume.

Comparing all treatments, drip irrigation with two tapes per tree row (water application rate of 1 inch) resulted in the highest DBH growth, height growth, and stem volume growth in 2003 (Table 2). Using one drip tape instead of two per tree row resulted in a reduction in DBH growth, height growth, and stem volume growth. For the microsprinkler-irrigated treatments, the highest growth in DBH and stem volume was achieved with a water application rate of 1 inch.

There were positive linear relationships, with similar slopes, between total water applied and stem volume growth for both the drip and microsprinkler systems (Fig. 1). However, the line for the drip system was above the line for the microsprinkler system, reflecting the higher water use efficiency of the drip system (Table 1).

The SWP at 8-inch depth was reduced, as expected, with the reductions in water application rate in the sprinkler treatments (Fig. 2, Table 3). There was no significant difference in 8-inch average SWP among the two drip treatments and the sprinkler treatment with 1 inch of water application rate. The SWP at 8-inch depth in the drip treatments oscillated with a higher amplitude (became wetter) than in the sprinkler plots, as expected, since the wetted area was smaller with drip irrigation. The SWP at 32-inch depth in the wettest sprinkler treatment remained drier than in the first foot during the season, suggesting that applied irrigation water was not lost to deep percolation.

The rate of increase in annual stem volume growth increased (growth approximately doubled every year) up to 2000, when the stem volume growth for the microsprinkler irrigated trees started to decline (Table 4). In 2002 the stem volume growth for the drip-irrigated trees started to decline. The decline in annual growth would not be expected until later when the trees are approaching harvest size. The reduction of the SWP 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 higher in 2003 and was approximately double the growth in 2002. The higher tree growth in 2003 could have been due to the change to a wetter irrigation threshold from -50 to -25 kPa. Season-long average soil water potential at 8-inch depth for the wettest microsprinkler treatment and for the treatment drip irrigated with two drip tapes was substantially higher (wetter) in 2003 than in the last 3 years (Table 4).

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Table 1. Irrigation rates, amounts, and water use efficiency for hybrid poplar submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Irrigation threshold	Water application	Irrigation system	Total number of irrigations	Total water applied†	Water use efficiency
	kPa*	inch			acre-inch/ acre	ft^3 of wood/acre-inch of water
1	-25	1	Microsprinkler	47	47.1	12.9
2	coincide with trt #1	0.77	Microsprinkler	47	35.8	8.2
3	coincide with trt #1	0.39	Microsprinkler	47	21.6	4.3
4	-25	1	Drip, 2 tubes	35	54.8	17.1
5	-25	0.5	Drip, 1 tube	35	29.8	14.8
LSD (0.05)				1	0.8	6.4

*Soil water potential at eight-inch depth.
†Includes 2.39 inches of precipitation from May through September.

Table 2. Height, diameter at breast height (DBH), and stem volume in early November 2003 and 2003 growth for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	November 2003 measurements			2003 growth increment		
	Height	DBH	Stem volume	Height	DBH	Stem volume
	ft	inch	ft^3/acre	ft	inch	ft^3/acre
1	56.5	8.27	1,697.0	7.7	1.50	605.9
2	47.0	6.96	1,020.0	5.6	0.98	293.7
3	32.5	5.00	351.0	2.5	0.71	91.4
4	63.6	8.45	2,090.0	14.0	1.89	937.9
5	51.7	7.73	1,370.0	7.1	1.27	438.2
LSD (0.05)	16.7	0.76	507.2	5.7	0.26	221

Table 3. Average soil water potential and volumetric soil water content for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Average soil water potential		
	1st ft	2nd ft	3rd ft
	------------------ kPa ------------------		
1	26.9	36.9	36.1
2	65.3	83.2	62.9
3	92.8	84.9	90.8
4	21.8	25.5	27.4
5	28.3	25.2	35.7
LSD (0.05)	20.8	25.8	26.0

Table 4. Annual stem volume growth and seasonal average soil water potential at 8-inch depth for hybrid poplar under drip and microsprinkler irrigation at highest irrigation intensities, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Stem volume growth		Seasonal average soil water potential at 8-inch depth	
Year	Drip	Microsprinkler	Drip	Microsprinkler
	---- ft³/acre ----		---- kPa ----	
1997		1.3		-21.4
1998		78.5		-20.0
1999		177.7		-22.2
2000	361.9	401.5	-24.2	-37.9
2001	448.7	354.7	-26.4	-33.9
2002	413.1	256.8	-31.3	-35.8
2003	937.9	605.9	-21.8	-26.9

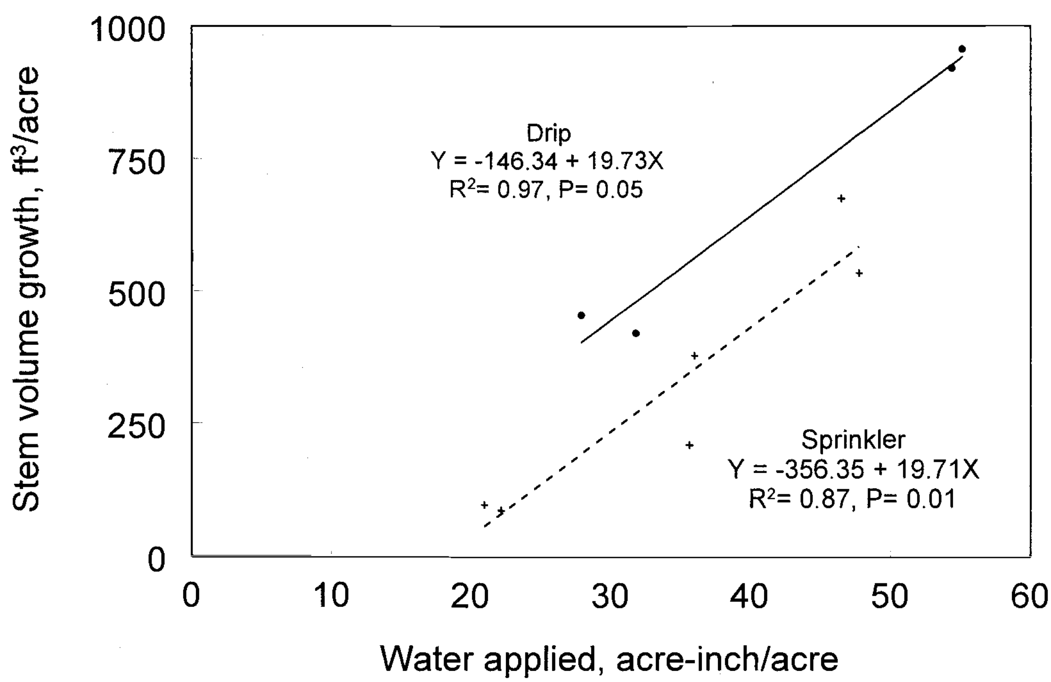

Figure 1. Response of stem volume growth to water applied in 2003 for hybrid poplar using microsprinkler and drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR.

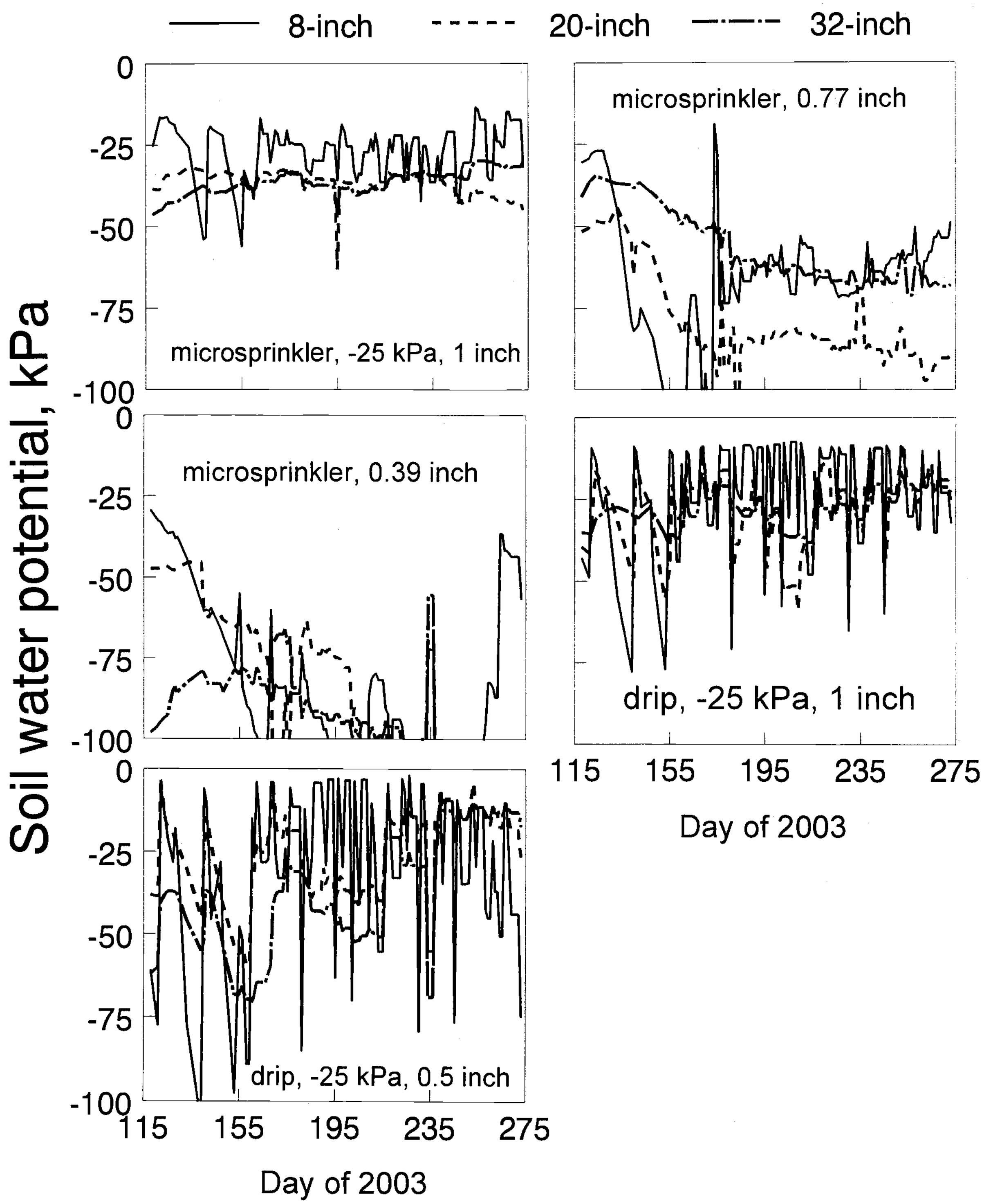

Figure 2. Soil water potential at three depths using granular matrix sensors in a poplar stand submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

EFFECT OF PRUNING SEVERITY ON THE ANNUAL GROWTH OF HYBRID POPLAR

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Summary

Hybrid poplar (clone OP-367) planted at 14-ft by 14-ft spacing are being submitted to five pruning treatments. Pruning treatments consist of the rate at which the side branches are removed from the tree to achieve an 18-ft branch-free stem. Starting with a 6-ft (from ground) pruned stem, 3-year-old trees are being pruned to 18 ft in either 3, 4, or 5 years. Starting in March 2000, the side branches on the stem were pruned to a height of 6, 9, or 12 ft. In subsequent years, the trees were pruned in 3 ft increments annually. A check treatment where trees were pruned only to 6 ft is included. In 2003 the percentage of the total tree height that was pruned stem ranged from 13 percent for the check treatment to 34 percent. Stem volume growth in 2003 and over the previous four seasons was not affected by pruning up to 25 percent of the total tree height. Another treatment compares the effect of pruning during tree dormancy to pruning after growth has resumed. There was no significant difference in epicormic sprouting between trees pruned while dormant and trees pruned after bud break.

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 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. 2002).

Pruning of the side branches of trees allows the early formation of clear, knot-free wood in the stem 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 timing of pruning could also affect the amount of epicormic sprouting (sprouts forming on pruned stem) during the season, wound healing, and insect damage at wound sites. The objective of this study was to evaluate the effect of pruning severity and timing on tree growth and health.

Materials and Methods

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 1997 and before that to alfalfa. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14-ft by 14-ft spacing. The field was used for irrigation management research (Shock et al. 2002) and groundcover research (Feibert et al. 2000) from 1997 through 1999. All side branches on the lower 6 ft of all trees had been pruned in February 1999.

In March 2000, the field was divided into 20 plots that were six rows wide and seven 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, 2003 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 trees in the two wetter microsprinkler-irrigated treatments and the drip-irrigated treatments averaged 26 ft in height and 4.2 inches diameter at breast height (DBH) in March 2000. The middle two rows in each irrigation plot were assigned to pruning treatment 3 (Table 1). The remaining 2 pairs of border rows in each plot were randomly assigned to pruning treatments 2, 4, and 5. The pruning treatments were replicated eight times. The trees in treatments 2, 3, and 4 were pruned on March 27, 2000, March 14, 2001, March 12, 2002, and March 12, 2003. Trees in treatment 5 were pruned on May 16, 2000, May 21, 2001, May 15, 2002, and May 14, 2003. Trees were pruned by cutting all the side branches up to the specified height measured from ground level. The side branches were cut using loppers and pole saws. An additional four plots, in which the trees would remain pruned only to 6 ft, were selected for a check treatment (treatment 1).

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. Stem 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). The trees were observed for insect damage at pruning cuts. Sprouts (epicormic branches) that formed during the season on the pruned length of the stem of trees in treatments 3 and 5 were counted, cut, and weighed on February 26, 2002. The amount of time to remove the sprouts in each plot of treatments 3 and 5 was recorded. Growth increments for height, DBH, and stem volume for 2003 were calculated as the difference in the respective parameter between October 2002 and October 2003. Growth increments for the four seasons (2000-2003) were calculated as the difference in the respective parameter between October 1999 and October 2003. Regression analyses were run for the percent of total tree height that was pruned stem against tree growth. The maximum percent of total stem height pruned that would not reduce tree growth was calculated by the first derivative (maximum = -b/2c) of the regression equation $Y = a + b \cdot X + c \cdot X^2$, where Y is the stem volume increment and X is the percent of the total height pruned.

Results and Discussion

In October 2003 the trees in the least severe pruning treatment (treatment 2) averaged 58 ft in height and 8.4 inches DBH. In 2003 the percentage of the total tree height that was pruned stem ranged from 13 percent for the check treatment to 34 percent for treatment 4 (Table 1).

Tree growth increased, reached a maximum, and then decreased with increasing pruning severity, both in 2003 and over the 4 years (Figs. 1 and 2). The response of tree growth to pruning suggests that pruning up to a certain severity is beneficial for tree growth. Pruning removes branches from the lower canopy that might not contribute much to the photosynthetic capacity of the tree due to shading. Pruning also changes the stem shape, with greater diameter growth occurring higher on the stem than in unpruned trees. The maximum stem volume growth was achieved by limiting the length of pruned stem to 25 percent of the total tree height, both in 2003 and over the 4 years. Tree growth reductions with stems pruned above 25 percent of total tree height in this study are inconsistent with the Oregon State University Extension recommendation to limit pruning to 50 percent of total height (Hibbs 1996).

There was no significant difference in the number of sprouts and sprout weight between the trees pruned in March and trees pruned in May (Table 1). There was no significant difference in growth between trees pruned in March and trees pruned in May.

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Table 1. Current and intended poplar pruning treatments and actual percentage of total height pruned (percentage of total height that is branch-free stem after pruning) in 2003. The amount of sprouting for trees pruned in winter is compared to spring. Trees were planted in April 1997. Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Pruning height* (ft from ground)						Actual percentage of total tree height that was pruned stem in March				No. of sprouts	Sprout weight	Time to prune sprouts
	1999	2000	2001	2002	2003	2004	2000	2001	2002	2003	#/acre	lb/acre	man-hours/ acre
1 Check	6	6	6	6	6	6	24.3	15.7	13.7	12.9			
2	6	6	9	12	15	18	22.2	22.9	26.1	28.1			
3	6	9	12	15	18	18	33.7	29.3	32.0	35.3	3,923	193.3	6.5
4	6	12	15	18	18	18	47.3	39.4	35.2	33.5			
5‡	6	9	12	15	18	18	33.7	31.5	34.8	38.7	2,956	123.3	4.9
LSD (0.05)							2.7	2.1	3.5	3.0	NS	NS	NS

*Stem height to which all side branches were removed in March of the respective year.
‡ Pruned in May. All others pruned when trees were dormant.

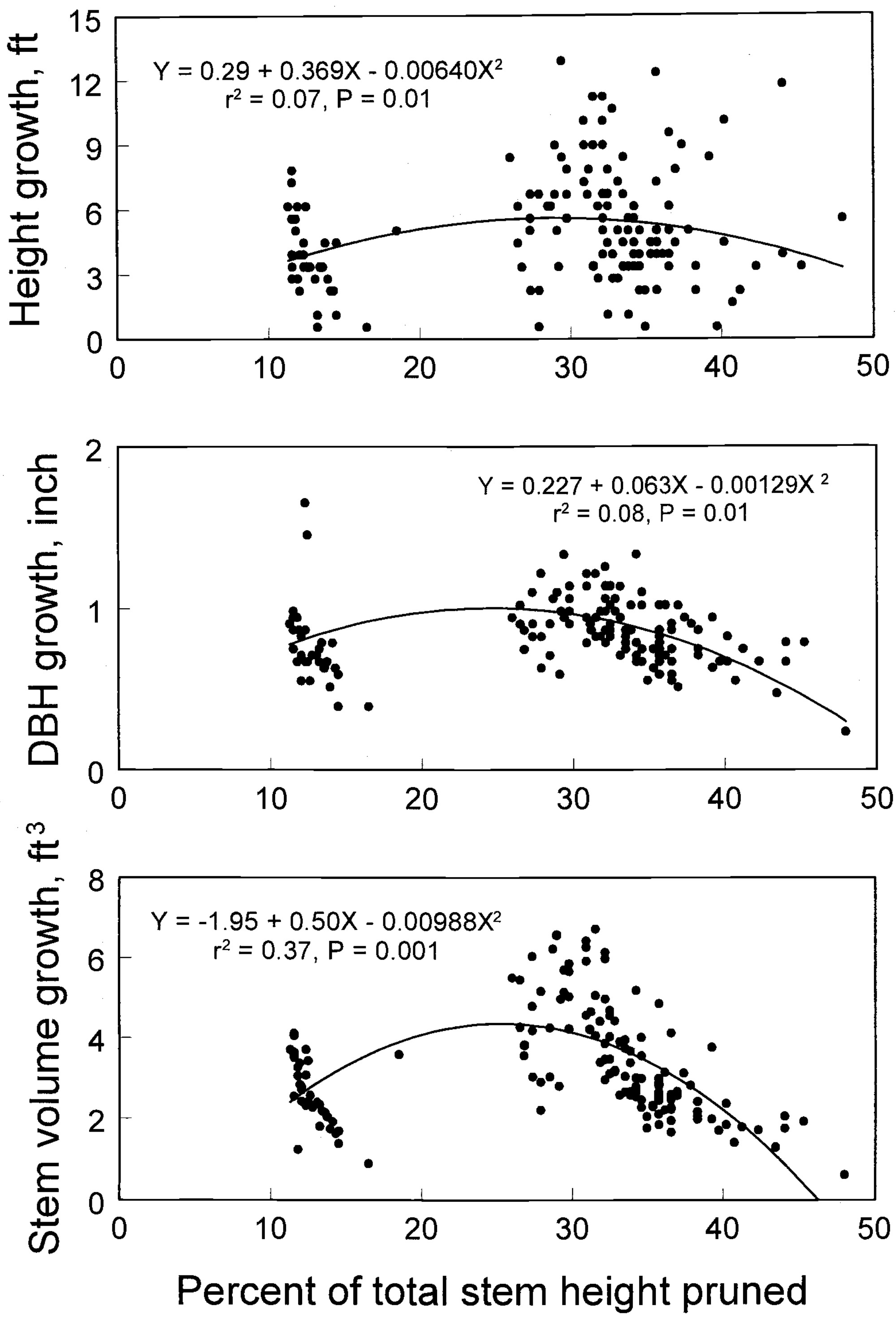

Figure 1. Poplar tree growth in 2003 in response to pruning severity, Malheur Experiment Station, Oregon State University, Ontario, OR.

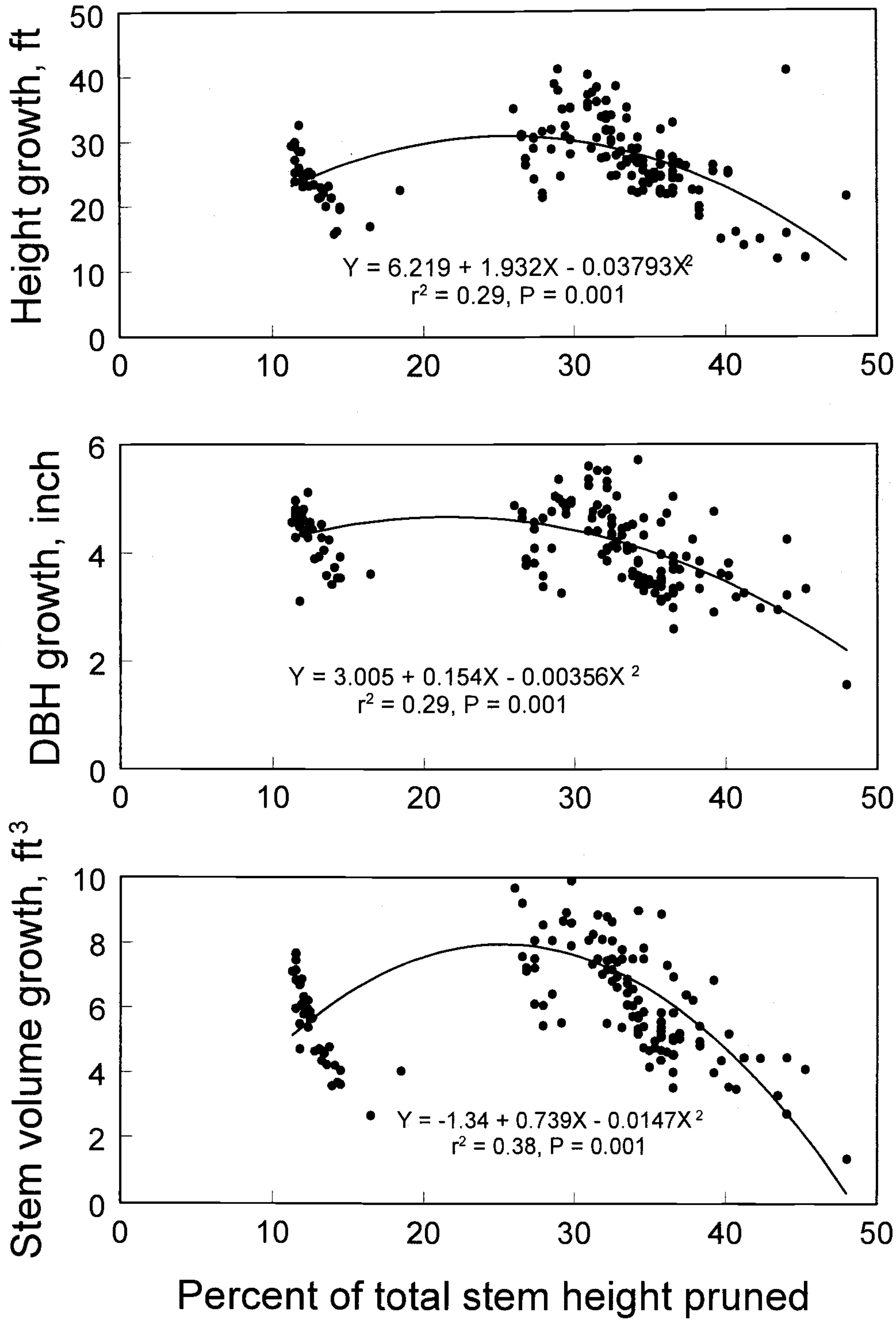

Figure 2. Poplar tree 4-year (2000-2003) growth in response to pruning severity, Malheur Experiment Station, Oregon State University, Ontario, OR.

SOYBEAN PERFORMANCE IN ONTARIO IN 2003

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Introduction

Soybean is a potentially valuable new crop for Oregon. Soybean could provide a high quality protein for animal nutrition and oil for human consumption, both 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 N_2-fixing capability. Because of the high-value irrigated crops typically grown in the Snake River valley, soybeans may be economically feasible only at 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. Those lines were 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 later two lines were crossed at our request for several years with early-maturing high-yielding semi-dwarf lines by R.L. Cooper to produce semi-dwarf lines with potential adaptation to the Pacific Northwest. Selection criteria at the Malheur Experiment Station included high yield, zero lodging, zero shatter, low plant height, and maturity in the available growing season. In 1992, 241 single plants were selected from five F5 lines that were originally bred and selected for adaptation to eastern Oregon. Seed from these selections was planted and evaluated in 1993. A total of 18 selections were found promising and selected for further testing in larger plots from 1994 through 1999. Of the 18 lines, 8 were selected for further testing. In 1999, selections from one of the lines were made by Peter Sexton at the Central Oregon Agricultural Research and Extension Center in Madras, Oregon. Sixteen of these Madras selections were chosen for further testing. In 2000 selections were made from six of the 1992 Ontario lines and from OR-6. This report summarizes work done in 2003 as part of the continuing breeding and selection program to adapt soybeans to eastern Oregon.

Methods

The trial was conducted on a Greenleaf silt loam previously planted to soybean. Fifty lbs of P, 100 lb of K, 2 lb of Cu, and 1 lb of B were broadcast in the fall of 2002. The field was then disked twice, moldboard plowed, groundhogged twice and bedded to 22-inch rows.

Five commercial cultivars, 5 older lines selected at the Malheur Experiment Station in 1992, 9 lines selected in 1999 at the Central Oregon Agricultural Research and Extension Center, and 24 lines selected in 2000 at the Malheur Experiment Station were planted in plots four rows by 25 ft. The plots were arranged in a randomized complete block design with four replicates. The seed was planted on May 23 at 200,000 seeds/acre in rows 22 inches apart. *Rhizobium japonicum* soil implant inoculant was applied in the seed furrow at planting. Emergence started on May 28. The field was furrow irrigated as necessary. The field was sprayed on July 16 with Warrior at 0.03 lb ai/acre and Lannate at 0.4 lb ai/acre for lygus bug and stinkbug control. The field was sprayed again on August 4 with Dimethoate at 0.4 lb ai/acre for stinkbug, lygus bug, and spider mite control.

Plant height and reproductive stage were measured weekly for each cultivar. Stand counts were made in 3 ft of the middle two rows in each plot. 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 rows in each four-row plot were harvested on October 8 using a Wintersteiger Nurserymaster small plot combine. Beans were cleaned, weighed, and oven dried to determine moisture content. 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

Yields ranged from 13.5 bu/acre for '203' to 61.6 bu/acre for 'M92-085' (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. Considerable yield advantages were obtained through continued selection.

Table 1. Performance of soybean cultivars ranked by yield in 2003, Malheur Experiment Station, Oregon State University, Ontario, OR. Cultivars M92-085 through M92-350 are from single plant selections made at the Malheur Experiment Station in 1992. Cultivars M1 through M16 are from single plant selections made from M92-330 by Peter Sexton at the Central Oregon Agricultural Research and Extension Center in Madras, OR in 1999.

Cultivar	Origin	Days to maturity	Days to harvest maturity	Lodging	Height	Seed count	Yield
		days from emergence		0-10	cm	seeds/lb	bu/acre
M92-085		100	107	3.3	90	2,021	61.6
M1		93	100	2.3	89	2,122	59.7
107	M92-085	93	100	2.5	90	2,073	59.5
Lambert		107	114	8.3	87	2,461	58.6
M2		100	107	3.3	87	2,065	57.9
104	M92-085	93	100	3.8	96	2,189	57.5
305	M92-220	107	114	1.8	93	2,421	57.4
M12		100	107	4	93	2,092	56.1
M16		93	100	2	93	2,123	55.6
M9		93	100	4	93	2,143	55.4
106	M92-085	100	107	2.3	91	2,004	55.4
M4		93	100	1.8	92	2,061	55.3
103	M92-085	100	107	2.5	88	1,937	55.3
Korada		107	114	3.8	88	2,333	55.2
303	M92-220	107	114	1.3	89	2,500	54.7
307	M92-220	100	107	1	84	2,509	54.5
601	M92-314	100	107	1.3	92	2,336	54.4
108	M92-085	100	107	2.5	90	2,048	54.3
313	M92-220	107	114	3.3	86	2,491	53.8
511	M92-237	100	107	1.3	83	2,388	53.8
M13		93	100	2.5	82	2,156	53.2
909	OR-6	93	100	6.8	80	2,300	53.2
312	M92-220	100	107	1	86	2,586	53.1
514	M92-237	93	100	0.3	88	2,166	52.5
M15		93	100	3.5	93	2,046	52.4
M3		93	100	2.3	90	2,089	52.1
311	M92-220	100	107	0.3	82	2,476	51.1
905	OR-6	93	100	6.8	80	2,428	50.3
M92-225		93	100	2.5	90	2,026	50.1
OR-6		93	100	7.8	74	2,282	49.6
M92-220		107	114	3.5	98	2,433	49.5
101	M92-085	100	107	2.5	89	1,975	49.5
608	M92-314	93	100	2	90	1,951	49.5
308	M92-220	107	114	1.3	86	2,491	49.4
Gnome 85		107	114	8.3	67	2,216	48.7
309	M92-220	107	114	1.5	93	2,480	48.4
Evans		107	114	9	74	2,164	41
Sibley		114	121	8.5	84	2,280	40.5
OR-8		107	114	8.5	82	2,272	39.4
211	M92-213	100	107	0	65	1,904	20.9
208	M92-213	107	114	0	53	1,822	14.3
202	M92-213	100	107	0	55	1,850	13.6
203	M92-213	100	107	0	65	1,892	13.5
LSD (0.05)				1.4		152	10.7

PREDICTING THE SPREAD AND SEVERITY OF POTATO LATE BLIGHT (*PHYTOPHTHORA INFESTANS*) IN OREGON, 2003

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Abstract

The 2003 season was not conducive to the development of late blight, therefore growers were able to save on fungicide applications for potato late blight control during 2003. Late blight was not predicted in 2003 at Klamath Falls, Malin, Culver, Madras, Ontario, or Owyhee Junction (near Adrian), and did not occur. Late blight was only predicted at Tulelake at the end of the season during harvest.

Seven potato fields in the Treasure Valley, central Oregon, and the Klamath Basin were monitored for temperature, relative humidity, and leaf wetness in the plant canopy. These data and rainfall data were recorded every 10 minutes and the data were forwarded via cellular phone daily to the Malheur Experiment Station. Data were used to estimate real-time late blight risk, using a model to predict potato late blight. Those estimates were distributed four to five times a week via the station web site at http://www.cropinfo.net/Potatoblight/blightcast.htm and e-mail.

Introduction

Economic Importance

Before the 1995 growing season, potato late blight (*Phytophthora infestans*) was not a management concern in the Treasure Valley, central Oregon, or the Klamath Basin. During the 1995 season, late blight spread rapidly throughout the Treasure Valley from initial outbreaks in low-lying, humid areas. Treasure Valley growers made three to six fungicide applications in 1995 at great expense. Lack of adequate late blight control in 1995 in the Treasure Valley resulted in yield losses and some losses during storage. Late blight outbreaks in 1997 and 1998 in the Klamath Basin also have caused considerable economic loss.

The ability to predict when late blight is most likely to cause economic loss and when conditions are conducive to its rapid spread would aid in grower decisions as to the necessity and timing of fungicide applications. The refinement of late blight predictions could save growers money by improving the efficiency of control measures. Accurate late blight predictions are needed now for areas both where the disease normally occurs and areas, such as the Treasure Valley and the Klamath Basin, where it has not been a problem in the past.

The Wallin Model

The Wallin model uses hours of duration of relative humidity above 90 percent along with the corresponding temperature range to calculate the extent to which the daily environment has been favorable for potato late blight disease development. The Wallin model program used at the Malheur Experiment Station accumulates environmental conditions favorable for the development of late blight, which are called "severity values." When the severity value total reaches 18, late blight is predicted and additional fungicide control measures are indicated. The Wallin and other predictive models are being compared to the actual onset and development of late blight. It is essential that instruments are monitoring field conditions from the beginning of potato emergence.

The Blitecast Model

Blitecast is a program module for late blight prediction that is part of the "Wisdom" software for potato crop and pest management from the University of Wisconsin, Madison. Like the Wallin Model, the Blitecast model uses hours of duration of relative humidity above 90 percent along with the corresponding temperature range to calculate the extent to which the daily environment has been favorable for disease development. The Blitecast model also includes rainfall duration and intensity in the risk for late blight, yet rainfall factors are usually not pertinent in arid eastern Oregon. The Blitecast program accumulates environmental conditions favorable for the development of late blight, which are called "severity values." When the severity value total reaches 18, late blight is predicted and additional fungicide control measures are indicated.

Objectives

1. Provide daily predictions of the risk of the expansion of potato late blight during the 2003 season in the Treasure Valley, Klamath Basin, and central Oregon using the Wallin model.

2. Help protect growers from economic loss to late blight. Help growers reduce their cost of production by avoiding unnecessary applications of fungicides.

3. Automate the collection of data from weather stations in growers' fields and AgriMet stations. Predictive models for potato late blight need to be adapted to the relatively arid areas of Oregon where potato growers are now suffering economic losses from late blight. Arid summer weather was not originally envisioned in the development of the Wallin model and other models to predict late blight.

Methods

During 2000, a visual basic program was refined at Ontario to allow the direct application of raw field weather data to a wide range of disease prediction models.

Model variations used included the substitution of leaf wetness for the duration of 90 percent relative humidity and the use of different relative humidity and leaf wetness criteria. The use of alternative criteria is not reported here.

During the 2003 season, data were collected from stations in seven potato fields and several AgriMet weather stations. Each of the seven stations in growers' fields consisted of a relative humidity sensor, a temperature sensor, a tipping bucket rain gauge, two Campbell Scientific Leaf Wetness Sensors (237LW, Campbell Scientific, Logan, UT), a portable stand, a data logger with battery and solar panel, a modem, and a cellular phone. Temperature, leaf wetness, and relative humidity in the plant canopy and the rainfall were recorded every 10 minutes. Data were forwarded daily via cellular phone or notebook computer to the Malheur Experiment Station. Weather data from outside of the crop canopy were collected every 15 minutes from seven AgriMet stations closest to the monitored commercial potato fields and forwarded electronically to the Malheur Experiment Station.

Data were used to estimate real-time late blight risk using the same relative humidity and temperature criteria used in the Wallin model, and those estimates were distributed via the station web site and e-mail.

Results, Discussion, and Conclusions

Disease Development and Predictions

The 2003 season was not conducive to the development of late blight. Late blight was not predicted in 2003 at Klamath Falls, Malin, Culver, Madras, Ontario, Nyssa, or Adrian, and did not occur. During the 2003 season, environmental conditions were favorable for the rapid spread of late blight at Tulelake in the Klamath Basin very late in the season, but late blight was apparently not present. The evaluation of the results of the last couple of years indicates only part of the value of predicting potato late blight. Access to late blight predictions since the program began has helped growers reduce fungicide costs by not making unneeded applications. The prediction of late blight before it has occurred has allowed timely fungicide applications and control of late blight.

Treasure Valley

Infield data were collected from four stations in 1996 and 1997, three stations in 1998-2002, and two stations in 2003. Starting in 1996, growers had access to late blight predictions.

Environmental conditions at Ontario, Nyssa, and Owyhee Junction near Adrian were particularly dry in 2000-2003. The estimated accumulated severity values did not pass 9 at any location; the threshold value is 18 (Fig. 1). The late blight outbreak was severe in 1995 prior to the beginning of this program (Fig. 2). Late blight was predicted before it occurred in both 1996 and 1997. Late blight was first detected close to Parma, Idaho near the Idaho-Oregon border on August 21, 1996, and on July 17, 1997. Between 1998 and 2003 late blight was not predicted and was not detected in these areas.

Central Oregon
Starting in 1997, the data collection in the potato canopy and late blight predictions were extended to Madras. Two stations have collected data near Madras since 1998. The Wallin model did not predict late blight in 1997-2003 and the occurrence of late blight was not recorded. The air in potato canopies was very dry at Culver (Fig. 3) and Madras (Fig. 4), resulting in low accumulation of severity values in recent years.

Klamath Basin
A single station was set up south of Klamath Falls in 1997, and three stations were used in 1998-2003 (Fig. 5). In 2003 late blight risk accumulated in late July and mid-August (Figs. 5 and 8).

In 1997, Wallin model severity values reached 17 at Klamath Falls before late blight was found in Tulelake, California (considerably to the south of the single in-field weather station). In 1998, late blight was found on a few isolated plants on July 10 before it was predicted on July 26. The Klamath Falls late blight epidemic in 1998 occurred later in August after it had been predicted (Fig. 6). The duration of high humidity in 2001 caused the severity index to reach 14 at Henley during 2001, in part due to irrigation patterns during the day that resulted in the potato canopy remaining wet from one night through to the next night on several occasions (Fig. 7). During the 2002 season, high humidity and a high severity index were caused by irrigation patterns. After the irrigation criteria was altered, no more severity values accumulated during the season. In 2003 late blight risk accumulated in late July and mid-August (Figs. 5 and 8).

Summary
In conclusion, the Wallin model worked well with the 90 percent relative humidity criteria to predict late blight in recent years, and the automated handling of data facilitated rapid evaluation and transmission of results.

Cooperators and Acknowledgments

We acknowledge the indispensable support of the Oregon Potato Commission for the last 6 years, as well as contributions by the regional growers' associations. This work would not have been possible without the cooperation of Steve James, Kerry Locke, Ken Rykbost, Harry Carlson, Brian Charlton, Don Kirby, Rob Hibbs, Al Mosley, Steve Iverson, Tom Kirsch, Wes Hagman, Jerry and Dave Mizuta, Bob and Alan Peterson, Bruce Corn, Doug Tracy, Kirk Kirkpatrick, Larry Cheyne, Jr., Steve Cheyne, Mark Trotman, Roy Hasebe, Rod Blackman, Mike McVay, and Dan Chin. Constructive suggestions by Ken Rykbost and Al Mosley have been appreciated greatly.

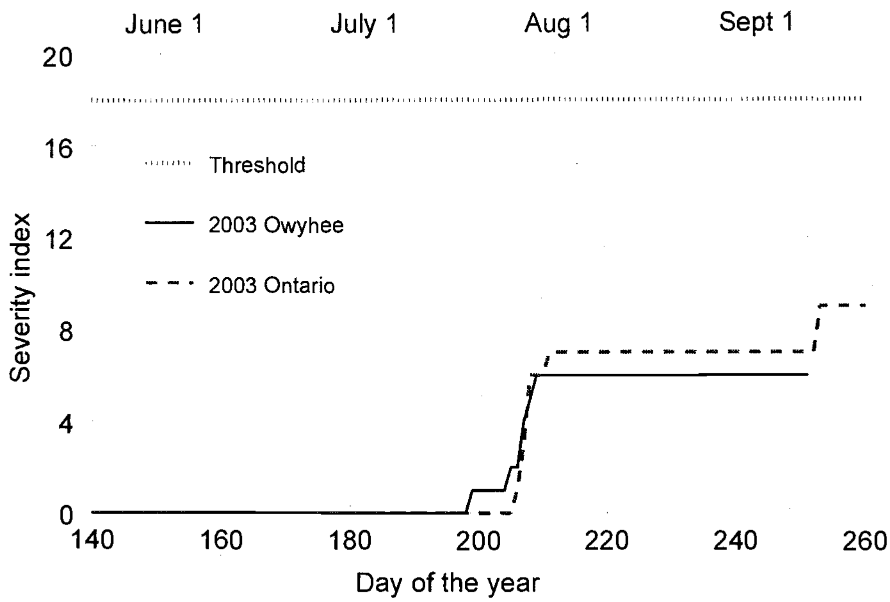

Figure 1. Comparison of two Treasure Valley locations (Ontario and Owyhee Jct. near Adrian) in the accumulation of estimated late blight risk during the 2003 season. Low relative humidity was associated with low accumulation of severity values in 2003; Malheur Experiment Station, Oregon State University, OR.

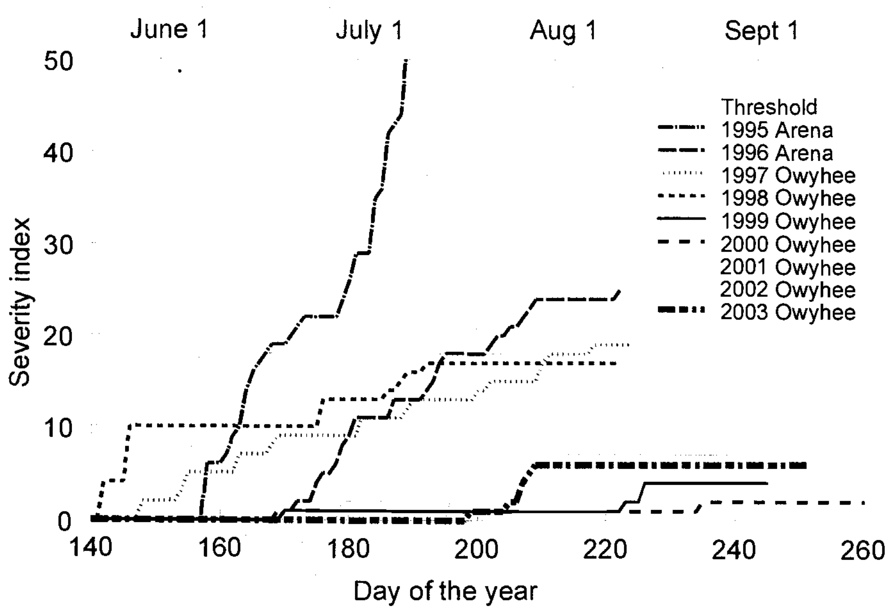

Figure 2. Comparison of late blight risk estimates over the last 9 years in the Treasure Valley. A severe late blight outbreak in 1995 was followed by a few late blight detections in 1996 and 1997. Late blight has not been predicted or detected the last 6 years; Malheur Experiment Station, Oregon State University, OR, 2003.

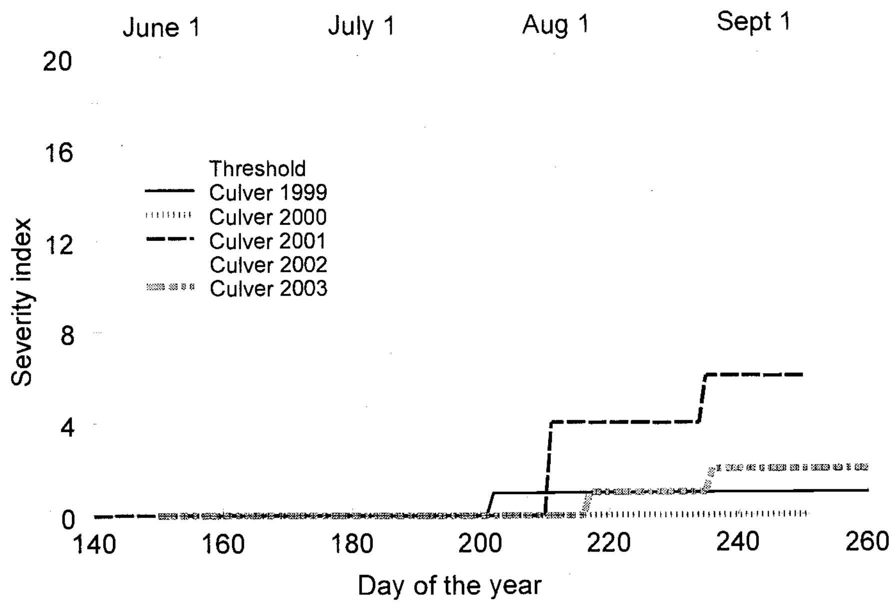

Figure 3. Accumulated severity values have remained low at Culver, Central Oregon during the last five seasons; Malheur Experiment Station, Oregon State University, OR, 2003.

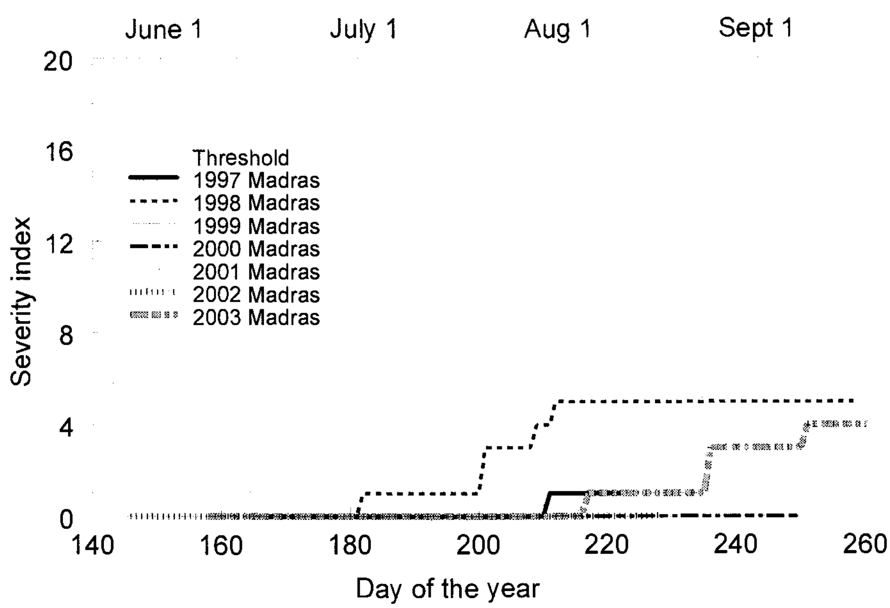

Figure 4. Accumulated severity values have remained low the last seven seasons at Madras in Central Oregon; Malheur Experiment Station, Oregon State University, OR, 2003.

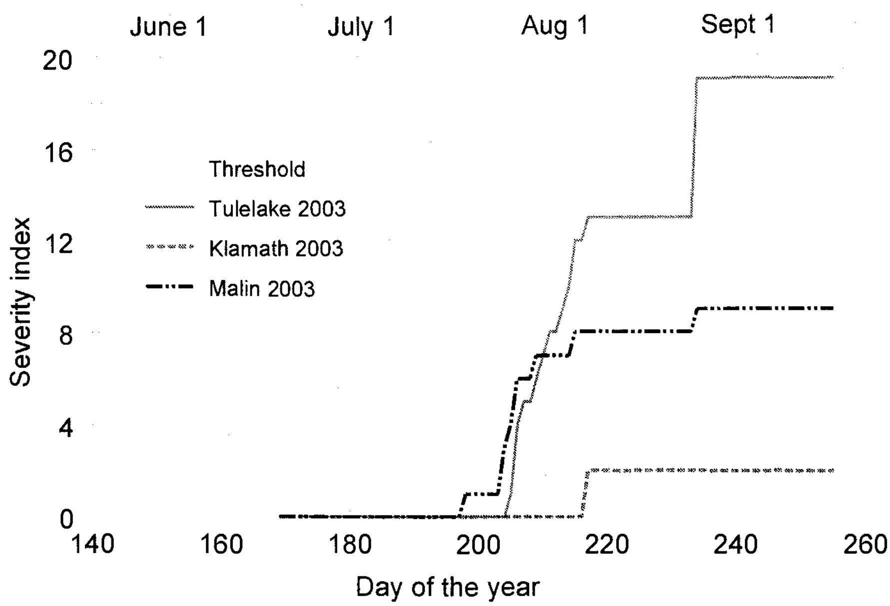

Figure 5. Comparison of three Klamath Basin locations in the accumulation of estimated late blight severity values during the 2003 season; Malheur Experiment Station, Oregon State University, OR.

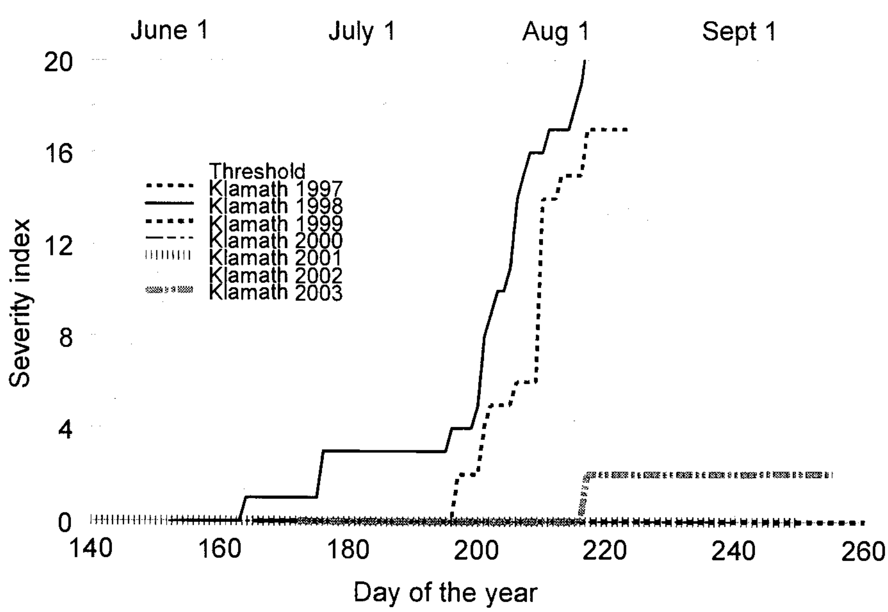

Figure 6. Comparison of late blight risk estimates over the last 7 years in the vicinity of Klamath Falls. Rapid accumulation of severity values in 1997 and 1998 was followed by losses to late blight. Risk estimates were low during 1999-2003; Malheur Experiment Station, Oregon State University, OR, 2003.

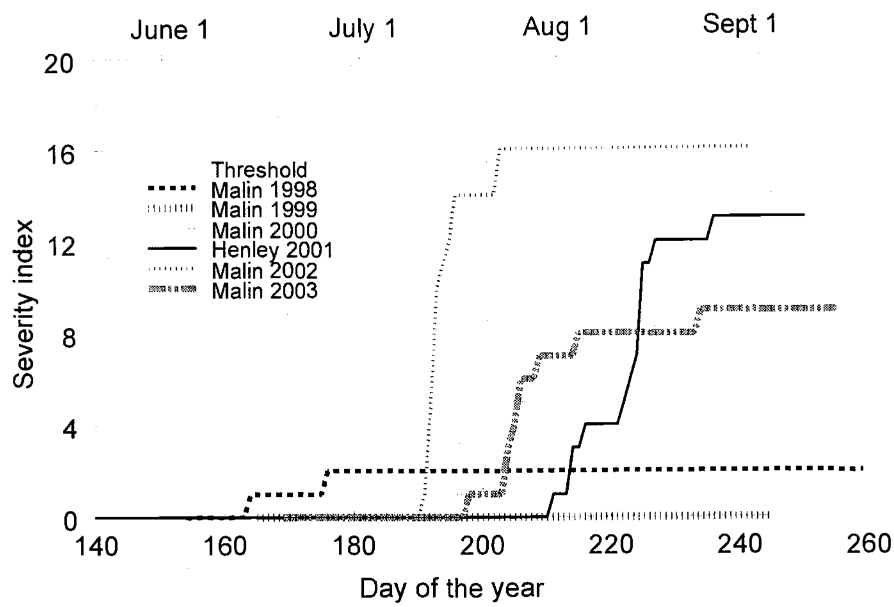

Figure 7. Comparison of the accumulation of estimated late blight severity values near Malin over the last 5 years. The severity index reached 18 at Malin only near the end of the 2000 growing cycle, apparently due to irrigation practices; Malheur Experiment Station, Oregon State University, OR, 2003.

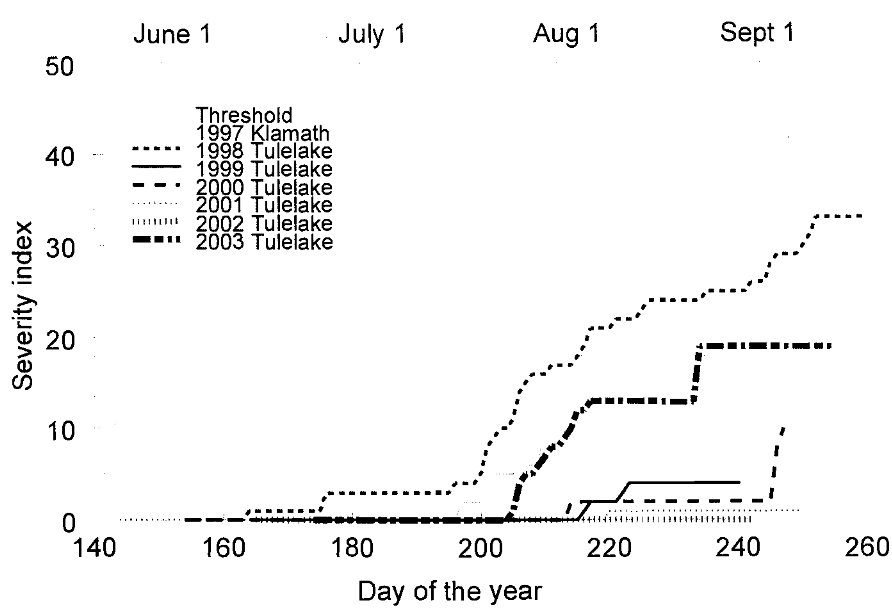

Figure 8. Comparison of late blight risk estimates over the last 7 years in the vicinity of Tulelake. Rapid accumulation of severity values in 1997 and 1998 was followed by losses to late blight; Malheur Experiment Station, Oregon State University, OR, 2003.

POTATO VARIETY TRIALS 2003

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Introduction

Potatoes are grown under contract in Malheur County for potato processors to produce frozen products for the food service industry. There is very little production for fresh pack or open market, and very few growers have potato storage buildings on their farms. There is also no production of varieties for making potato chips. There is no potato seed production in Malheur County because high populations of aphids result in virus infection in the tubers. The varieties grown are mainly 'Shepody', 'Ranger Russet' and 'Russet Burbank'. Harvest begins in July, providing potatoes to processing plants directly from the field. Yields are limited by "early die" syndrome, causing early senescence of the vines. Early die is caused by a complex of soil pathogens, including bacteria, nematodes, and fungi, and is worse when rotations between potato crops are shorter.

Small acreages of some advanced selections or new varieties are contracted by processors each year to study the feasibility of expanding the use of the new varieties. 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 Russet Burbank. The tubers need to have low reducing sugars for light, uniform 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 if it is a variety for early harvest. Or, if it is a late-harvest variety, it should be resistant to early die.

Potato variety development trials at Malheur Experiment Station in 2003 included a trial of 9 selected strains of Umatilla Russet, an 8-Hill trial of 54 long russet clones from the USDA Agricultural Research Service (ARS) potato breeding program at Aberdeen, Idaho; the Oregon Preliminary Yield Trial with 99 entries; the Oregon Statewide Trial with 28 entries; the Western Regional Early Harvest Trial with 19 entries; and the Western Regional Late Harvest Trial with 17 entries. Through these trials and active cooperation with other scientists in Idaho, Oregon, and Washington, promising new lines are bred, evaluated, and eventually released as new varieties.

Materials and Methods

The six potato variety trials were grown under sprinkler irrigation on Owyhee silt loam, where winter wheat was the previous crop. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken September 9, 2002 showed 18 ppm NO_3, 18 ppm P, 306 ppm K, organic matter 2.2 percent, and pH 7.6. Fall fertilizer was broadcast to apply 21 lb N/acre, 100 lb P_2O_5/acre, 60 lb K_2O/acre, 60 lb S/acre, 30 lb Mg/acre, 4 lb Zn/acre, 2 lb Cu/acre, 1 lb Mn/acre, and 1 lb B/acre. The field was ripped, Telone II was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Seed of all varieties was hand cut into approximately 2-oz seed pieces and treated with Tops-MZ + Gaucho dust 1-2 weeks before planting and placed in storage at approximately 90 percent relative humidity and 45°F to suberize. On April 4, 2003, Roundup was applied at 1 qt/acre to control winter annual weeds and volunteer wheat. The Western Regional Early Harvest Trial was planted on April 10, 2003, the Preliminary Yield Trial was planted on April 17, and the other trials were planted on April 18. The 8-Hill Trial was unreplicated, the Preliminary Yield Trial had two replicates, and the Umatilla Strain, Statewide, Western Regional Early Harvest, and Western Regional Late Harvest trials each had four replicates.

Potatoes were planted in single row plots using a two-row cup planter with seed spacing 9 inches in the row, with rows 36 inches apart. Red potatoes were planted between each pair of plots to serve as markers to separate the plots at harvest. After planting, hills were formed over the rows with a Lilliston rolling cultivator. Prowl at 1 lb/acre plus Dual at 2 lb/acre was applied on May 1 and was incorporated by a total of 0.42 inch of rain May 3-5. Matrix herbicide was applied at 1.25 oz/acre on May 28 and was incorporated with a 1.5-inch sprinkler irrigation on May 29.

Fungicide applications to help control early blight and prevent late blight infection started with an aerial application of Ridomil Gold and Bravo at 1.5 pint/acre on June 7, which was repeated on June 25. Bravo fungicide plus liquid sulfur was applied by aerial applicator on July 2, and again on August 8. Sulfur dust was applied by aerial applicator on July 20 at 40 lb S/acre to prevent mite infestation and powdery mildew infection.

Petiole tests were taken every 2 weeks from June 12, and fertilizer was injected into the sprinkler line during irrigation to supply the crop nutrient needs. A total of 103 lb N/acre, 50 lb P_2O_5/acre, 21 lb K_2O/acre, 53 lb SO_4/acre, 40 lb S/acre, 0.5 lb Mg/acre, 0.55 lb Mn/acre, 0.32 lb Cu/acre, 0.1 lb Fe/acre, and 0.02 lb B/acre were applied. The sprinkler system was operated 22 times, from May 29 to September 23, with scheduling based on potato evapotranspiration (ET), which was calculated based on measurements made by a U.S. Bureau of Reclamation AgriMet weather station at the Malheur Experiment Station. The soil water potential was monitored with 6 Watermark soil moisture sensors (Irrometer Co. Inc., Riverside, CA) logged every 8 hours by a Hansen AM400 (M. K. Hansen Co., East Wenatchee, WA). The AM400 unit was read frequently through the summer to predict crop water needs, with the objective to apply an irrigation just before the average soil moisture in the potato root zone at the seedpiece depth reached -60 kPa. Water applied was measured by recording the sprinkler set duration at 55 psi.

Vines were flailed in the early harvest trial on August 19, and in the late harvest trials on October 2. The vines of most varieties had died by the date of the last irrigation on September 23. Western Regional Early Harvest Trial potatoes were lifted August 20 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 made of tuber defects such as growth cracks, knobs, curved or irregularly shaped tubers, pointed ends, stem-end decay, stolons that remained attached, folded bud ends, rough skin due to excessive russetting, pigmented eyes, or any other defect, and a note 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. After grading, a 20-tuber sample from each plot in the Western Regional Early Harvest Trial was evaluated for tuber quality traits for processing. Specific gravity was measured using the weight-in-air, weight-in-water method, and 10 tubers per plot were cut lengthwise and examined for internal defects. Center slices from 10 tubers 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 model 577 Photovolt Reflectance Meter (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.

The potatoes in the Preliminary Yield Trial were dug on October 7, and the potatoes in the Statewide Trial on October 8. Western Regional Late Harvest and 8-Hill Trial tubers were dug on October 14, and the Umatilla Strain Trial tubers were dug on October 15. At each harvest, the potatoes in each plot were visually evaluated. Tubers were graded and a 20-tuber sample from each plot was placed into storage. The storage was kept near 90 percent relative humidity and the temperature was gradually reduced to 45°F. Tubers were removed from storage November 3 through 13 and evaluated for tuber quality traits, specific gravity, and fry color as described above.

Results and Discussion

At the Malheur Experiment Station in 2003, spring weather was cool and wet, followed by prolonged heat and a record high temperature on July 22 of 110°F. The extreme heat stressed the potato plants, causing reduced yields and early senescence. Dry weather prevented late blight from developing in 2003. No powdery mildew or mite problems were observed in the field.

Precipitation for May 1 through September 30 was 2.38 inches, the crop ET for the late-harvest trials totaled 30.34 inches, and the trials received 31.19 inches of irrigation plus precipitation, or 103 percent of crop ET (Fig. 1). The step increases in the irrigation plus rainfall curve show the 22 sprinkler irrigations applied during the growing season.

The trend of soil moisture during the growing season is shown in Figure 2. The data were not recorded frequently enough to show the individual irrigations, and the sensors did not always respond to an irrigation. Although the irrigation plus rainfall was in excess of the AgriMet ET prediction through the growing season, sensor data show that average root zone soil water potential became drier than -60 kPa at least three times during the hottest part of the season.

Soil water potential at the seedpiece depth was allowed to become drier than -60 kPa at the end of the growing season, after the vines died on the early maturing varieties, by applying frequent sprinkler irrigations of short duration, as shown in Figure 1. This was necessary to avoid swollen lenticels and the associated potential for rotting the tubers of the early senescing varieties, while continuing to apply the ET requirement for the late maturing varieties in shallow moisture increments.

Umatilla Strain Trial

This was the first year of a Umatilla Strain Trial, which was conducted at this location (MES) and also at the Hermiston Agricultural Research and Extension Center (HAREC). Umatilla Russet was released jointly by the Oregon, Idaho, and Washington Agricultural Experiment Stations and the USDA ARS in 1998, and over the years some plants had been selected in the field that appeared to be superior strains. Nine of these strains were compared to Russet Burbank and Umatilla Russet (Table 1). Four of the strains had adequate yield, produced a high percent of U.S. No. 1 tubers and had acceptable processing quality. Based on the data from MES and HAREC trials, UM407, UM418, UM432, and OURS311 were advanced to the 2004 Statewide Trial.

8-Hill Trial

Eight hills were grown of each of 54 clones selected for long, russeted tubers from the Aberdeen ARS potato breeding program, including 11 clones with the LB suffix that were bred for resistance to late blight. The 54 clones were evaluated for tuber type, yield, grade, and processing quality (Table 2). Several of the clones had high yields, produced a high percent of U.S. No. 1 tubers, and had good processing quality. The clone 'A96112-20' yielded a total of 905 cwt/acre, with 90 percent U.S. No. 1 grade tubers, specific gravity of 1.0978 g/cm^3, and an average fry strip light reflectance of 49.5 percent, which was acceptable for processing, with 0 percent sugar ends. The clone 'A96783-109LB' yielded 828 cwt/acre total, with 91 percent U.S. No. 1 grade, with specific gravity 1.1092, and fry strip light reflectance of 45.3 percent. The clone 'A99123-1' yielded 751 cwt/acre total, with 97 percent U.S. No. 1 grade, with specific gravity 1.0887, fry strip light reflectance of 49.1 percent and 0 percent sugar ends. The clone 'A99133-6' produced a total yield of 769 cwt, with 99 percent U.S. No. 1, specific gravity 1.1038, average fry strip light reflectance 54.4, and 0 percent sugar ends.

Preliminary Yield Trial

In the Preliminary Yield Trial, 94 numbered clones were compared to Russet Burbank, Ranger Russet, Shepody, 'Norkotah', and 'Umatilla Russet' (Table 3). The Oregon potato variety selection committee kept 12 clones to advance to the Statewide Trial for 2004. The clones that were advanced were: 'AO9006-4', 'AO94007-1', 'AO96047-2', 'AO96073-2', 'AO96162-1', 'AO98114-2', 'AO98141-2', 'AO99002-4', 'AO99002-7', 'AO99024-8', 'AO99060-5', and 'AO99099-3', and are marked with an asterisk in the entry list. These clones yielded well across the four locations (Hermiston, Klamath

Falls, and Powell Butte data are not shown in this report), had low incidence of undesirable characteristics, had high percent U.S. No. 1 grade tubers, and if selected as promising clones for processing, had high specific gravity and light fry color.

Oregon Statewide Trial

In the Oregon Statewide Trial, five clones were retained by the variety selection committee, 'AO96160-3', 'AO96141-3', 'AO96205-3', 'AO98133-2' and 'AO98133-4' will be maintained in the Statewide Trial in 2004 (Table 4). The clone 'AO96160-3' will be recommended for advancement to the Western Regional Trials for 2004, and 'AO96141-3' will be discarded unless there is interest in it from the other states.

At this location in 2003, AO96160-3 produced total yield of 452 cwt/acre, with 89 percent U.S. No. 1, specific gravity of 1.093 g/cm^3, and fry strip light reflectance of 52.2 percent, with no sugar ends. AO96141-3 produced total yield of 497 cwt/acre, with 75 percent U.S. No. 1, specific gravity of 1.091 g/cm^3, and fry strip light reflectance of 51.4 percent, and 3 percent sugar ends. AO96205-3 produced total yield of 534 cwt/acre, with 83 percent U.S. No. 1, specific gravity of 1.097 g/cm^3, and fry strip light reflectance of 47.9 percent with no sugar ends. AO98133-2 produced total yield of 395 cwt/acre, with 94 percent U.S. No. 1, specific gravity of 1.098, and fry strip light reflectance of 51.6 percent, with 3 percent sugar ends. AO98133-4 produced total yield of 380 cwt/acre, with 83 percent U.S. No. 1, specific gravity of 1.095, and fry strip light reflectance of 44.5 percent, with 8 percent sugar ends. Russet Burbank had 63 percent sugar ends, far more than any other variety.

Western Regional Early Harvest Trial

In the Western Regional Early Harvest Trial, 'A91814-5' with 641 cwt/acre total yield, 'A92294-6' with 608 cwt/acre total yield, Shepody with 603 cwt/acre, and Russet Burbank with 602 cwt/acre, were among the highest in total yields (Table 5). All of those clones except Russet Burbank had acceptable specific gravity and fry color. In production of marketable tubers (the total of U.S. No.1 plus U.S. No. 2 grades), Shepody with 574 cwt/acre, and Russet Burbank with 522 cwt/acre, were among the highest.

Western Regional Late Harvest Trial

In the Western Regional Late Harvest Trial, among the highest for total yield were, 'A91814-5' with 719 cwt/acre, 'A9305-10' with 714 cwt/acre, 'A92294-6' with 713 cwt/acre, Ranger Russet with 629 cwt/acre, 'A93157-6LS' with 627 cwt/acre, and Russet Burbank with 570 cwt/acre (Table 6). Among the highest for marketable yield, A9305-10 yielded 678 cwt/acre marketable yield, Ranger Russet produced 610 cwt/acre marketable yield, and A91814-5 yielded 576 cwt/acre marketable yield. Russet Burbank produced 279 cwt/acre U.S. No. 2 tubers, and A92294-6 produced 217 cwt/acre U.S. No. 2 tubers, which were significantly more than other clones in this trial. The clone A91814-5 produced 143 cwt/acre undersized tubers under 4 oz, significantly more than the other clones.

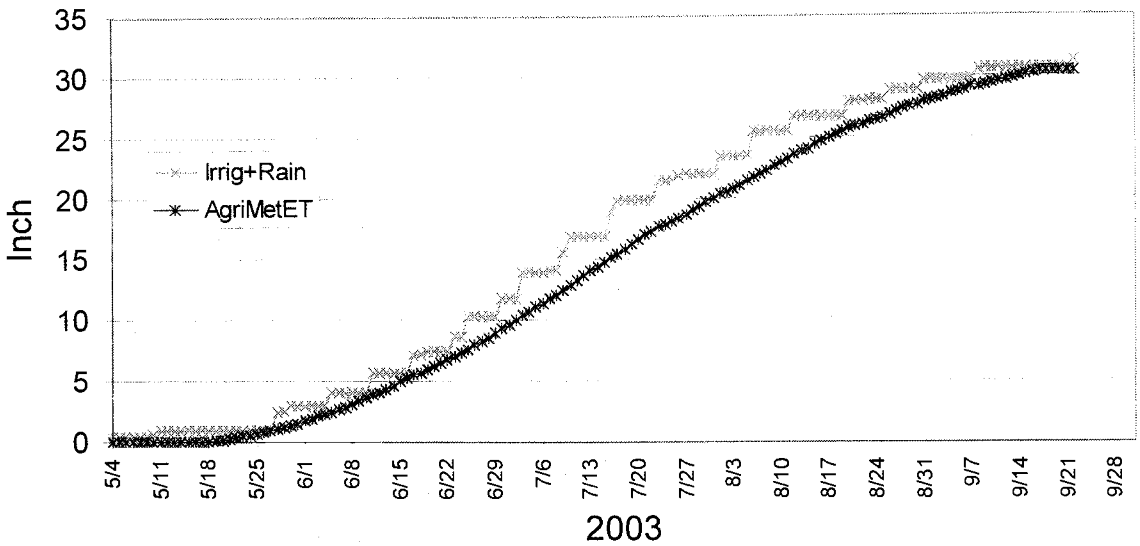

Figure 1. Evapotranspiration (ET) and sprinkler irrigation applied (plus rain) to potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

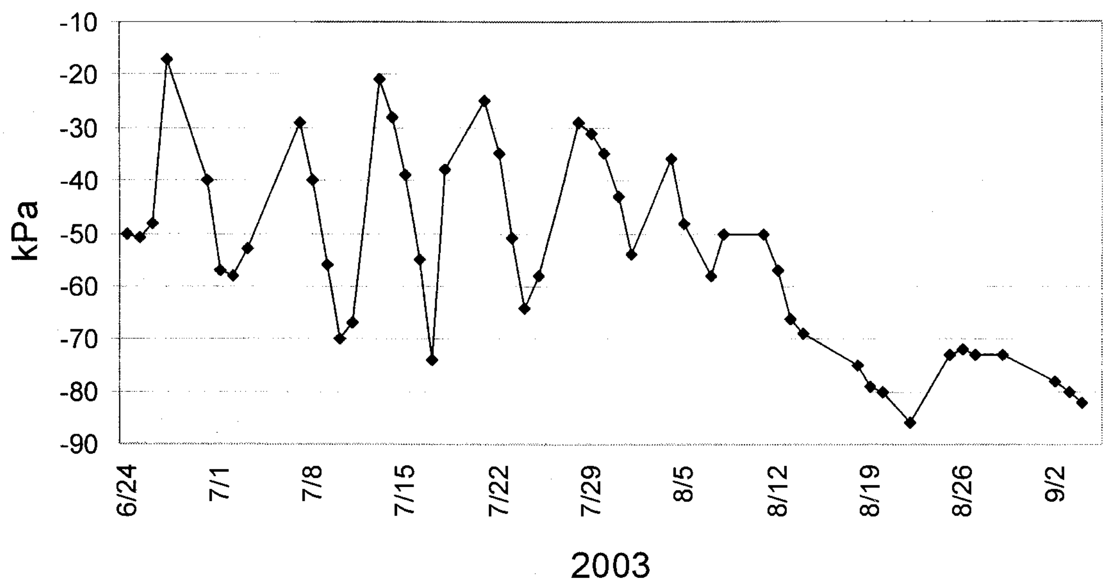

Figure 2. Soil moisture data for sprinkler-irrigated potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 1. Umatilla Strain Trial: yield, grade, and processing quality of Umatilla Russet strains grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Clone or Strain	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 4-6 oz	U.S. No. 1 6-12 oz	U.S.No. 2	Market-able	<4 oz	Rot	Length/ width	Specific gravity	Average fry color, light reflectance	Percent sugar ends
	cwt/acre	%					oz				ratio	g cm^{-3}	%	%
Russet Burbank	640.9	55.6	355.3	83.1	200.0	72.2	214.0	569.2	64.1	7.6	2.31	1.069	35.24	45.00
Umatilla Russet	660.1	72.1	474.4	175.8	231.1	67.5	141.3	615.7	40.8	3.6	1.95	1.082	44.66	0.00
*UM407	627.7	75.6	468.2	184.9	224.3	59.0	115.0	583.2	41.6	2.9	1.96	1.085	45.53	0.00
*UM418	590.2	81.8	480.6	159.5	248.2	72.9	67.8	548.4	41.1	0.7	1.88	1.086	47.20	0.00
*UM432	533.0	78.6	421.1	139.5	234.6	47.1	75.1	496.2	29.8	7.0	1.98	1.090	46.37	0.00
UM433	644.3	70.8	459.8	170.6	216.5	72.6	144.2	603.9	40.3	0.0	2.06	1.089	45.86	2.50
UM436	618.9	77.7	478.0	140.8	275.5	61.7	100.8	578.8	39.3	0.8	1.86	1.085	45.25	0.00
UM446	626.0	65.0	407.8	135.9	200.7	71.2	173.9	581.6	43.8	0.6	1.96	1.084	45.05	2.50
OURS307	633.0	63.1	400.5	151.7	192.4	56.4	192.6	593.2	39.3	0.5	2.05	1.090	44.49	5.00
*OURS311	632.3	79.5	502.8	159.9	267.6	75.2	89.9	592.7	37.8	1.8	1.89	1.084	48.17	0.00
OURS313	643.5	59.6	382.7	112.6	196.9	73.2	187.7	570.3	70.3	2.9	1.89	1.089	45.99	7.50
mean	622.7	70.9	439.2	146.7	226.2	66.3	136.6	575.8	44.4	2.6	1.98	1.085	44.89	5.68
LSD (0.05)	NS	7.5	NS	NS	53.3	NS	53.0	NS	15.5	NS	0.06	0.005	2.94	10.12

*Advanced to the 2004 Statewide Trial, based on the data from Malheur Experiment Station and Hermiston Agriculture Research and Extension Center.

Table 2. Yield, grade, and processing quality of 54 early selections in an unreplicated 8-Hill Trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 4-12 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}	%	%
A95061-67LB	715	85	607	78	353	177	617	10	97	1.62	1.077	44.2	0
A95061-93LB	709	89	630	454	123	53	693	63	16	1.86	1.095	44.8	0
A95061-94LB	869	92	803	234	422	147	815	12	54	1.75	1.105	47.5	0
A96002-38	560	91	509	315	165	29	521	12	40	1.79	1.102	54.8	0
A96002-55	706	85	598	308	239	52	675	77	31	1.96	1.076	44.5	0
A96005-31	960	69	660	260	307	94	917	256	44	1.78	1.091	49.3	0
A96108-16	807	85	685	164	405	116	685	0	122	1.64	1.087	43.4	10
A96108-27	599	80	479	79	374	27	496	17	103	1.88	1.085	39.9	20
A96111-12	779	68	527	49	344	133	665	137	114	1.59	1.102	41.9	10
A96112-20	905	90	816	272	503	41	854	38	31	2.04	1.098	49.5	0
A96783-109LB	828	91	754	212	470	73	754	0	74	1.57	1.109	45.3	0
A96783-114LB	706	76	535	308	189	39	672	137	33	1.71	1.095	47.2	10
A97044-107LB	930	81	757	120	399	238	838	80	92	1.55	1.087	35.6	10
A97044-112LB	762	91	693	313	285	95	707	14	55	1.50	1.103	46.2	0
A97110-27	623	97	602	362	211	29	602	0	21	2.50	1.068	34.1	60
A97110-29	466	86	399	105	218	76	441	42	25	1.88	1.094	41.7	0
A97130-22	805	82	658	140	455	64	762	104	43	2.04	1.08	49.9	10
A97130-25	630	87	550	258	239	53	558	8	62	2.08	1.080	51.3	0
A97130-28	608	89	541	60	410	70	581	41	26	2.00	1.086	51.1	0
A97179-29	608	90	548	211	297	39	582	34	26	1.71	1.090	51.9	0
A97198-20	607	81	493	62	297	135	567	74	39	2.33	1.082	46.8	0
A99001-7	529	88	468	165	228	74	468	0	62	1.80	1.086	41.4	10
A99006-3	655	87	568	81	386	101	576	8	79	1.62	1.0947	51.5	0
A99007-12	554	68	378	254	93	31	524	146	30	2.25	1.096	54.6	0
A99007-13	724	78	564	447	96	21	673	109	17	2.50	1.094	47.8	0
A99007-5	734	74	544	326	171	47	643	99	91	1.79	1.071	40.9	0
A99008-6	677	70	474	325	116	33	597	123	79	2.00	1.081	39.4	20

Table 2. *(continued)* Yield, grade, and processing quality of 54 early selections in an unreplicated 8-Hill Trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 4-12 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}	%	%
A99015-1	644	96	618	197	355	67	618	0	26	2.29	1.080	48.5	0
A99017-1	555	84	467	52	394	21	507	39	48	1.62	1.079	41.7	0
A99020-3	796	83	664	415	226	23	773	109	23	1.78	1.080	34.2	60
A99039-10	627	94	588	454	97	36	588	0	39	1.74	1.088	47.0	0
A99041-18	817	80	653	218	338	98	750	97	36	1.81	1.092	49.0	0
A99041-7	600	77	463	153	253	57	548	85	52	1.71	1.083	44.8	0
A99043-1	672	94	629	262	255	112	635	6	37	1.46	1.092	49.7	0
A99048-2	628	90	566	171	309	86	577	11	51	1.88	1.086	44.7	30
A99048-8	325	88	287	87	177	23	308	21	17	1.77	1.097	47.7	0
A99051-2	605	66	398	27	216	155	520	122	85	1.96	1.094	47.9	10
A99052-14	652	85	556	164	274	118	563	8	89	1.62	1.085	38.5	10
A99052-2	649	77	500	169	276	55	612	112	37	1.65	1.090	42.4	30
A99054-1	1082	93	1005	750	216	39	1060	55	23	1.81	1.085	46.8	10
A99054-8	563	77	434	160	239	35	497	62	66	1.85	1.068	35.0	70
A99068-9	925	90	829	297	416	116	894	66	31	1.75	1.091	44.5	0
A99073-1	851	82	698	555	136	8	836	137	15	1.48	1.083	47.9	0
A99080-3	964	83	803	619	153	31	936	133	28	1.89	1.094	47.4	0
A99123-1	751	97	727	358	309	60	727	0	24	1.69	1.089	49.1	0
A99133-6	769	99	759	454	283	22	759	0	10	1.64	1.104	54.4	0
A99394-55LB	611	84	516	102	308	106	535	19	76	1.48	1.101	48.3	0
A99394-58LB	1010	74	751	242	345	165	925	174	85	1.59	1.090	50.0	0
A99394-61LB	480	82	392	33	287	71	436	44	45	2.04	1.085	44.1	10
A99396-53LB	740	93	690	265	302	123	708	18	32	1.37	1.093	50.5	0
A99396-56LB	656	63	415	225	113	77	623	208	33	1.79	1.088	49.9	0
A99439-3	670	78	521	56	288	177	521	0	149	1.63	1.077	45.8	0
A99453-2	573	80	459	162	244	53	513	54	60	1.77	1.084	44.2	0
COA99163-7	687	75	517	266	165	86	647	130	41	1.88	1.082	49.3	0
Mean	703	84	588	238	273	76	650	62	51	1.8	1.089	45.9	7

Table 3. Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								ratio	g cm^{-3}	%	%
R. Burbank	422	55	228	8	130	91	135	363	54	0	2.3	1.063	40.5	20
Ranger	501	72	361	98	199	64	95	456	43	0	2.1	1.087	42.2	10
Shepody	466	69	328	116	153	59	119	447	18	0	1.8	1.084	51.6	0
Norkotah	370	88	325	26	221	77	1	326	44	0	1.8	1.070	35.4	0
Umatilla	460	80	367	44	218	106	34	401	59	0	2.0	1.083	47.2	0
AO94006-3	414	79	332	98	191	43	57	389	25	0	2.2	1.079	51.4	0
*AO94006-4	462	88	409	100	249	60	24	433	29	0	2.0	1.080	47.4	0
*AO94007-1	477	87	415	34	272	109	6	421	55	0	2.0	1.085	56.7	0
AO94020-1	446	82	368	24	243	101	17	385	61	0	2.0	1.070	42.6	5
AO94030-1	404	56	227	0	69	159	49	276	125	0	2.0	1.070	44.8	5
AO94032-2	433	86	373	38	219	117	15	388	45	0	1.3	1.081	55.5	0
AO94032-4	469	74	353	93	172	87	34	386	83	0	1.6	1.083	53.6	0
AO94047-1	316	73	232	0	131	101	12	244	72	0	2.0	1.083	50.9	0
AO94047-2	484	61	292	35	139	118	46	337	147	0	1.9	1.098	49.1	5
AO94047-3	480	72	344	34	198	113	51	396	85	0	2.3	1.077	50.0	0
AO94047-4	390	79	309	56	187	66	37	346	44	0	1.8	1.088	48.0	0
AO94048-1	275	70	198	9	114	75	6	204	70	0	1.8	1.088	54.2	0
AO95101-2	491	85	422	37	257	128	0	422	66	0	1.6	1.084	48.2	10
AO95101-3	396	54	214	36	104	74	147	360	34	0	2.3	1.084	53.6	0
AO95102-4	353	63	222	13	73	136	11	232	121	0	1.9	1.077	53.8	0
AO95102-6	301	79	241	55	139	46	24	265	37	0	1.5	1.086	49.9	5
AO95109-1	343	73	254	53	140	62	55	309	35	0	1.9	1.080	47.8	5
AO95154-4	568	79	452	154	228	70	68	520	48	0	2.4	1.084	47.3	0
AO95179-2	479	89	429	84	270	75	29	458	21	0	1.8	1.073	54.7	0
AO95179-3	478	68	328	61	205	62	106	434	44	0	1.7	1.066	46.2	0
AO95185-2	379	83	313	39	173	102	11	324	55	0	1.7	1.074	54.0	0
AO95188-2	437	82	356	33	210	113	4	360	77	0	1.5	1.074	52.4	0
AO95189-1	591	73	444	88	232	124	34	478	113	0	1.6	1.086	51.3	0

Table 3. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								ratio	g cm^{-3}	%	%
AO95191-1	542	84	457	150	237	69	45	502	40	0	1.7	1.084	40.4	20
*AO96047-2	446	92	411	32	253	126	2	414	33	0	1.6	1.097	51.7	0
AO96049-1	505	93	468	120	276	72	21	489	16	0	1.8	1.093	47.8	0
AO96049-2	494	76	378	182	154	42	61	438	41	11	2.0	1.063	39.2	30
AO96073-1	477	55	274	18	134	122	106	380	82	0	2.3	1.077	41.3	20
*AO96073-2	388	66	265	20	131	114	6	271	117	0	1.8	1.079	42.3	10
AO96073-5	494	90	448	173	215	59	10	457	37	0	1.7	1.089	42.3	20
AO96075-1	395	80	315	30	172	113	3	318	77	0	1.6	1.083	46.8	0
AO96081-2	421	62	261	20	117	124	8	269	152	0	1.7	1.080	42.9	10
AO96084-3	496	90	445	38	290	117	0	445	51	0	1.6	1.087	52.8	0
AO96084-4	480	62	294	155	125	13	166	460	20	0	1.7	1.095	50.8	0
AO96109-1	481	81	395	16	235	143	5	399	81	0	1.8	1.090	47.4	0
*AO96162-1	464	61	281	9	82	190	30	311	153	0	2.0	1.096	57.3	0
AO96162-2	287	66	191	4	109	78	1	192	95	0	1.9	1.077	54.5	0
AO96168-3	499	73	365	23	229	112	39	404	95	0	2.0	1.072	39.0	0
AO96277-3	469	62	290	29	164	97	125	415	54	0	2.0	1.085	49.1	0
AO96279-2	513	63	324	28	166	130	70	393	119	0	1.6	1.084	48.5	0
AO97256-4	464	70	346	154	122	71	64	410	54	0	1.6	1.085	46.1	5
AO97286-5	552	83	457	127	231	99	45	502	50	0	1.6	1.092	52.6	0
AO97296-1	563	95	535	235	260	40	0	535	24	0	1.5	1.085	39.8	10
AO97297-1	292	60	177	4	58	115	11	188	104	0	1.7	1.078	46.2	0
AO97299-2	286	89	255	69	147	39	2	257	29	0	1.8	1.076	52.2	0
AO97308-2	492	85	419	192	179	47	34	453	39	0	1.6	1.092	50.7	0
AO97310-3	655	70	464	65	268	132	80	545	111	0	1.6	1.069	40.4	40
AO97315-5	325	65	214	4	102	108	12	225	99	0	1.8	1.083	48.7	0
AO97315-6	485	81	392	55	242	94	16	408	77	0	1.7	1.097	49.2	0
AO97316-1	435	87	380	16	266	97	3	383	52	0	1.7	1.077	47.4	0
AO97373-4	365	81	298	53	183	62	22	320	42	0	1.8	1.085	46.3	0

Table 3. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								ratio	g cm^{-3}	%	%
AO97375-2	383	87	335	29	192	114	3	338	45	0	1.7	1.080	53.4	0
AO98076-2	391	83	327	108	161	58	28	355	36	0	2.2	1.090	49.4	0
AO98082-1	501	89	442	184	210	48	41	483	17	0	1.8	1.080	45.3	0
AO98082-3	604	94	569	256	260	54	6	575	29	0	1.7	1.080	45	10
AO98082-4	377	85	321	46	214	61	20	340	37	0	1.8	1.073	44.3	0
AO98083-2	563	69	393	44	205	145	29	423	132	0	1.8	1.079	51.5	0
AO98114-1	397	83	330	48	194	89	5	336	61	0	1.8	1.104	50.0	0
AO98114-2	377	85	321	87	170	64	18	339	39	0	2.1	1.086	48.9	0
*AO98114-6	508	78	393	34	253	106	27	420	88	0	1.9	1.086	43.2	5
AO98114-8	419	42	196	4	71	121	15	211	208	0	1.5	1.089	46.5	0
AO98131-1	347	87	306	89	136	80	0	306	41	0	1.4	1.086	52.0	0
*AO98141-2	412	75	309	9	172	128	6	315	97	0	1.8	1.082	52.3	0
AO98147-1	342	67	230	30	107	93	27	257	85	0	2.0	1.094	52.9	0
AO98164-1	393	61	251	8	123	119	3	253	140	0	1.6	1.070	48.3	0
AO98216-1	487	92	449	212	205	31	19	468	19	0	2.1	1.077	38.0	45
AO98217-1	486	84	407	103	202	101	24	431	56	0	1.9	1.095	45.6	0
AO98218-1	362	88	318	77	185	57	12	330	32	0	1.5	1.077	54.0	0
AO98231-3	292	70	204	8	94	102	7	211	81	0	1.8	1.083	52.1	0
*AO99002-4	387	94	365	73	243	49	2	367	20	0	1.8	1.075	52.1	0
AO99002-5	310	79	244	63	126	55	27	271	39	0	1.9	1.074	43.5	0
AO99002-6	263	83	217	15	147	55	8	225	37	0	1.7	1.075	53.6	0
*AO99002-7	448	93	417	210	186	22	6	423	24	0	2.0	1.082	50.6	0
AO99002-8	339	69	236	57	123	56	60	296	44	0	2.2	1.082	47.3	0
AO99003-1	585	65	381	28	181	172	62	443	142	0	2.2	1.079	43.0	5
AO99004-6	448	85	386	83	246	57	28	414	34	0	1.9	1.082	51.7	0
AO99004-7	205	54	114	4	53	56	13	127	79	0	1.9	1.069	42.6	10
AO99012-4	414	88	375	89	203	84	0	375	38	0	1.9	1.087	47.1	0
AO99024-2	397	77	308	15	206	87	39	347	50	0	2.0	1.085	50.9	5

Table 3. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								ratio	$g\ cm^{-3}$	%	%
AO99024-3	326	81	263	20	177	66	17	279	47	0	1.8	1.068	38.4	15
*AO99024-8	484	80	394	25	237	132	2	395	89	0	1.5	1.103	57.0	0
AO99029-4	416	87	362	56	208	98	11	373	42	0	1.9	1.089	50.1	0
AO99040-1	641	89	570	125	338	107	33	604	37	0	1.6	1.094	47.6	5
AO99041-1	342	71	245	0	138	107	20	264	77	0	1.9	1.082	39.8	55
AO99041-2	438	54	241	4	125	112	50	291	147	0	1.8	1.071	44.5	5
AO99042-1	511	85	428	73	264	91	55	483	28	0	1.8	1.087	51.3	0
AO99042-4	339	93	316	45	211	60	0	316	23	0	1.6	1.077	48.9	0
*AO99060-5	536	92	501	277	202	22	24	525	11	0	2.0	1.078	46.7	0
AO99060-6	368	73	269	9	129	132	14	283	85	0	1.5	1.072	50.9	0
AO99064-3	436	90	395	37	278	81	15	410	26	0	2.2	1.076	50.4	0
AO99092-3	382	71	270	118	105	47	50	320	62	0	2.0	1.080	49.2	5
AO99099-1	545	78	439	169	223	47	35	474	71	0	1.8	1.083	46.0	10
*AO99099-3	337	69	255	35	145	75	15	271	66	0	1.6	1.079	49.8	0
AO96180-2	358	78	281	0	142	139	0	281	77	0	1.5	1.079	47.8	5

*Advanced to 2004 Statewide Trial based on the results from four locations.

Table 4. Oregon Statewide Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	--------	--------	--------	--------	cwt/acre	--------	--------	--------	ratio	g cm^{-3}	%	%
Russet Burbank	445	69	307	26	206	76	85	392	45	0	2.3	1.067	33.0	63
Ranger	518	82	424	120	241	62	60	484	32	2	2.1	1.095	41.7	13
Shepody	459	83	381	178	173	31	55	436	22	0	1.7	1.083	46.2	3
Norkotah	390	84	328	37	207	84	9	337	52	0	2.0	1.068	32.8	8
Umatilla	456	78	350	71	197	82	48	398	58	0	1.9	1.086	45.9	0
AO96160-3	452	89	400	29	266	106	4	404	48	0	1.9	1.093	52.2	0
AO96164-1	450	90	403	88	255	60	20	422	26	1	2.0	1.088	49.5	0
AO97178-1	488	85	415	64	276	76	34	450	39	0	1.9	1.097	40.0	13
AO97133-2	375	84	317	31	185	101	11	328	47	0	1.7	1.077	46.0	0
AO97143-1	512	77	395	38	199	159	26	421	91	0	1.9	1.090	45.3	3
AO97175-13	471	63	297	50	182	65	119	415	55	0	2.0	1.087	42.9	0
AO95250-4	377	88	330	66	203	62	16	346	31	0	2.0	1.089	54.4	0
AO95250-5	491	90	443	126	254	64	19	463	29	0	2.0	1.094	57.1	0
AO96128-10	470	70	332	16	203	113	63	395	75	0	2.1	1.093	48.8	3
AO96141-3	497	75	368	56	217	95	77	445	52	0	2.1	1.091	51.4	3
AO96148-1	523	87	452	165	231	56	34	486	34	0	2.0	1.087	45.2	18
AO96201-1	499	74	379	63	205	111	39	418	80	0	2.0	1.092	47.0	3
AO96205-3	534	83	443	104	275	64	51	494	37	1	2.0	1.097	47.9	0
AO96212-3	523	77	408	96	218	94	65	473	50	0	2.1	1.089	42.1	13
AO96212-6	419	80	335	46	210	79	42	377	41	0	2.1	1.091	47.7	5
AO96213-3	487	73	362	15	213	134	33	394	93	0	1.8	1.085	47.3	8
AO96240-5	575	69	398	122	234	43	151	549	25	0	2.2	1.084	47.2	3
AO96241-3	580	81	472	50	297	124	42	514	67	0	1.8	1.074	49.3	0
AO96249-16	481	92	441	212	198	31	27	468	13	0	2.0	1.091	45.5	3
AO96261-2	582	89	523	246	230	47	33	555	25	0	1.9	1.090	42.6	10
AO98130-1	381	88	336	65	201	71	10	346	33	2	1.9	1.088	48.4	0
AO98133-2	395	94	370	252	101	17	18	388	7	0	1.9	1.098	51.6	3
AO98133-4	380	83	317	55	189	73	8	324	55	0	1.8	1.095	44.5	8
Mean	472	81	383	89	217	78	43	426	45	0	2.0	1.088	46.2	6
(LSD 0.05)	91	10	95	64	72	29	42	102	26	NS*	0.1	0.005	3.6	13

*NS = Not significant.

Table 5. Western Regional Early Harvest Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total No. 1	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	US 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	602	63	378	35	218	125	144	522	72	6	2.20	1.077	45.18	0.00
Shepody	603	80	483	250	183	51	91	574	17	12	1.83	1.085	55.78	0.00
Ranger Russet	499	65	324	117	162	45	98	422	26	50	2.00	1.096	49.28	0.00
Russet Norkotah	522	86	447	58	283	105	19	465	48	7	1.95	1.074	47.68	0.00
A91186-2	381	77	294	33	172	89	31	325	27	26	2.33	1.083	54.30	0.00
A91814-5	641	72	462	22	205	235	21	483	149	6	1.33	1.094	53.83	0.00
A92030-5	458	86	393	186	168	39	17	410	25	22	1.80	1.092	53.33	0.00
A92294-6	608	76	462	26	253	183	42	503	70	33	2.08	1.092	56.03	0.00
A9304-3	510	81	414	169	203	43	23	437	13	53	2.13	1.094	56.00	0.00
A9305-10	559	83	462	108	259	96	19	481	39	38	1.88	1.085	56.63	0.00
A93157-6LS	507	87	440	78	276	86	29	469	24	14	1.95	1.092	50.35	0.00
AC92009-4RU	483	85	408	61	271	76	6	414	26	39	1.79	1.098	54.10	0.00
AC93026-9RU	490	82	402	102	225	75	30	432	53	4	2.18	1.086	50.38	0.00
ATX9202-1RU	493	86	426	91	247	87	15	440	43	8	1.90	1.091	59.48	0.00
ATX92230-1RU	467	88	413	83	267	63	24	437	14	15	1.93	1.085	58.63	0.00
CO93001-11RU	514	82	424	39	254	131	24	448	50	16	2.13	1.079	48.55	0.00
CO93016-3RU	522	74	387	45	200	141	24	411	86	24	2.00	1.083	49.98	0.00
PA95A11-14	528	71	375	33	239	103	65	440	75	11	1.93	1.081	51.80	0.00
TC1675-1RU	494	87	428	75	229	124	9	437	54	3	1.78	1.100	56.95	0.00
Mean	520	80	412	85	227	100	38	450	48	20	1.95	1.088	53.06	0.00
LSD (0.05)	60	10	70	55	51	33	37	68	21	NS*	0.162	0.004	3.95	NS

*NS = Not significant.

Table 6. Western Regional Late Harvest Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Variety	Total yield	U.S. No. 1 Percent No. 1	U.S. No. 1 Total No. 1	U.S. No. 1 >12 oz	U.S. No. 1 6-12 oz	U.S. No. 1 4-6 oz	U.S. No. 2	Marketable	<4 oz	Cull	Length/ width	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	----------	----------	----------	----------	cwt/acre	----------	----------	----------	ratio	g cm^{-3}	%	%
Russet Burbank	570	44	224	17	138	69	279	503	58	0	2.3	1.070	32.4	45.0
Ranger Russet	629	73	455	223	192	39	155	610	19	0	2.0	1.096	41.3	0.0
Russet Norkotah	473	84	400	61	238	102	29	428	45	0	2.0	1.069	29.3	12.5
A91186-2	514	63	314	58	201	55	159	473	42	0	2.1	1.082	45.1	2.5
A91814-5	719	73	523	40	285	198	53	576	143	0	1.3	1.090	51.6	0.0
A92030-5	473	86	409	199	163	47	36	445	28	0	1.7	1.089	47.1	0.0
A92294-6	713	64	450	60	272	118	217	667	43	0	2.0	1.093	48.6	2.5
A9304-3	579	75	434	232	171	31	125	559	9	0	2.2	1.090	47.3	0.0
A9305-10	714	80	571	219	283	69	107	678	35	2	1.9	1.087	48.6	0.0
A93157-6LS	627	88	548	279	230	39	56	604	24	0	1.9	1.097	45.3	0.0
AC92009-4RU	472	93	438	210	198	30	17	455	18	0	1.8	1.095	45.2	0.0
AC93026-9RU	548	73	401	190	159	52	115	516	29	0	2.1	1.085	36.3	32.5
ATX9202-1RU	491	87	425	155	214	56	41	466	25	0	1.9	1.085	46.6	12.5
ATX92230-1RU	518	88	456	148	245	64	38	494	24	0	1.8	1.085	49.0	0.0
CO93001-11RU	497	81	402	49	247	107	28	430	67	0	1.9	1.074	44.0	0.0
CO93016-3RU	577	71	408	54	224	130	88	496	80	0	1.9	1.088	33.5	35.0
TC1675-1RU	544	90	491	137	271	83	10	501	43	0	1.7	1.095	50.0	0.0
Mean	568	0	432	137	219	76	91	523	43		1.9	1.086	43.6	8.4
LSD (0.05)	103	13	83	61	52	25	99	102	17	NS*	0.2	0.005	3.9	14.9

*NS = Not significant.

POTATO TUBER BULKING RATE AND PROCESSING QUALITY FOR EARLY HARVEST

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Introduction

The six potato varieties 'Alturas', 'Ranger Russet', 'Russet Burbank', 'Shepody', 'Umatilla Russet', 'Wallowa Russet', and the five numbered clones, 'A9014-2', 'A9045-7', 'A90586-11', 'A92294-6', and 'A93157-6LS' were compared for tuber yield, size distribution, and processing quality at six harvest dates. Russet Burbank, Shepody and Ranger are currently grown in the Treasure Valley for processing and served as the check varieties. Umatilla and Wallowa Russet are new releases from Oregon State University (OSU) that have demonstrated yield, grade, and processing quality superior to Russet Burbank, Shepody, and Ranger Russet in some trials. The numbered clones have performed well at Ontario in previous variety trials, including the Western Regional Early Harvest Trial, over several years. The first objective of this study was to test potato cultivars that are currently available, and some numbered clones that may soon be released, for very early harvest, compared to the varieties currently grown for early harvest for processing. The second objective was to determine if any of these clones would continue to bulk tubers late in the season.

Materials and Methods

The soil was Owyhee silt loam where winter wheat was the previous crop. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken September 9, 2002 showed 18 ppm NO_3, 18 ppm P, 306 ppm K, organic matter 2.2 percent, and pH 7.6. Fall fertilizer consisting of 21 lb N/acre, 100 lb P_2O_5/acre, 60 lb K_2O/acre, 60 lb S/acre, 30 lb Mg/acre, 4 lb Zn/acre, 2 lb Cu/acre, 1 lb Mn/acre, and 1 lb B/acre was broadcast. The field was ripped, Telone II was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

The experiment had a split-plot design, with the six harvest dates as the main plots replicated four times and with varieties randomized as sub-plots within each main plot. This was accomplished by planting the rows so that each harvest date pass through each replicate would include all of the varieties.

Potato seed was obtained from the OSU Potato Variety Development program at Powell Butte, and placed into storage at 42°F. Seed of the cultivar Ranger Russet was donated by J.R. Simplot Co., Caldwell, ID, from commercial certified seed produced in eastern Idaho. Seed tubers were cut by hand into approximately 2 oz pieces, treated with Tops MZ + Gaucho seed treating dust, and counted into bags of 15 seed pieces for each row of the two-row plots.

The potato clones were planted on April 10 with rows spaced 36 inches apart and 9-inch spacing between seed pieces in the row. The soil condition was excellent, with good tilth and good soil moisture. The soil temperature at the 10-inch seed piece depth was almost 50°F.

A two-row per bed configuration was maintained at planting by leaving off the center furrowing shovel of the two-row planter. On May 5, the beds were formed with a spike harrow with wide shovels that also carried the shank to install a drip tape at 3-inch depth in the top of the bed between the two potato rows. Drip tape was 5/8-inch diameter, 5-mil wall thickness, 12-inch emitter spacing, 0.22-gpm/100 ft flow rate (T-tape, T Systems International, San Diego, CA).

Soil water potential was measured with six Watermark sensors (Irrometer Corp., Riverside, CA) installed in the potato row at the seedpiece depth and connected to an AM400 datalogger (M.K. Hansen, East Wenatchee, WA). Water potential readings were recorded manually from the data logger. Irrigations were scheduled to replace evapotranspiration (Et) estimated by an automated AgriMet (U.S. Bureau of Reclamation, Boise, ID) station located less than 0.25 mile away on the Malheur Experiment Station.

Prowl at 1 lb/acre plus Dual at 2 lb/acre was applied on May 1, before any potato plants had emerged, and was incorporated by a total of 0.42 inch of rain May 3 through 5. Matrix herbicide was applied at 1.25 oz/acre on May 28, and was incorporated by 0.57 inch of rain during subsequent days. Vydate insecticide/nematicide was injected through the drip tape in the first irrigation on June 6 at a rate of 2 pints/acre. During Vydate injection, the irrigation water was acidified to approximately pH 5 by injecting dilute sulfuric acid into the mainline upstream of the Vydate injection.

Fungicide applications to protect the potato foliage from early blight and potential late blight infection started with an aerial application of Ridomil Gold and Bravo at 1.5 pint/acre on June 7, which was repeated on June 25. Bravo fungicide plus liquid sulfur was applied by aerial applicator on July 2, and again on August 8. Sulfur dust was applied by aerial applicator on July 20 at 40 lb S/acre to prevent mite infestation and powdery mildew infection.

Petiole tests were taken every 2 weeks from June 12, and fertilizer was injected into the drip system during irrigation to supply nutrient needs (Table 1). Fertilizer was applied by fertilizer injection into the drip irrigation system only in response to petiole tests.

Tuber initiation was noted on several plants on June 3. On June 19, the first tubers were dug from one row in each replicate. Tubers were sorted by weight and counted. On July 10, tubers were harvested from each replicate, and graded by the U.S. No. 1 and No. 2 processing standard, sorted by weight, and counted in each weight category.

Marketable yield for processing was defined as all of the U.S. No. 1 and No. 2 tubers larger than 4 oz. Specific gravity and length-to-width ratio were measured using a sample of 10 tubers. Fry color was determined from a 20 tuber sample from each plot. The subsequent harvests, on July 31, August 21, September 11, and October 2, followed the same procedure as the second harvest.

Yield and quality results data were compared using analysis of variance (Number Cruncher Statistical Systems, Kaysville, UT). Tuber development over time was evaluated using regression of the ratio of polynomials equation:

$y = (a+bx+cx^2) / (1+dx+ex^2)$, where y is the yield and x is days after planting (DAP).

Results and Discussion

The 2003 growing season was marked by record heat, with 110°F recorded on July 20, and prolonged heat throughout the summer. Irrigation plus rain supplied 29.7 inches of water, or 94.2 percent of AgriMet Et, which totaled 31.5 inches through the growing season (Fig. 1). The early season moisture deficit indicated that more water should have been applied early in the season to more closely match Et (Fig. 2) starting at 31 DAP. Excessively dry readings may have been partially due to sensor placement.

Potato clones varied in yield and tuber size distribution at the last three harvest dates (Table 2). Umatilla Russet was among the heavier bulking clones when harvested 132 DAP. Marketable yields for Umatilla Russet showed the earliest bulking potential at 132 DAP with 513 cwt/acre, compared to Russet Burbank and Shepody with 473 and 425 cwt/acre, respectively. The percent U.S. No. 1 yields were 87, 59, and 69 percent, respectively. Russet Burbank also had a sugar end incidence of 37.5 percent, the highest of any clone at this harvest date.

Growers can only plant varieties that have seed available and that have been accepted by processing companies for contract production. At present, seed is available for Umatilla Russet, Shepody, and Ranger Russet. When the bulking rate of Umatilla Russet, Shepody, and Ranger Russet are compared over the last three harvest dates, Umatilla Russet tended to have a yield advantage. Other clones, such as A92294-6 and A93157-6LS, were also promising (Table 2).

Tubers in the larger than 12 oz size category are too big for optimum production of frozen french fries. Because 6-10 oz tubers are considered ideal for processing, the yield of that size category was graphed over time, along with total yield and marketable yield for each potato clone (Figs. 2-14).

In previous work Shock et al. (2003) showed that a major factor limiting potato productivity in Malheur County is the failure of tubers to continue to bulk late in the growing season. In the current work, most varieties and experimental clones failed to have substantial marketable yield increases after 153 DAP (Figs. 3-5, 8-13). This lack of increase in marketable yield after 153 DAP was noted for Ranger Russet, Russet

Burbank, Shepody, and Umatilla Russet (Figs. 9-12). In contrast, A92294-6 and A93157-6LS continued their upward trends in marketable yield to 174 DAP (Figs. 6 and 7), finishing with 689 and 658 cwt/acre, respectively. These clones deserve special attention in future trials and possible tests for resistance to early death through heat stress and the component pathogens of the "early die" syndrome (Fig. 14).

The average date of last frost at Malheur Experiment Station is April 29. In this trial planted on April 10, 2003, an overnight low of 32°F occurred on the night of May 19, but no frost injury was observed. Any early harvest yield advantage of early planting dates has to be weighed in relation to the risk of frost damage.

Although Shepody is widely used as an early harvest variety, it is not especially suited as an early harvest variety. Many other clones included in this trial bulked fairly early (Figs. 3-5, and 14) compared to Shepody. Of these, A90586-11 has shown resistance to late blight in addition to having good yield and processing quality. From the Western Regional Early Potato Variety Trials in Ontario over the past few years several additional new clones have shown promise for early harvest (data not shown).

References

Shock, C.C., E.P. Eldredge, and L.D. Saunders. 2003. Tuber bulking rate of processing potato clones in relation to planting date. Oregon State University Agricultural Experiment Station, Special Report 1048:152-158.

Table 1. Fertilizer applied to potato clones and varieties grown under drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Date	NO_3	P_2O_5	K_2O	SO_4	S	Fe	Mg	Mn	Zn	Cu	B
	------------lb/acre------------										
6/19	28.5							0.36		0.23	
7/1	20.0	6.0		1.3			0.5	0.25	0.25	0.25	
7/17	20.0			43.0				0.25	0.25		
7/19					40.0						
7/28	3.2	10.0	1.1						0.09		
8/5	16.0	11.4	11.4	10.0		0.57		0.28	0.23	0.28	0.01
8/14	20.0							0.25		0.20	
total	107.7	27.4	12.5	54.3	40.0	0.57	0.5	1.39	0.82	0.96	0.01

Table 2. Tuber yield, grade, length-to-width ratio, specific gravity, and fry color of five potato clones and six potato varieties that grew until vine removal on August 20, September 5, or October 1. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Days after planting		Total yield	U.S. No.1		Marketable yield		Tubers	Length	Specific	Fry color light reflectance			Sugar
				Yield	Percent	Total	6-10oz	<4 oz	/width	gravity	stem	bud	avg.	ends
Cultivar/clone	Hrv	DAP	-cwt/acre-		%	-------cwt/acre--------			ratio	gcm^{-3}	------------%------------			
A9014-2	8/20	132	496	469	98	481	146	15	1.60	1.085	57	59	58	0.0
	9/5	153	545	507	96	528	143	17	1.64	1.086	58	58	58	0.0
	10/1	174	567	539	98	553	97	14	1.71	1.082	55	57	56	1.3
A9045-7	8/20	132	514	435	89	489	184	24	1.62	1.089	45	42	43	0.0
	9/5	153	538	425	83	504	152	34	1.70	1.088	40	43	41	3.8
	10/1	174	624	513	87	586	137	38	1.68	1.086	39	42	40	5.0
A90586-11	8/20	132	483	353	80	441	183	42	1.83	1.086	48	44	46	1.3
	9/5	153	505	329	71	464	160	41	1.87	1.090	37	46	42	5.0
	10/1	174	596	363	66	557	170	39	1.84	1.090	35	44	40	12.5
A92294-6	8/20	132	535	438	89	492	268	43	2.07	1.092	55	52	54	0.0
	9/5	153	643	431	72	605	233	38	2.06	1.089	45	56	51	2.5
	10/1	174	728	556	80	689	269	39	2.08	1.089	46	56	50	1.3
A93157-6LS	8/20	132	483	423	94	451	192	32	1.81	1.085	47	39	43	13.8
	9/5	153	561	470	91	516	174	45	1.89	1.092	44	47	46	13.8
	10/1	174	694	575	87	658	154	36	1.89	1.088	38	45	42	5.0
Alturas	8/20	132	456	341	91	375	181	81	1.47	1.081	57	57	57	0.0
	9/5	153	574	447	91	490	222	84	1.47	1.081	57	56	57	0.0
	10/1	174	641	503	93	544	220	97	1.49	1.080	55	56	55	1.3
Ranger R.	8/20	132	474	370	82	454	141	19	1.95	1.090	49	43	46	0.0
	9/5	153	532	367	72	516	110	16	1.99	1.092	45	49	47	0.0
	10/1	174	563	353	66	532	115	31	2.02	1.090	42	47	45	0.0
R. Burbank	8/20	132	515	279	59	473	209	43	2.10	1.077	48	29	39	37.5
	9/5	153	544	274	56	485	188	59	2.05	1.075	25	45	35	28.8
	10/1	174	582	239	44	521	177	62	2.10	1.071	26	43	35	37.5
Shepody	8/20	132	442	289	69	425	108	17	1.67	1.080	52	45	49	0.0
	9/5	153	474	247	55	458	110	17	1.73	1.081	46	51	49	1.3
	10/1	174	473	264	58	455	103	18	1.63	1.080	46	50	48	0.0
Umatilla R.	8/20	132	551	448	87	513	212	38	1.86	1.083	50	37	43	10.0
	9/5	153	600	406	77	532	222	68	1.86	1.086	48	49	48	0.0
	10/1	174	628	437	77	566	205	61	1.91	1.081	43	48	45	1.3
Wallowa R.	8/20	132	520	420	88	480	218	40	1.88	1.088	49	39	44	3.8
	9/5	153	517	373	78	471	198	45	1.84	1.087	40	47	44	1.3
	10/1	174	631	450	77	578	207	53	1.86	1.083	39	44	42	5.0
Mean	8/20	132	497	388	84	461	186	36	1.80	1.081	51	44	47	6.0
	9/5	153	548	389	76	506	174	42	1.83	1.086	44	50	47	5.1
	10/1	174	612	436	76	567	169	44	1.84	1.084	42	48	45	6.4
LSD (0.05)	Harvest		20	24	4	21	12	6	0.08	0.002	1	1	1	4.8
	Cultivar		25	30	4	26	16	8	0.10	0.002	1	2	1	6.0
	Hrv x Cltvr		61	72	11	63	38	20	0.23	0.005	3	4	3	14.7

Table 3. Tuber grade and size distribution of five potato clones and six potato varieties that grew until vine removal on August 20, September 5, or October 1, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

			U.S. No. 1, oz sizes						U.S. No. 2, oz sizes					
			4-6	6-8	8-10	10-12	12-16	>16	4-6	6-8	8-10	10-12	12-16	>16
Cultivar, clone	Harv	DAP	cwt/acre											
A9014-2	8/20	132	32	56	85	99	196	0	1	2	3	3	4	0
	9/5	153	42	45	89	71	103	158	1	5	5	4	4	4
	10/1	174	24	52	44	68	104	247	1	1	0	1	4	6
A9045-7	8/20	132	46	58	110	63	158	0	5	6	10	7	28	0
	9/5	153	50	65	73	78	94	65	10	4	10	7	12	37
	10/1	174	50	58	65	82	111	147	5	4	10	11	15	29
A90586-11	8/20	132	68	63	94	36	94	0	7	9	19	9	44	0
	9/5	153	55	55	61	39	58	62	14	21	24	26	27	23
	10/1	174	57	70	46	75	56	61	14	20	35	47	33	46
A92294-6	8/20	132	78	111	132	60	59	0	9	14	12	7	12	0
	9/5	153	69	103	77	86	64	32	19	25	29	37	41	25
	10/1	174	72	110	115	89	99	72	9	20	24	26	32	23
A93157-6LS	8/20	132	44	51	127	86	116	0	1	7	7	5	9	0
	9/5	153	46	68	93	69	88	107	4	7	7	13	0	15
	10/1	174	41	62	77	83	125	188	2	9	7	13	17	37
Alturas	8/20	132	108	82	84	35	34	0	8	11	5	3	7	0
	9/5	153	129	128	75	62	42	10	11	13	5	4	8	2
	10/1	174	118	118	87	89	59	32	10	8	7	6	9	2
Ranger R.	8/20	132	29	38	73	51	180	0	4	9	22	14	37	0
	9/5	153	22	36	46	44	82	137	5	8	20	29	29	58
	10/1	174	26	38	51	58	63	118	6	13	13	22	37	87
R. Burbank	8/20	132	49	51	87	38	54	0	21	30	41	27	76	0
	9/5	153	55	68	46	46	36	24	23	35	40	39	34	41
	10/1	174	47	53	44	36	32	27	30	34	47	54	53	64
Shepody	8/20	132	34	41	43	33	138	0	9	9	15	19	86	0
	9/5	153	29	31	44	26	52	66	4	17	18	32	53	86
	10/1	174	26	33	43	30	61	72	5	13	15	38	47	73
Umatilla R.	8/20	132	70	87	105	55	131	0	4	10	11	11	30	0
	9/5	153	88	83	103	55	55	24	17	16	20	20	15	38
	10/1	174	86	98	61	74	61	57	14	29	17	29	22	20
Wallowa R.	8/20	132	73	87	105	56	100	0	6	11	16	6	22	0
	9/5	153	76	94	68	57	46	32	9	19	18	19	23	11
	10/1	174	73	85	72	83	68	70	10	27	23	31	26	12
Mean	8/20	132	57	66	95	55	115	0	7	11	15	10	32	0
	9/5	153	60	70	71	58	65	65	11	15	18	21	22	31
	10/1	174	56	71	64	69	76	99	10	16	18	25	27	36
LSD (0.05)	Harvest		7	8	9	9	12	15	3	4	5	5	9	9
	Cultivar		9	10	11	11	16	19	4	5	6	6	11	11
	Hrv x Cltvr		22	25	28	28	38	45	9	12	14	15	26	26

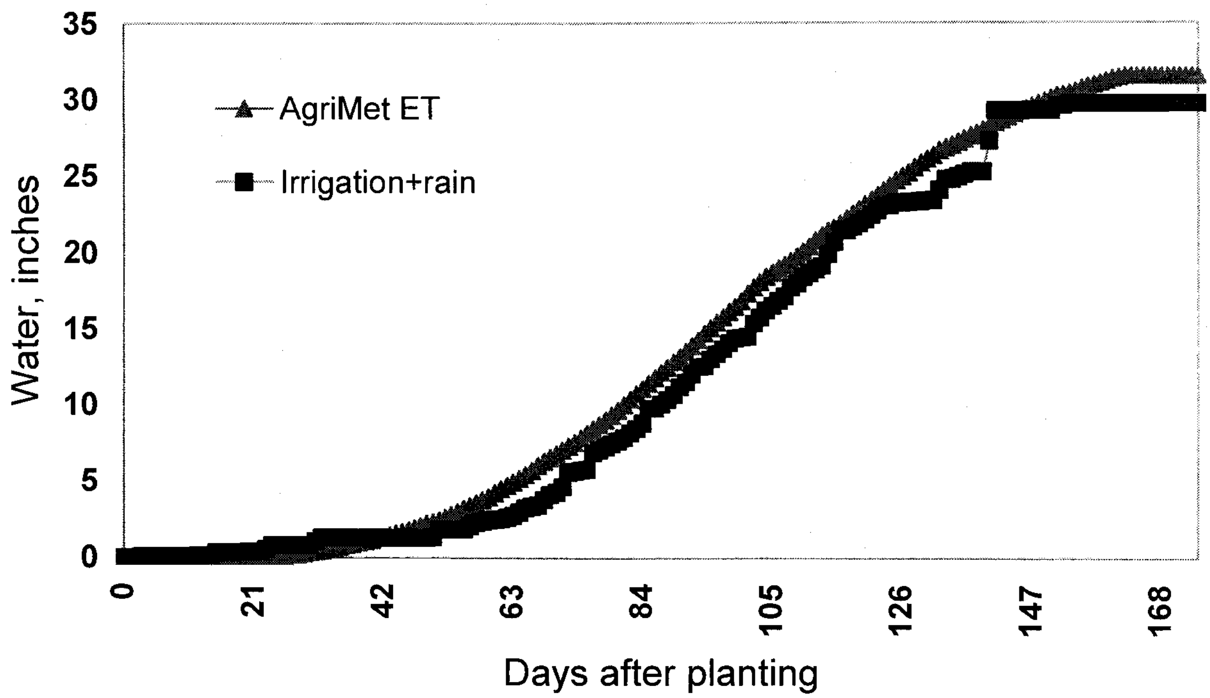

Figure 1. Irrigation water applied through the growing season compared to evapotranspiration (ET) estimated by an AgriMet weather station, Oregon State University, Malheur Experiment Station, Ontario, OR, 2003.

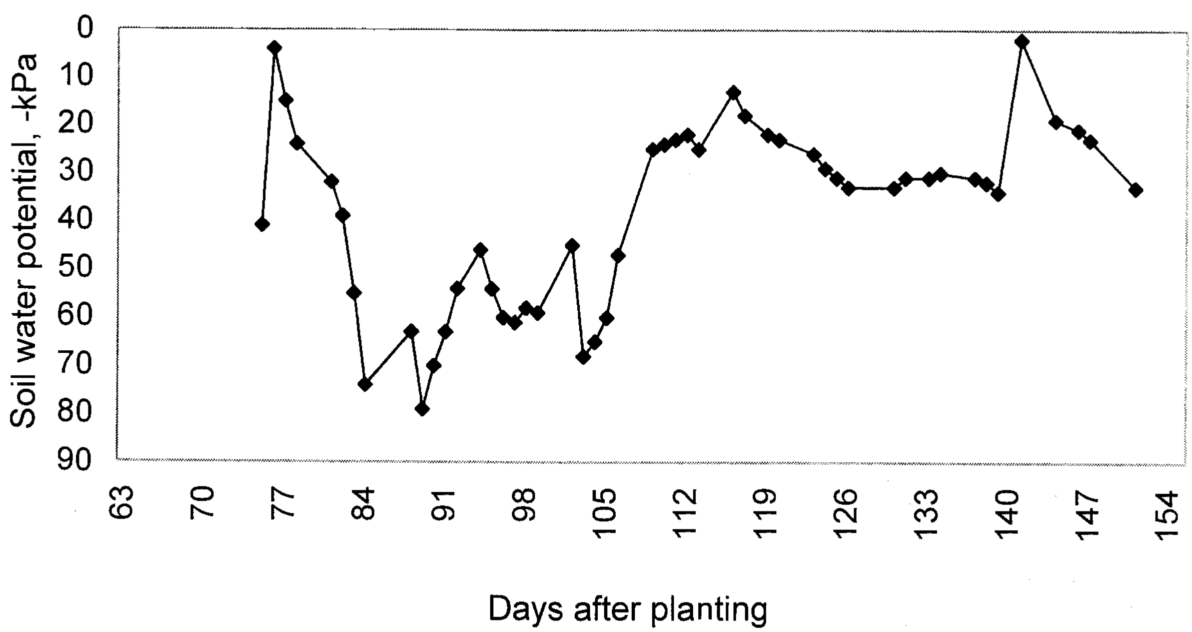

Figure 2. Soil water potential measured by Watermark sensors during the irrigation period of drip-irrigated potato clones, Oregon State University, Malheur Experiment Station, Ontario, OR, 2003.

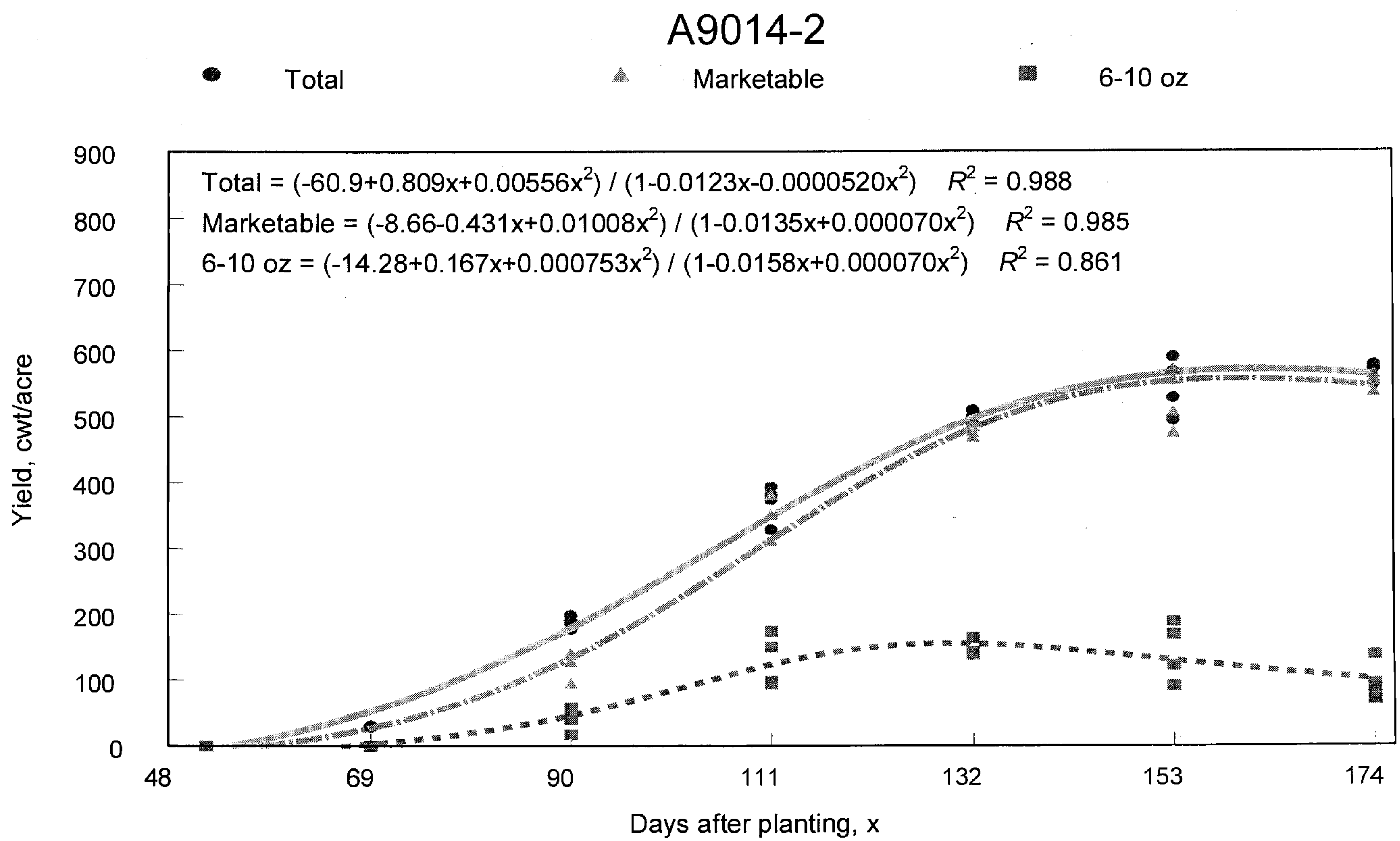

Figure 3. Tuber bulking over time for the clone A9014-2, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

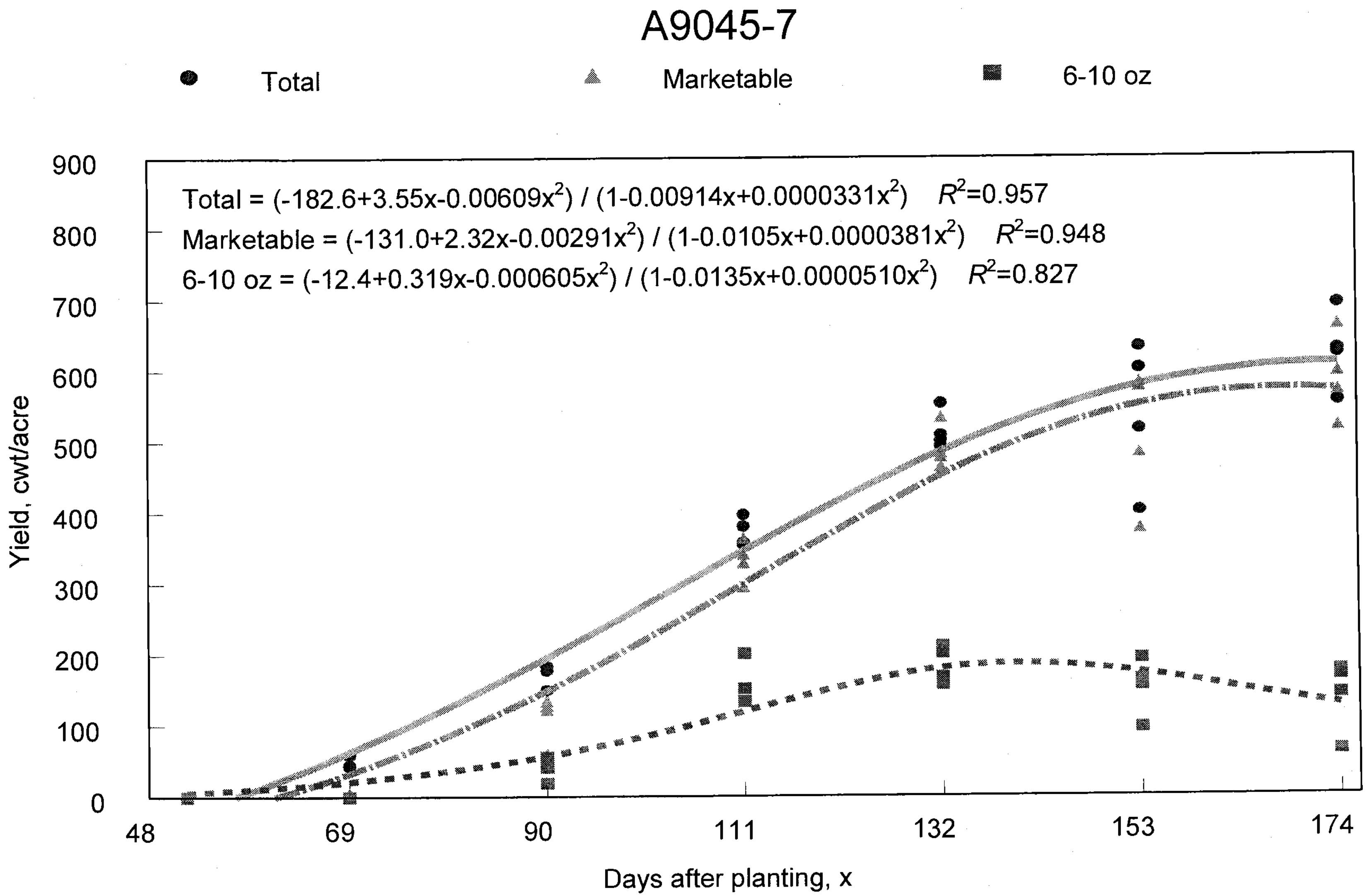

Figure 4. Tuber bulking over time for the clone A9045-7, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

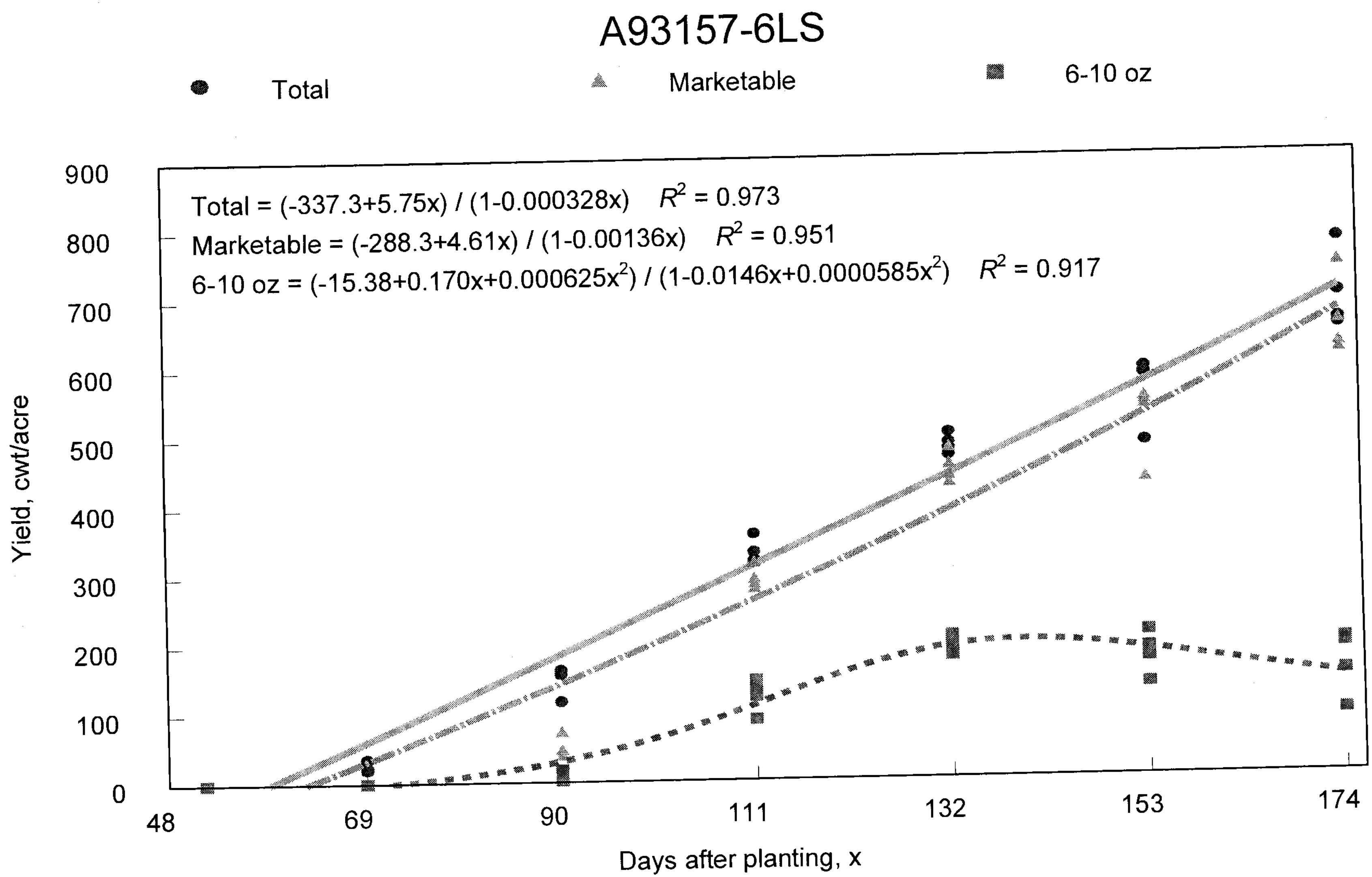

Figure 7. Tuber bulking over time for the clone A93157-6LS, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

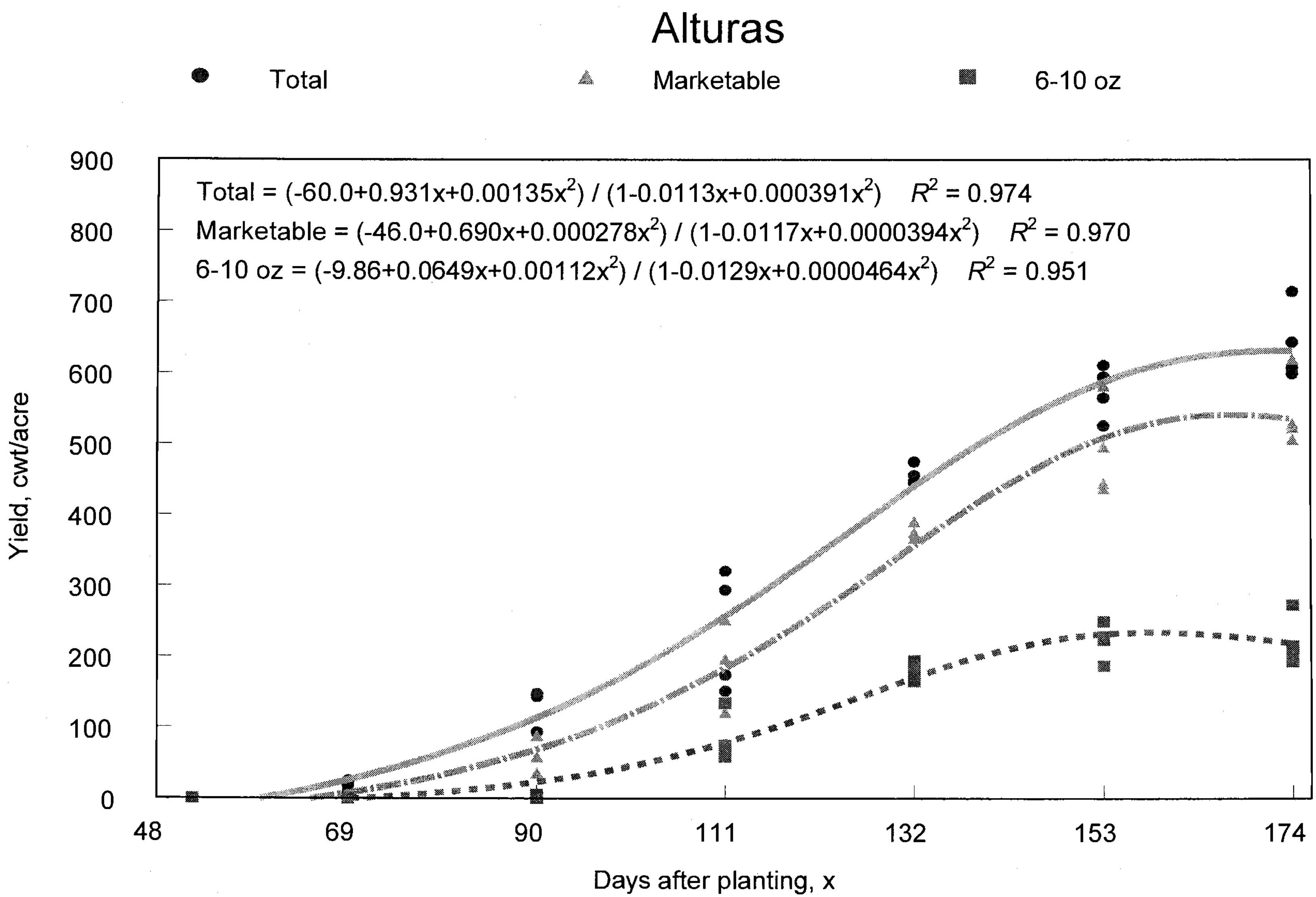

Figure 8. Tuber bulking over time for the cultivar Alturas, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

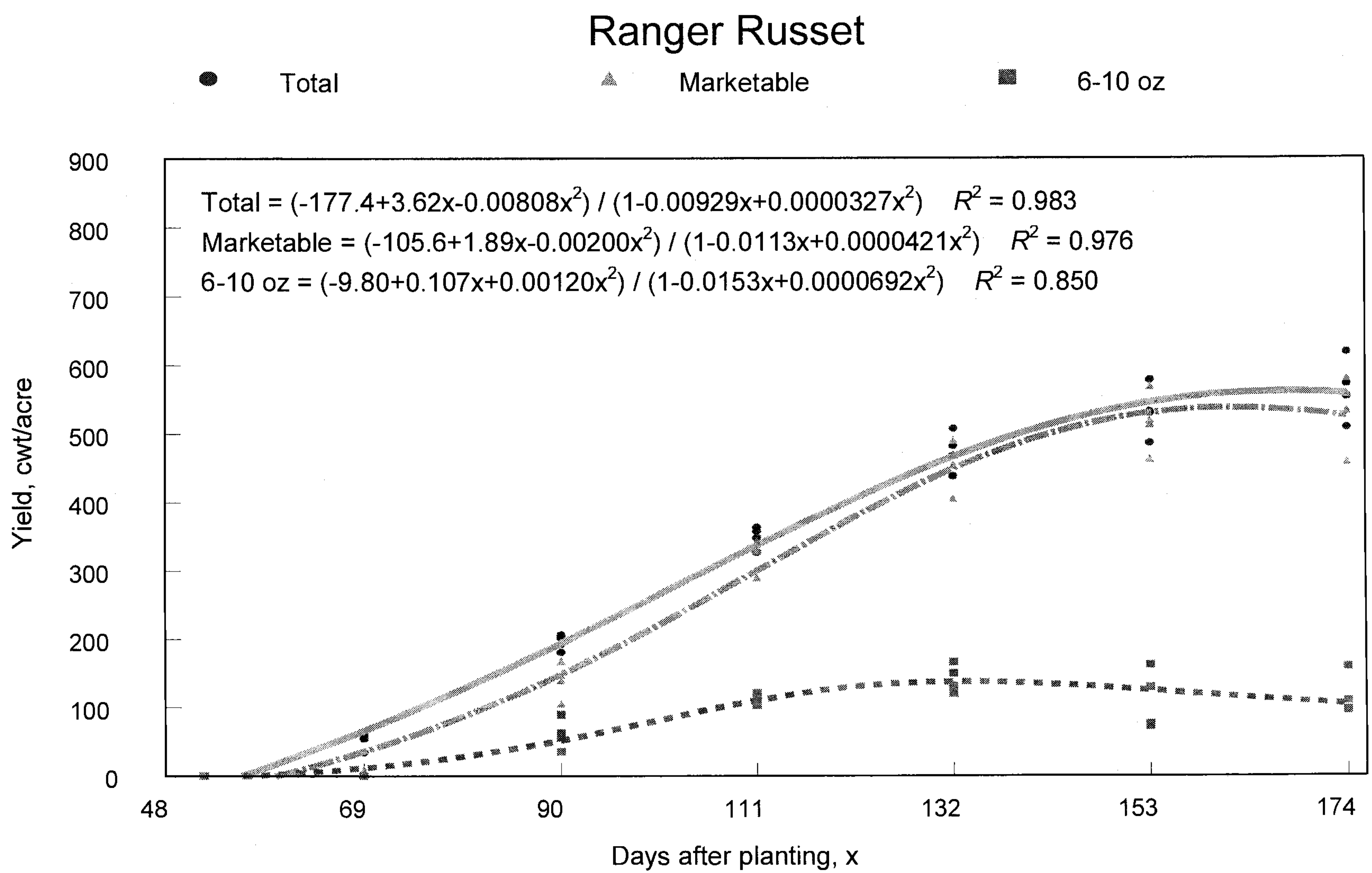

Figure 9. Tuber bulking over time for the cultivar Ranger Russet, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

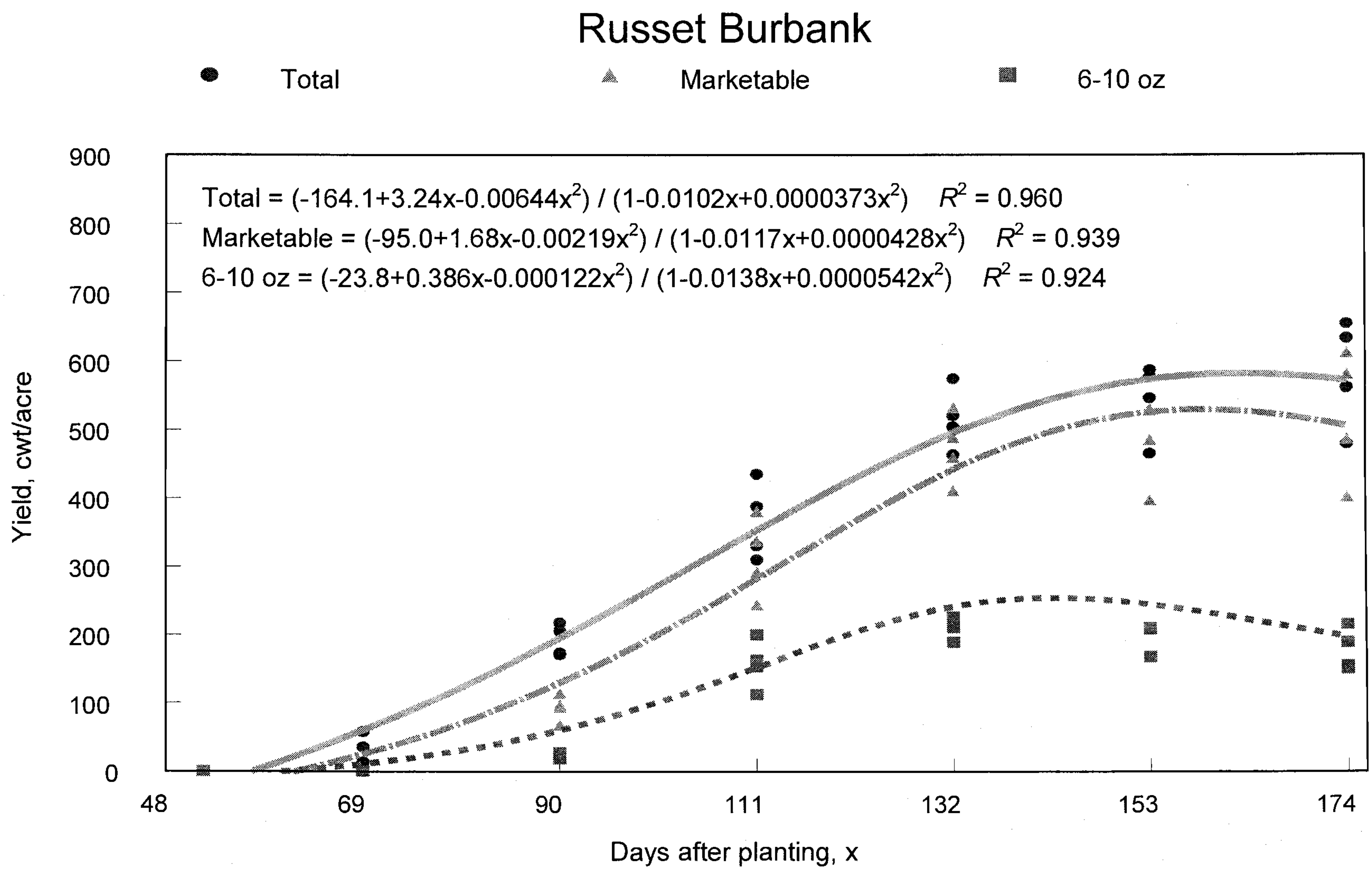

Figure 10. Tuber bulking over time for the cultivar Russet Burbank, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

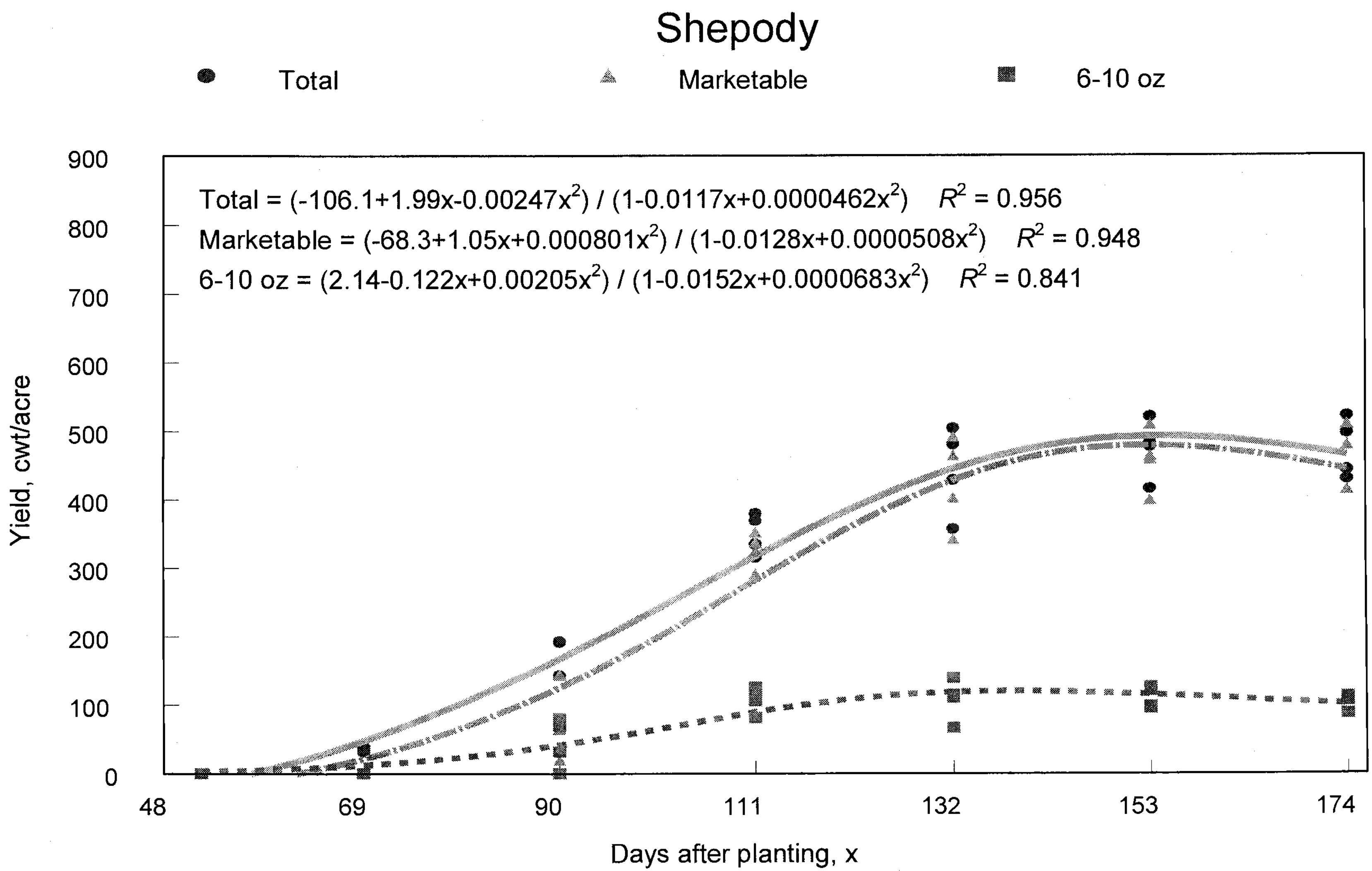

Figure 11. Tuber bulking over time for the cultivar Shepody, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

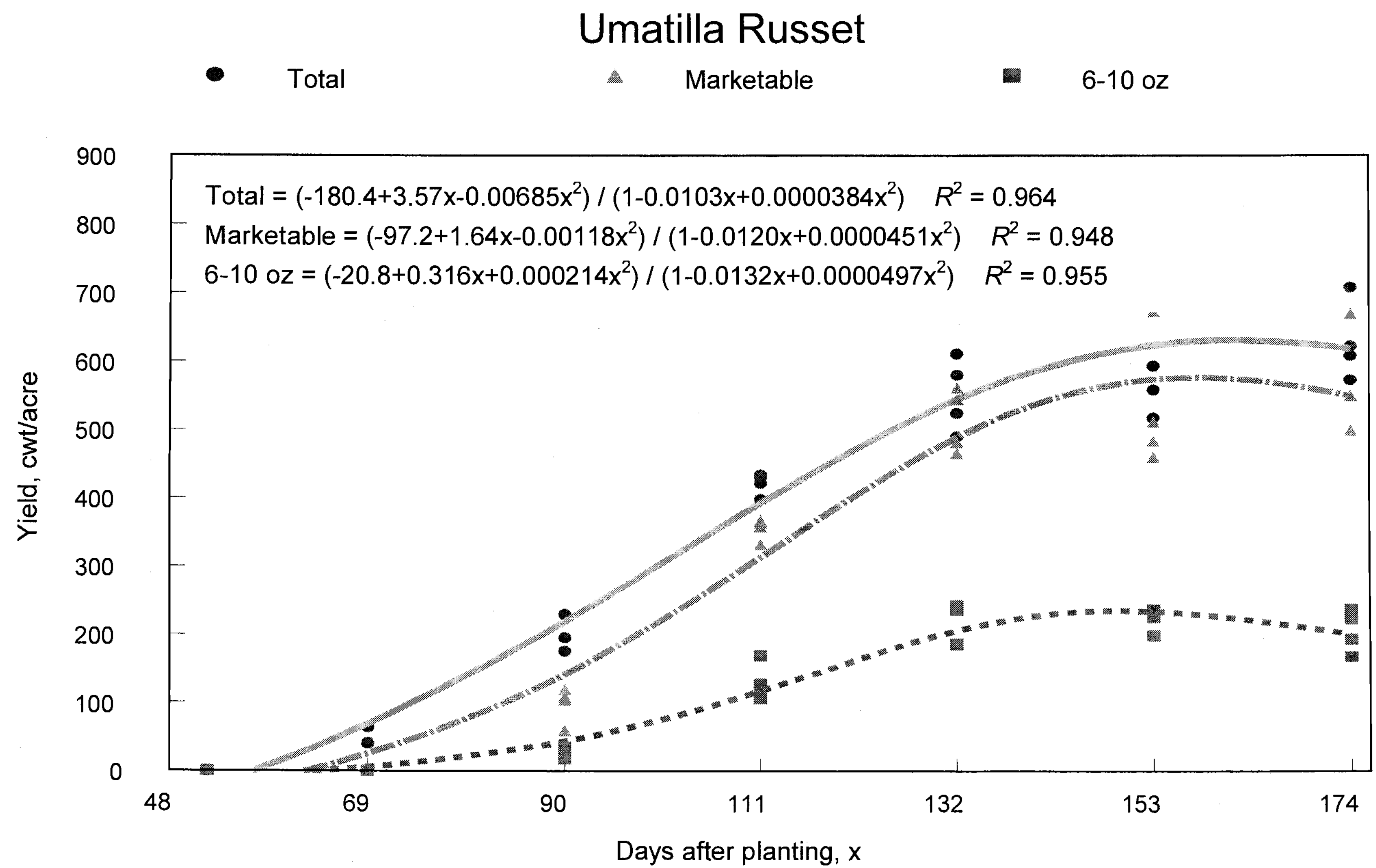

Figure 12. Tuber bulking over time for the cultivar Umatilla Russet, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

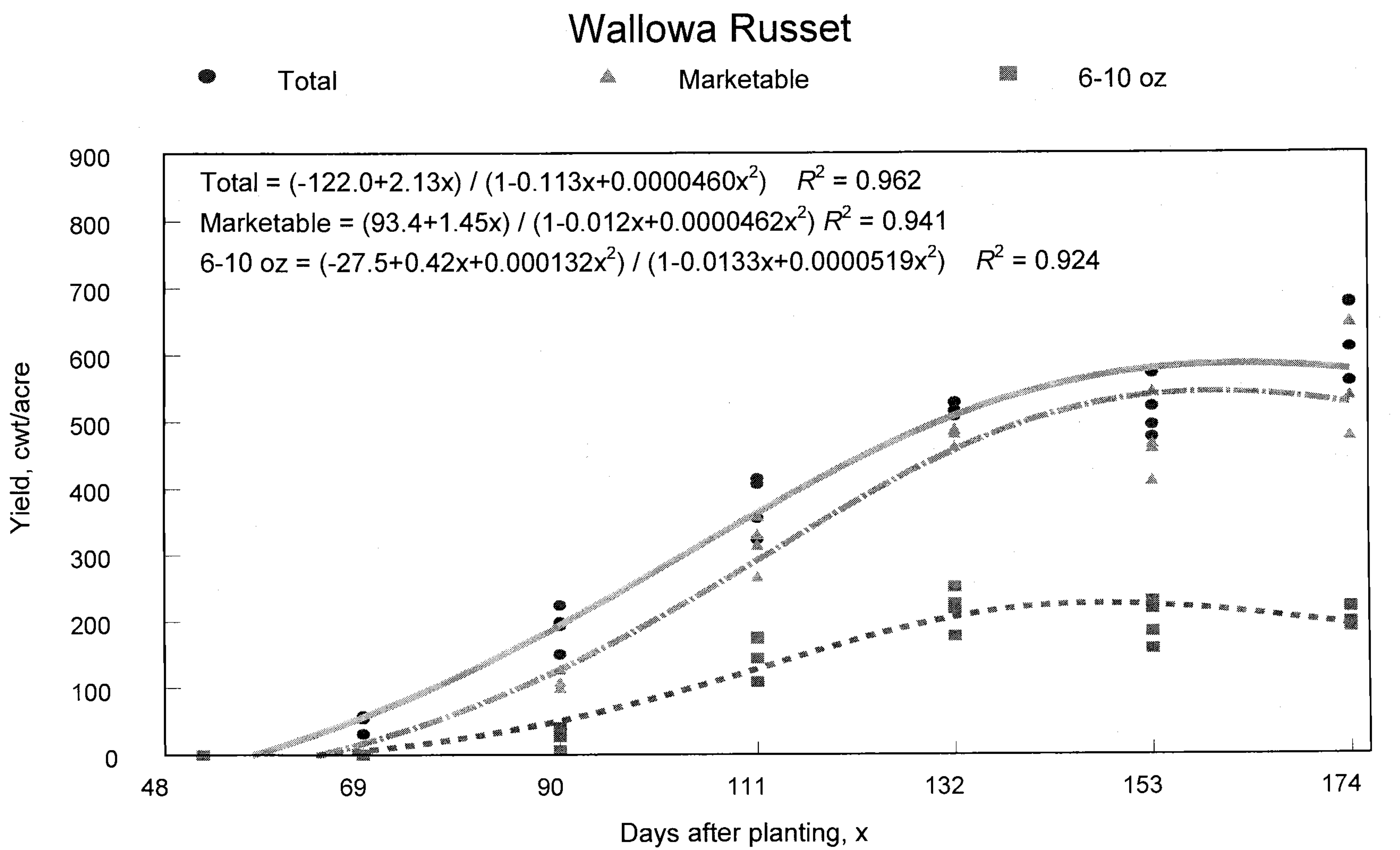

Figure 13. Tuber bulking over time for the cultivar Wallowa Russet, Oregon State University Malheur Experiment Station, Ontario, OR, 2003.

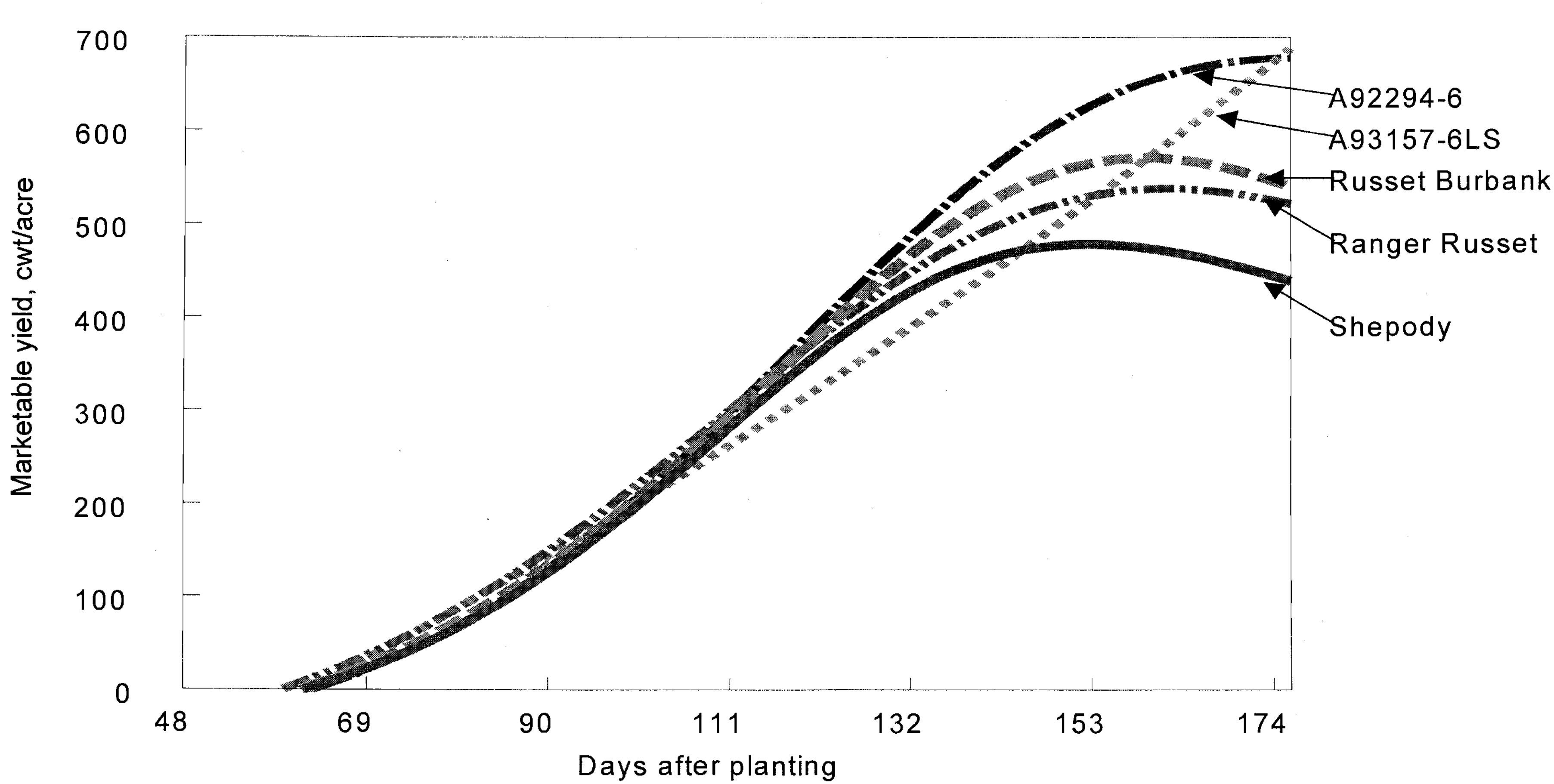

Figure 14. Marketable yield of A92294-6 and A93157-6LS over time compared to the marketable yield of Russet Burbank, Shepody, and Ranger Russet. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

PLANTING CONFIGURATION AND PLANT POPULATION EFFECTS ON DRIP-IRRIGATED UMATILLA RUSSET YIELD AND GRADE

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Ontario, OR, 2003

Introduction

Drip irrigation of potato for processing in theTreasure Valley is not a standard production practice. However, drip irrigation could provide several advantages to growers, including no tailwater runoff from the field, the ability to apply fertilizer to the crop root zone, precise irrigation application, minimal leaching of chemicals or salts to the groundwater, and reduced canopy moisture with reduced risk of fungal foliar diseases. Drip irrigation systems are costly to install and manage, and growers are reluctant to install them on fields where capital has already been spent to install furrow or sprinkler irrigation systems. To be profitable for potato production, drip irrigation should provide yield and quality above that obtainable with other irrigation methods. This study was conducted to test modified planting configurations on the standard 72-inch tractor wheel spacing used in Treasure Valley potato production, to test whether changes in the planting configuration could improve 'Umatilla Russet' response to drip irrigation.

By placing two rows on a single bed, plants would be spread apart over the soil surface. They should not come immediately into competition with each other for sunlight during June, increasing yield potential. Spreading the plants across the bed allows a higher plant population, which could enhance yield and reduce the number of oversize potatoes. Furthermore, the distribution of plants across the soil surface would provide better soil shading during June, a factor that might result in better tuber quality. When potato seeds are planted directly in line with the drip tape, the roots and new tubers are directly in the most saturated part of the soil. By placing the drip tape offset from the seed, roots and tubers would develop in a less saturated part of the potato bed, favoring tuber quality.

Methods

The experiment was conducted on Owyhee silt loam, following winter wheat, where potato had not been planted for 3 years. In September 2002, after the wheat stubble had been chopped and irrigated, the field was disked. A soil test taken on September 9, 2002 showed 18 ppm NO_3, 18 ppm P, 306 ppm K, organic matter 2.2 percent, and pH 7.6. Fall fertilizer was spread to apply 21 lb N/acre, 100 lb P_2O_5/acre, 60 lb K_2O/acre, 60 lb S/acre, 30 lb Mg/acre, 4 lb Zn/acre, 2 lb Cu/acre, 1 lb Mn/acre, and 1 lb B/acre. The field was deep ripped, disked, and Telone II was applied at 25 gal/acre, and the soil was bedded on 36-inch spacing. On April 4, 2003, Roundup was applied at 1 qt/acre to control winter annual weeds and volunteer wheat.

Certified seed of Umatilla Russet was cut by hand into 2-oz seed pieces and treated with Tops MZ + Gaucho dust. On April 23 and 24, the cut seed was planted 8 inches deep using a custom-built potato plot planter. The planter used cups on chains driven by a ground wheel, with interchangeable drive sprockets providing the adjustment of seed spacing in the row. Four individual planter units could be slid to different positions on the frame so that two or four rows could be planted at various between-row spacings. On April 28, the beds were shaped using a spike bed harrow pulling wide shovels to maintain the wheel furrows and dragging a chain to pull soil into the center of the bed and smooth the top flat.

The treatments consisted of two populations, 18,150 and 24,200 plants per acre, with each population planted in three configurations. Drip tapes were shanked into the beds on May 6. Configuration 1 was 2 rows 36 inches apart on a nominal 72-inch bed (72 inches furrow to furrow) with a drip tape directly above each row of potatoes (Table 1). Configuration 2 was 2 rows 36 inches apart on a 72-inch bed with the drip tapes offset 7 inches to the inside of the bed from each potato row. Configuration 3 was 4 rows on a 72-inch bed with 16 inches between the pairs of rows, and the paired rows 14 inches apart, with the drip tape centered between the pairs of rows. Plants were staggered in the paired rows. Plots were 20 ft long by two beds (12 ft) wide, replicated four times.

Prowl at 1 lb/acre plus Dual at 2 lb/acre was applied on May 1. On May 6 the drip tape was installed in each plot using a pair of drip tape injectors and spools mounted on a tool bar and moved to the correct spacing for each treatment. The drip tape was T-tape 0.22 gal/hour/100 ft, with 12-inch emitter spacing. Matrix herbicide was applied at 1.25 oz/acre on May 28. The first irrigation was applied on June 6, and included Vydate at 2.1 pint/acre in irrigation water acidified to pH 5 by injection of sulfuric acid. Bravo plus Ridomil Gold was applied by aerial application on June 7, and again on June 25. Bravo fungicide plus liquid sulfur was applied by aerial applicator on July 2, and again on August 8. Sulfur dust was applied by aerial applicator on July 20 at 40 lb S/acre.

Irrigations were controlled by a CR10 data logger (Campbell Scientific, Logan, UT) connected to a multiplexer that provided connections for two Watermark (Irrometer, Riverside, CA) soil moisture sensors in each plot. The sensors were installed in a plant row at the seedpiece depth. The data logger was connected through relays to a 24VAC solenoid valve for each treatment. The drip tape on each set of four plots of a treatment was plumbed through 0.5-inch PVC pipe to six solenoid valves supplied with water under constant pressure. The soil moisture sensors were read by the datalogger every 3 hours. At midnight and noon the datalogger calculated the average sensor readings for each treatment. If the average soil water potential for a treatment was below -30 kPa, the valve opened for 3 hours to apply a 0.2-inch irrigation.

Fertilizer solution was injected into the drip system in response to bi-weekly petiole tests. The total fertilizer applied from June 19 to August 14, both through the drip system and by aerial application, was 108 lb N/acre, 28 lb P_2O_5/acre, 12 lb K_2O/acre, 14 lb SO_4/acre, 40 lb S/acre, 0.03 lb Ca/acre, 0.5 lb Mg/acre, 0.61 lb Zn/acre, 1.15 lb Mn/acre, 0.69 lb Cu/acre, 0.06 lb Fe/acre, and 0.01 lb B/acre.

On October 2 the vines were flailed from the potato plants and on October 9 the potatoes were dug. The tubers from 15 ft of the center two rows of each four row plot were bagged and graded. Data were statistically analyzed using the ANOVA procedure in NCSS.

Results and Discussion

There was a significant interaction between planting configuration and plant population in total yield (Table 2). The low-population standard configuration yielded 556 cwt/acre, significantly more than the 470 cwt/acre total yield in the standard configuration at the high plant population, 24,200 plants per acre.

For the marketable yield category, comprised of the U.S. No. 1 and No. 2 tubers over 4 oz, there was a significant difference between the high and the low plant population on the standard configuration. The average marketable yield was higher with the low plant population, and there was a significant interaction between population and configuration because the marketable yield of the standard configuration at the high plant population was 333 cwt/acre, which was significantly lower than all other treatments.

There were no significant differences in percent of U.S. No. 1 tubers among the treatments. The overall average percent of U.S. No. 1 tubers, 66 percent, was lower than usual for Umatilla Russet at this location. Percent U.S. No. 1 tubers ranged from 70 percent for the staggered double row (configuration 3) at the low plant population, to 63 percent for the two rows per bed with the drip tapes offset 7 inches (configuration 2) at the high population.

The high plant population produced significantly more small, 4- to 6-oz, U.S. No. 1 tubers, and undersized tubers. There were no significant differences in yield of 6- to 12-oz U.S. No. 1 tubers. The high plant population produced less 12- to 16-oz and over 16-oz U.S. No. 1 yield. Total U.S. No. 1 yield was significantly higher at the low plant population with configuration 1.

The yield of U.S. No. 2 tubers was significantly greater with the low plant population. The high plant population standard configuration produced the least U.S. No. 2 yield, but that treatment also produced the most undersize tubers of less than 4 oz. Based on this trial for one season at one location, there was no advantage to plant double rows of Umatilla Russet, increase the plant population, or offset the drip tape 7 inches from the plant row.

Table 1. Relationship of planting configuration treatments in the planting configuration trial to one common potato production planting configuration, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Configuration	Rows and row widths	Plant population	Drip tape placement relative to plant row
	per 36-inch bed	Plants/acre	
Common grower practice	1 row	18,150	none
Treatments in this trial	per 72-inch bed		
Treatment 1	2 rows	18,150	in row
Treatment 2	2 rows	18,150	offset 7 inches from row
Treatment 3	2 double rows	18,150	between double rows
Treatment 4	2 rows	24,200	in row
Treatment 5	2rows	24,200	offset 7 inches from row
Treatment 6	2 double rows	24,200	between double rows

Table 2. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Population		Total yield	Total marketable yield	U.S. No. 1 yield >4 oz						U.S. No. 2 >4 oz	Undersized < 4 oz
				Percent	4-6 oz	6-12 oz	12-16 oz	>16 oz	Total		
plants/acre	Tape configuration	--------cwt/acre--------		%	--cwt/acre--						
18,150	1	556.4	469.9	67.9	77.6	191.8	58.9	48.8	377.1	92.8	86.4
18,150	2	516.7	447.4	65.4	70.3	178.4	54	36.6	339.2	108.2	69.2
18,150	3	516	459.3	70.4	68.9	201.9	66.4	24.7	361.9	97.4	56.7
Mean		529.7	458.9	67.9	72.3	190.7	59.8	36.7	359.4	99.5	70.8
24,200	1	469.7	333.3	63.4	113.3	155.1	18.1	11.1	297.6	35.7	136.4
24,200	2	530.9	424.8	62.7	91.8	169.3	47.8	26.7	335.6	89.2	106.1
24,200	3	533	447.2	67	98.4	200.7	43.1	15.4	357.6	89.6	85.8
Mean		511.2	401.8	64.4	101.2	175	36.3	17.7	330.3	71.5	109.4
Average	1	513.1	401.6	64.1	95.5	173.5	38.5	30	337.4	64.3	111.4
Average	2	523.8	436.1		81.1	173.9	50.9	31.7	337.4	98.7	87.7
Average	3	524.5	453.3	68.7	83.7	201.3	54.8	20.1	359.8	93.5	71.3
Overall mean		520.5	430.3	66.1	86.7	182.9	48.1	27.2	344.8	85.5	90.1
LSD (0.05) Population		22.5	31.8	NS	13.5	NS	13.4	13.3	33.1	19.2	22.7
LSD (0.05) Configuration		NS	39	NS	16.6	NS	NS	NS	NS	23.2	27.8
LSD (0.05) PxC.		39	55.1	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Replicate		NS	45	NS	NS	40.6	NS	NS	46.8	NS	32

DEVELOPMENT OF NEW HERBICIDE OPTIONS FOR WEED CONTROL IN POTATO PRODUCTION

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Introduction

Weed control in potatoes is essential for production of high yielding, marketable tubers. Herbicide options in potato production are limited. Outlook (dimethenamid-P), Spartan (sulfentrazone), and Chateau (flumioxazin) are new herbicides that have demonstrated great promise for use in potato. Spartan and Chateau (reported as Valor in previous reports) represent a mode of action that is not currently used in potatoes and offer excellent hairy nightshade control. In previous weed control trials at the Malheur Experiment Station, Outlook (dimethenamid-P) has controlled a larger spectrum of weeds than several other herbicides registered in potato. Trials were conducted to evaluate these new herbicides for weed control in potatoes. The results of our research have been provided to herbicide companies, the IR4 program, and state regulators in support of additional herbicide registrations in potatoes. Spartan has been registered for use in potato this year and a full label for Outlook is expected for 2005. The registration of these herbicides gives producers additional tools to use for controlling weeds and may increase economic returns through improved weed control.

Materials and Methods

A field trial was conducted at the Malheur Experiment Station to evaluate new herbicides for weed control efficacy and crop tolerance in potatoes. In the fall of 2002, 100 lbs P, 150 lbs K, 40 lbs elemental S, 6 lbs Mn, 2 lbs Zn, 2 lbs Cu, and 1 lb B/acre were applied to the trial area prior to bedding. Potatoes were planted April 24, 2003 in an Owyhee silt loam soil with pH 7.6, 2.1 percent organic matter content, and a cation exchange capacity of 20. 'Russet Burbank' seed pieces were planted every 9 inches in 36-inch-wide rows. Experimental plots were four rows wide and 30 ft long. Plots were sidedressed with 100 lb N/acre on May 13 and rehilled on May 19. Preemergence herbicide treatments were applied and immediately incorporated with 0.5 inch of sprinkler-applied irrigation water on May 19. Herbicides were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. On June 23, 20 lb N/acre was applied through the sprinkler. On August 8, 10 lb/acre of 'HighPhos PKS' (10-45-10) including 3 percent S, 0.02 percent B, 0.05 percent Cu, 0.1 percent Fe, 0.05 percent Mn, 0.0005 percent Mo, and 0.05 percent Zn was applied by airplane. Disease and insect management were accomplished by appliying Ridomil Gold plus Bravo (2 lb/acre) on June 19, sulfur dust (40 lb/acre) on July 20, and Bravo (1.5 pt/acre) plus Sulpreme (1 gal/acre) on August 4. Potato injury and weed control were evaluated throughout the growing season and tuber yields were determined by harvesting the center two rows of each plot on September 9-11. Potatoes were graded for yield and size on September 12-17.

Results and Discussion

Many herbicides provided excellent weed control in this trial (Table 1). Sencor (metribuzin) alone provided greater than 95 percent control of all weed species. Control of pigweed species was the lowest with Prowl (pendimethalin) and was less than 70 percent with Dual Magnum (s-metolachlor), Eptam (EPTC), and Chateau alone. Dual Magnum plus Prowl also had less pigweed control than other tank mixtures. On August 25, common lambsquarters control was lowest with Dual Magnum. Prowl and Chateau alone provided only 59 and 52 percent control of common lambsquarters while other treatments provided 68-100 percent control. Matrix (rimsulfuron) alone provided the least hairy nightshade control. Control with all other herbicides applied alone provided 90-100 percent hairy nightshade control. Chateau provided little barnyardgrass control unless tank mixed with another herbicide. Spartan gave greater than 94 percent control of all broadleaf weeds and 89 percent control of barnyardgrass. Chateau caused up to 21 percent injury 22 days after treatment, but no treatments had any injury 35 days after treatment (data not shown). In general, yields reflected weed control; treatments with poor weed control also had reduced potato yields (Table 2). There were cases where treatments providing similar weed control had significantly different yields. Spartan plus Prowl and Spartan plus Dual Magnum provided nearly identical levels of weed control, but Spartan plus Prowl had significantly higher tuber yields. These differences could not be explained by crop injury since no differences in potato injury between these treatments were observed during the season.

Table 1. Outlook, Spartan, and Chateau combinations for weed control in potato, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

		Weed control								
		Pigweed spp.†		Common lambsquarters		Hairy nightshade		Kochia		Barnyard-grass
Treatment*	Rate	6-23	8-25	6-23	8-25	6-23	8-25	6-23	8-25	8-25
	lb ai/acre	%								
Untreated control	--	-	-	-	-	-	-	-	-	-
Handweeded	--	-	-	-	-	-	-	-	-	-
Sencor	0.5	99	98	100	100	100	95	100	100	96
Prowl	1.0	69	40	84	59	100	90	100	93	74
Dual Magnum	1.34	84	66	73	21	97	96	83	59	95
Eptam	3.0	89	68	86	84	98	94	96	79	98
Spartan	0.141	100	95	98	94	100	100	100	100	89
Chateau	0.094	94	68	97	52	100	93	100	94	31
Outlook	0.656	96	90	94	73	99	90	99	95	98
Matrix	0.023	97	88	92	68	94	76	98	93	69
Spartan + Sencor	0.141 + 0.5	100	100	97	100	100	100	100	100	100
Spartan + Prowl	0.141 + 1.0	100	98	100	100	100	100	100	100	100
Spartan + Dual Magnum	0.141 + 1.34	100	98	100	100	100	100	100	100	98
Spartan + Eptam	0.141 + 3.0	100	98	100	99	100	100	100	100	100
Spartan + Matrix	0.141 + 0.023	100	98	100	97	100	100	100	100	91
Chateau + Sencor	0.094 + 0.5	100	100	100	100	100	100	100	100	97
Chateau + Prowl	0.094 + 1.0	100	88	99	79	100	100	100	97	61
Chateau + Dual Magnum	0.094 + 1.34	100	100	98	93	100	100	100	99	76
Chateau + Eptam	0.094 + 3.0	100	100	100	97	100	100	100	100	100
Chateau + Matrix	0.094 + 0.023	100	98	100	90	100	98	100	100	98
Outlook + Sencor	0.656 + 0.5	100	98	100	98	100	100	100	100	100
Outlook + Matrix	0.656 + 0.023	100	99	99	95	100	100	100	100	100
Spartan + Outlook	0.141 + 0.656	100	100	100	98	100	100	100	100	100
Chateau + Outlook	0.094 + 0.656	100	96	100	97	100	100	100	100	93
Prowl + Matrix	1.0 + 0.023	100	92	100	92	98	81	100	100	92
Outlook + Prowl	0.656 + 1.0	96	95	100	97	100	100	100	98	98
Dual Magnum + Prowl	1.34 + 1.0	92	76	99	86	100	94	100	98	97
Dual Magnum + Sencor	1.34 + 0.5	100	100	100	98	100	100	100	100	99
Dual Magnum + Matrix	1.34 + 0.023	100	98	97	83	98	100	100	100	100
Prowl + Eptam	1.0 + 3.0	100	91	100	100	100	100	98	98	98
LSD (0.05)		7	17	7	17	3	13	5	13	24

*Herbicide treatments were applied preemergence on May 19. Chateau was reported as Valor in previous reports.
†Pigweed species were a combination of Powell amaranth and redroot pigweed.

Table 2. Outlook, Spartan, and Chateau combinations for weed control in potato, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment*	Rate	Potato yield† U.S. No. 1 4-6 oz	6-12 oz	>12 oz	Total	Percent	Total No. 2	Total marketable	Total yield
	lb ai/acre	cwt/acre	cwt/acre	cwt/acre	cwt/acre	%	cwt/acre	cwt/acre	cwt/acre
Untreated control	--	36	19	0	55	64	4	59	151
Handweeded	--	87	125	19	231	33	26	257	342
Sencor	0.5	89	163	29	282	31	40	322	406
Prowl	1.0	82	87	7	176	42	19	195	293
Dual Magnum	1.34	75	88	9	171	41	18	189	291
Eptam	3.0	89	117	8	214	37	40	255	338
Spartan	0.141	79	156	23	257	35	44	301	388
Chateau	0.094	70	127	22	220	32	22	242	315
Outlook	0.656	84	148	34	265	32	36	302	388
Matrix	0.023	84	114	17	215	38	31	246	342
Spartan + Sencor	0.141 + 0.5	92	173	26	291	32	43	334	428
Spartan + Prowl	0.141 + 1.0	95	188	38	322	28	50	372	448
Spartan + Dual Magnum	0.141 + 1.34	92	138	24	254	33	41	295	382
Spartan + Eptam	0.141 + 3.0	84	162	39	285	30	38	323	406
Spartan + Matrix	0.141 + 0.023	95	158	34	286	32	49	336	418
Chateau + Sencor	0.094 + 0.5	82	155	31	267	29	27	294	373
Chateau + Prowl	0.094 + 1.0	89	136	19	244	33	28	273	364
Chateau + Dual Magnum	0.094 + 1.34	79	160	42	282	28	31	312	391
Chateau + Eptam	0.094 + 3.0	91	161	25	287	29	31	318	402
Chateau + Matrix	0.094 + 0.023	85	176	31	292	28	42	334	403
Outlook + Sencor	0.656 + 0.5	101	183	35	319	28	38	357	443
Outlook + Matrix	0.656 + 0.023	97	165	31	294	31	33	327	422
Spartan + Outlook	0.141 + 0.656	87	169	33	289	31	50	339	420
Chateau + Outlook	0.094 + 0.656	89	160	30	280	28	25	305	389
Prowl + Matrix	1.0 + 0.023	90	180	36	306	29	42	348	429
Outlook + Prowl	0.656 + 1.0	91	176	40	307	29	30	337	431
Dual Magnum + Prowl	1.34 + 1.0	100	138	26	264	32	24	288	385
Dual Magnum + Sencor	1.34 + 0.5	92	167	28	287	29	35	322	405
Dual Magnum + Matrix	1.34 + 0.023	103	182	35	320	27	30	350	439
Prowl + Eptam	1.0 + 3.0	105	167	29	301	30	28	329	429
LSD (0.05)		18	36	16	54	7	13	53	52

*Herbicide treatments were applied preemergence on May 19. Chateau was reported as Valor in previous reports.
†Potatoes were harvested September 9 to11.

SUGAR BEET VARIETY 2003 TESTING RESULTS

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Introduction

The sugar beet industry, in cooperation with Oregon State University (OSU), 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 combined data to choose the best varieties for sugar beet production. This report provides the agronomic practices, experimental procedures, and sugar beet yields and quality for the OSU Malheur Experiment Station location of the 2003 trials.

Methods

The sugar beet trials were grown on an Owyhee silt loam that had grown winter wheat the year before. The field was plowed and disked, then 82 lb P_2O_5/acre, 93 lb K_2O/acre, 99 lb SO_4/acre, 3 lb Zn/acre, 47 lb Mg/acre, 1 lb Mn/acre, 2 lb Cu/acre, and 1 lb B/acre fertilizer was applied according to fall soil sampling results. The field was then ripped, disked, groundhogged, fumigated with Telone C17 at 20 gal/acre, and fall bedded on 22-inch rows.

On March 29 the beds were remade using a spike-tooth bed harrow and preplant herbicide Nortron SC at 6 pint/acre was applied and incorporated using the bed harrow. A soil test taken on April 3, 2003, showed 51 lb $N0_3$/acre available in the top foot of soil, 24 ppm extractable P, 322 ppm exchangeable K, 2.5 ppm Zn, pH 7.3, and 1.3 percent organic matter.

Sugar beet varieties were entered by ACH Seeds, Betaseed, Hilleshog/Syngenta, Holly Hybrids-Spreckels, and Seedex in 2003. Twenty-seven varieties were tested in the Commercial Trial, and 32 varieties (including 4 commercial check varieties) were tested in the Experimental Trial. Seed for the Commercial Trial was organized by Amalgamated. Seed of varieties in the Experimental Trial was sent by the seed companies. Both the Experimental Trial and the Commercial Trial were planted on March 31. Seeds were planted with John Deere model 71 flexi-planter units with double disc furrow openers and cone seeders fed from a spinner divider to uniformly distribute the seed. The seeding rate was 12 viable seed/ft of row. Each entry was replicated eight times in a randomized complete block design.

On April 4 Counter 20CR was applied in a band over the row at 8.6 lb/acre (5 oz/1,000 ft of row). On April 10 Roundup herbicide was applied at 1 quart/acre, and on April 11 crust busters were rolled over the rows to ensure uniform emergence. Full emergence was observed on April 14. On May 2, Betamix Progress at 24 oz/acre, Upbeet at 0.5 oz/acre, and Stinger at 3 oz/acre were applied for weed control. On May 14, urea was sidedressed to supply 170 lb N/acre. Seedlings were thinned by hand to one plant every 6.4 inches in the row on May 19 and 20. Plots of each variety were four rows wide by 23 ft long, with 4-ft alleys separating tiers of plots. The field was sidedressed with Temik at 10 lb/acre on May 21 to control sugar beet root maggot. On May 22, trifluralin was applied at 1.5 pint/acre and incorporated with an Alloway cultivator.

The field was furrow irrigated with surge irrigation from gated pipe. Irrigation was monitored with Watermark (Irrometer Co. Inc., Riverside, CA) soil moisture sensors connected to an AM400 Hansen datalogger (M.K. Hansen Co., Wenatchee, WA) to maintain the soil water potential wetter than -70 centibar at 10-inch depth in the beet row. The first irrigation was applied on May 23, for 16 hours, to move the insecticide with the wetting front into the sugar beet seedlings' root zone. The field was recorrugated the final time on June 10.

Headline fungicide was applied at 12 oz/acre by aerial applicator on June 17 for control of powdery mildew. Headline fungicide at 12 oz/acre with liquid sulfur at 12 lb S/acre was applied by aerial applicator on July 17. Sulfur dust was applied at 40 lb S/acre by aerial applicator on July 20. A petiole test was taken on July 31, and 0.2 lb B/acre was applied in the irrigation water. Topsin M at 0.5 lb/acre with 0.44 lb S/acre, 0.22 lb Fe/acre, 0.22 lb Mn/acre, and 0.33 lb Zn/acre was applied by aerial applicator on August 4. On August 7, 4.6 lb N/acre, 10 lb SO_4/acre, 0.25 lb Zn/acre, and 0.25 lb Cu/acre were applied in the irrigation water. On August 11, a second petiole test was taken, and on August 14, 7.8 lb N/acre, 10.7 lb P_2O_5/acre, 1.2 lb K_2O/acre, 9.5 lb SO_4/acre, 0.02 lb B/acre, 0.01 lb Fe/acre, 0.01 lb Zn/acre, and 0.21 lb Cu/acre were applied in the irrigation water. The final irrigation was on September 23.

Sugar beets were harvested from the Commercial Trial on October 22 and 23, and from the Experimental Trial on October 23 and 24. 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 delivered each day to the Snake River Sugar factory in Nyssa for laboratory analysis of percent sucrose (Sug), nitrate concentration, and conductivity (Cond).

The root weight data were examined for outliers as is customary for calculations of sugar beet variety data by Amalgamated 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 with the erroneous readings being dropped from the data set. The companion samples of all missing or deleted sugar data were good, so no plots were lost due to sugar sample errors. The weight of sugar beets from each plot was multiplied by 0.95 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 with two samples from each plot were averaged for analysis. The percent extraction (Ext) was calculated using the formula:

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

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 4490 R', Hilleshog/Syngenta 'HM2986 Rz', and Seedex 'Raptor Rz'. OSU reports of previous years' variety trials are available online at cropinfo.net.

Results

Stand establishment was excellent in the 2003 sugar beet variety trials at Malheur Experiment Station, with frequent gentle rains that totaled 1.12 inches in April and 1.52 inches in May. Record heat of 110°F on July 22, along with prolonged heat throughout the growing season, stressed the sugar beets. Hot, dry weather during the summer promoted powdery mildew infection on sugar beet foliage in growers' fields in the area. Powdery mildew developed on foliage in these trials in September. Record heat in October may have reduced potential sugar content increases.

Variety performance was grouped by seed company for the Commercial Trial (Table 1) and the Experimental Trial (Table 2). Within each seed company's varieties, the varieties are ranked in descending order of estimated recoverable sugar in pounds per acre.

Root yield in the Commercial Trial averaged 50.32 ton/acre, average sugar content was 17.27 percent, and average estimated recoverable sugar was 14,702 lb/acre. The varieties yielding among the highest estimated recoverable sugar in the Commercial Trial were 'Beta 8600' with 16,209 lb/acre, 'SX Cascade' with 15,605 lb/acre, 'HH125' with 15,564 lb/acre, 'SX Orbit' with 15,429 lb/acre, and 'Beta 8220B' with 15,388 lb/acre.

Data for the Experimental Trial are reported in Table 2. Root yield in the Experimental Trial averaged 50.22 ton/acre, with average sugar content 17.96 percent, and average estimated recoverable sugar 15,289 lb/acre. The varieties yielding among the highest estimated recoverable sugar in the Experimental Trial were 'HM2990' with 16,795 lb/acre, '03HX351RZ' with 16,315 lb/acre, 'HM2987' with 16,265 lb/acre, 'SX 1520' with 16,213 lb/acre, and 'Crystal 316 R' with 16,109 lb/acre.

Table 1. Commercial sugar beet variety root yield, sugar content, root quality, and recoverable sugar from varieties entered in the trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar	
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre
Hilleshog/Syngenta							
HM 2980RZ	52.38	17.35	18,188	0.859	83.61	290.2	15,214
HM Oasis	50.94	17.27	17,591	0.695	85.77	296.3	15,090
HM 1642	49.25	17.75	17,494	0.766	84.91	301.5	14,867
HM PM21	49.65	17.41	17,308	0.693	85.82	298.9	14,864
HM Owyhee	51.77	16.89	17,468	0.746	85.02	287.3	14,858
HM 2984RZ	48.16	17.34	16,709	0.740	85.19	295.4	14,235
HM 2986RZ	47.81	17.35	16,598	0.736	85.23	295.8	14,156
Holly Hybrids-Spreckels							
HH 125	50.36	17.96	18,087	0.683	86.05	309.1	15,564
PhoenixRZ	53.64	16.97	18,207	0.844	83.74	284.2	15,246
AcclaimRZ	53.30	16.79	17,906	0.879	83.23	279.6	14,912
EagleRZ	53.24	16.52	17,591	0.870	83.30	275.3	14,652
HH 120	48.92	17.14	16,770	0.823	84.05	288.3	14,099
Seedex							
SX Cascade	53.03	17.05	18,082	0.651	86.30	294.3	15,605
SX Orbit	50.30	17.84	17,955	0.694	85.88	306.5	15,429
SX RaptorRZ	51.98	17.00	17,664	0.834	83.88	285.1	14,815
SX Puma	48.46	16.93	16,377	0.703	85.59	289.8	14,023
ACH Seeds Inc.							
ACH Mustang	50.45	17.20	17,359	0.818	84.13	289.4	14,609
Crystal 9906R	44.38	17.61	15,624	0.759	84.98	299.3	13,278
Crystal 217R	44.44	17.75	15,771	0.853	83.77	297.4	13,215
Betaseed							
Beta 8600	57.38	16.71	19,187	0.788	84.43	282.3	16,209
Beta 8220B	55.27	16.63	18,383	0.842	83.69	278.3	15,388
Beta 8859	49.13	17.74	17,430	0.650	86.43	306.7	15,056
Beta 4199R	49.22	17.85	17,575	0.829	84.10	300.3	14,783
Beta 4490R	50.11	17.32	17,357	0.818	84.16	291.6	14,612
Beta 4773R	48.02	17.65	16,952	0.825	84.12	297.0	14,264
Beta 4035R	48.58	17.26	16,770	0.826	84.02	290.2	14,095
Beta 8348	48.85	16.87	16,495	0.846	83.69	282.5	13,811
Mean	50.32	17.27	17,365	0.780	84.64	292.4	14,702
LSD (0.05)	2.66	0.48	1,018	0.053	0.75	9.8	899
LSD (0.10)	2.23	0.40	853	0.044	0.63	8.2	754
CV (percent)	5.3	2.8	5.9	6.8	0.9	3.4	6.1

Table 2. Experimental sugar beet variety root yield, sugar content, root quality, and recoverable sugar from varieties entered in the trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar	
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre
Hilleshog/Syngenta							
HM 2990	53.00	18.40	19,489	0.681	86.15	317.0	16,795
HM 2987	50.96	18.37	18,727	0.626	86.86	319.2	16,265
HM 2988RZ	48.86	18.43	18,016	0.705	85.84	316.5	15,467
HM 2986RZ	49.71	17.90	17,800	0.764	84.98	304.3	15,128
HM 2989RZ	48.21	18.20	17,560	0.773	84.91	309.2	14,913
Holly Hybrids-Spreckels							
03HX351RZ	55.36	17.47	19,349	0.809	84.30	294.6	16,315
01HX047RZ	52.41	17.88	18,738	0.691	85.92	307.3	16,100
00HX011RZ	52.08	17.76	18,501	0.679	86.06	305.7	15,931
03HX359RZ	52.57	17.44	18,332	0.854	83.69	292.0	15,344
03HX356	49.87	18.14	18,075	0.797	84.58	307.0	15,289
03HX353RZ	47.20	18.57	17,536	0.717	85.71	318.4	15,033
02HX226RZ	49.56	17.57	17,414	0.765	84.90	298.3	14,786
03HX355RZ	46.25	17.97	16,604	0.811	84.37	303.2	14,009
Seedex Inc.							
SX1520	52.01	18.11	18,828	0.681	86.10	311.8	16,213
SX RaptorRZ	52.96	17.70	18,739	0.835	84.00	297.3	15,739
SX1519	52.08	17.70	18,427	0.867	83.57	295.8	15,398
SX1521	46.86	18.64	17,474	0.762	85.13	317.4	14,877
SX1518	38.98	18.49	14,426	0.723	85.61	316.6	12,355
ACH Seeds Inc.							
Crystal 316R	51.92	18.16	18,880	0.743	85.30	309.9	16,109
Crystal 318R	50.42	18.05	18,186	0.651	86.46	312.2	15,721
Crystal 317R	51.46	17.85	18,374	0.779	84.76	302.4	15,571
Crystal 103	52.14	17.78	18,513	0.829	84.08	299.0	15,565
Crystal 319R	51.71	17.43	18,033	0.904	83.01	289.4	14,974
Crystal 217R	45.21	18.00	16,274	0.869	83.60	301.0	13,605
Betaseed							
Beta 2YK0016	51.86	17.98	18,651	0.851	83.84	301.6	15,638
Beta 3YK0019	50.75	18.10	18,369	0.801	84.52	305.9	15,524
Beta 4490R	50.42	18.04	18,193	0.825	84.18	303.6	15,316
Beta 3YK0021	52.33	17.46	18,278	0.881	83.34	291.0	15,229
Beta 3YK0018	49.90	17.87	17,828	0.753	85.12	304.2	15,176
Beta 2YK0014	52.01	17.28	17,969	0.819	84.13	290.7	15,118
Beta 3YK0022	48.95	18.13	17,740	0.769	84.94	308.0	15,069
Beta 3YK0020	48.39	17.89	17,306	0.822	84.20	301.3	14,576
Mean	50.22	17.96	18,024	0.780	84.82	304.6	15,289
LSD (0.05)	2.17	0.47	866	0.056	0.77	9.2	759
LSD (0.10)	1.82	0.39	726	0.047	0.64	7.8	636
CV (percent)	4.3	2.6	4.8	7.2	0.9	3.0	5.0

KOCHIA CONTROL WITH PREEMERGENCE NORTRON® IN STANDARD AND MICRO-RATE HERBICIDE PROGRAMS

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Introduction

The distribution of kochia resistant to UpBeet (triflusulfuron) herbicide and other acetolactate synthase (ALS) inhibitors (i.e., sulfonylureas, imidazolinones, and triazolopyrimidines) has increased in recent years and poses a serious problem in sugar beet production, as none of the currently registered postemergence herbicides effectively control ALS-resistant kochia. In these trials, Nortron (ethofumesate) was evaluated for preemergence control of kochia in sugar beet. Nortron is a soil-active herbicide used preemergence or early postemergence to control annual grasses and broadleaf weeds.

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 4, 2003. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 3, kochia seed was spread over the entire experimental area to promote an even weed distribution. After planting, the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 13 and 14. Plots were sidedressed on June 3 with 176 lb nitrogen (urea), 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre boron. All plots were treated with Roundup (0.75 lb ai/acre) on April 11 prior to sugar beet emergence. On May 16, Temik 15G (14 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline (12 fl oz/acre) was applied on June 17 and again on July 2 with Super Six liquid sulfur (16 pt/acre). Topsin M (0.5 lb/acre) was applied on August 4. All fungicide treatments were applied by air. Herbicide treatments were broadcast applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates.

The treatments in this trial consisted of both standard and micro-rate postemergence weed control programs applied with or without a preemergence application of Nortron at either 16.0, 24.0, or 32.0 oz ai/acre with and without postemergence UpBeet. UpBeet was omitted from selected treatments to simulate ALS resistance and to better evaluate preemergence Nortron efficacy on kochia. Nortron was applied preemergence on April 11. The standard rate program included three applications with the first applied to full cotyledon sugar beets on April 23, the second to 2-leaf sugar beets on April 30, and the third application to 10-leaf sugar beets on May 16. Progress (ethofumesate + phenmedipham + desmedipham) was applied at 4.0, 5.4, and 6.75 oz ai/acre in the first, second, and third applications, respectively. UpBeet was applied at 0.25 oz ai/acre in all three applications except those treatments where UpBeet was omitted. Stinger (clopyralid) was applied in the second and third applications at 1.5 oz ai/acre. The micro-rate program consisted of four applications with the first applied to cotyledon sugar beets on April 19, the second to cotyledon to 2-leaf sugar beets on April 26, the third applied to 2- to 4-leaf sugar beets on May 1, and the fourth to 10-leaf sugar beets on May 16. In the micro-rate program, Progress was applied at 1.28 oz ai/acre in the first two applications and at 2.0 oz ai/acre in the last two applications. All four micro-rate applications included UpBeet at 0.08 oz ai/acre (excluding treatments where UpBeet was omitted), Stinger at 0.5 oz ai/acre, and a methylated seed oil (MSO) at 1.5 percent v/v.

Sugar beet injury and weed control were evaluated throughout the season. Sugar beet yields were determined by harvesting the center two rows of each plot on October 6 and 7. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

Kochia control with the standard rate and micro-rate programs without preemergence Nortron was 97 and 96 percent, respectively (Table 1). All treatments including both preemergence Nortron and postemergence UpBeet provided 100 percent control of kochia 66 days after treatment (DAT) on July 21. Kochia control with standard rate treatments without UpBeet gave 92-98 percent control and did not improve with increasing Nortron rates. Applying Nortron preemergence at 16, 24, or 32 oz ai/acre followed by the standard rate program minus UpBeet gave similar kochia control compared with the standard treatment with UpBeet. The micro-rate program minus UpBeet gave 85, 89, and 93 percent kochia control with preemergence Nortron at 16, 24, and 32 oz ai/acre, respectively. When Nortron was applied prior to the micro-rate treatment minus UpBeet only, the 32 oz ai/acre rate provided similar kochia control compared to the micro-rate with UpBeet. Results from previous trials at the Malheur Experiment Station showed that Nortron applied preemergence at 48 oz ai/acre as part of a standard or micro-rate program minus UpBeet provided kochia control similar to both standard and micro-rate programs with UpBeet. The kochia population in this year's trial was less than in previous years and control obtained with Nortron at the evaluated rates may not hold up under greater kochia pressure. These data suggest that in field situations where ALS-resistant kochia is present, preemergence Nortron can improve control. Higher Nortron rates are required when using a micro-rate versus a standard rate program.

All herbicide treatments gave 100 percent control of common lambsquarters and hairy nightshade. Pigweed control (i.e., Powell amaranth and redroot pigweed) was good to excellent (92-100 percent) with all treatments. The removal of UpBeet from the micro-rate program resulted in a significant decrease in barnyardgrass control compared to the micro-rate treatments with or without preemergence Nortron. The standard rate program with UpBeet following Nortron at 16 oz ai/acre provided 45 percent greater barnyardgrass control than the same treatment without UpBeet. Increasing the preemergence Nortron rate from 16 to 24 oz ai/acre and from 16 to 32 oz ai/acre in the standard rate program without UpBeet resulted in 33 and 40 percent greater barnyardgrass control, respectively.

Sugar beet injury on May 5, 4 days after the third micro-rate application and 5 days after the second standard rate application, ranged from 25 to 33 percent with the micro-rate treatments and from 15 to 19 percent with the standard rate treatments (Table 2). By June 2, 17 days after the last application, sugar beet injury was similar among all treatments. Sugar beet injury was not related to increasing Nortron rates. Sugar beet root yields ranged from 44.8 to 49.7 tons/acre in herbicide-treated plots (Table 2). Nortron applied at 16 oz ai/acre followed by the micro-rate without UpBeet produced 44.8 tons/acre root yield, which was significantly less than Nortron at 32 oz ai/acre followed by the standard with UpBeet and Nortron at 24 oz ai/acre followed by the micro-rate with UpBeet, both of which produced root yields of 49.7 tons/acre. These treatments represent the only significant differences in root yield among all herbicide treatments. The herbicide treatment with the lowest root yield, as mentioned above, also provided the lowest kochia control of any treatment at 85 percent. In this trial, each additional 5 percent increase in kochia control resulted in a sugar beet root yield increase of 1.56 tons/acre. When we combined data from the last 3 years of kochia control trials at the Malheur Experiment Station, there is an increase in root yield of 1.7 tons/acre with each additional 5 percent kochia control (Fig. 1).

There were no differences among treatments with regard to percent sucrose content or percent extraction (Table 2). Estimated recoverable sucrose (ERS) yields ranged from 11,514 to 13,648 lbs/acre in herbicide-treated plots (Table 2). Nortron at 24 oz ai/acre preceding the standard program with UpBeet resulted in a significantly higher ERS yield than the total postemergence standard rate treatment with UpBeet. Nortron applied at 16 oz ai/acre followed by the micro-rate with UpBeet resulted in 1,932 and 1,972 lbs/acre greater ERS than Nortron applied at either 16 or 24 oz ai/acre followed by the micro-rate without UpBeet.

Table 1. Kochia control in sugar beets with preemergence Nortron in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control‡					
			Kochia		Pigweed spp.§	Lambs-quarters	Hairy Nightshade	Barnyard-grass
Treatment*	Rate	Timing†	6-16	7-21	7-21	7-21	7-21	6-16
	oz ai/acre		%					
Untreated control	--	--	--	--	--	--	--	--
Standard Rate Program								
Progress + UpBeet	4.0 + 0.25	3	100	97	93	100	100	89
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	5						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	7						
Micro-Rate Program								
Progress + UpBeet + Stinger + MSO	1.28 + 0.083 + 0.5 + 1.5% v/v	2, 4	98	96	98	100	100	94
Progress + UpBeet + Stinger + MSO	1.95 + 0.083 + 0.5 + 1.5% v/v	6, 7						
Nortron fb	16.0	1	100	100	100	100	100	86
Standard with UpBeet	--	3,5,7						
Nortron fb	24.0	1	100	100	100	100	100	90
Standard with UpBeet	--	3,5,7						
Nortron fb	32.0	1	100	100	100	100	100	93
Standard with UpBeet	--	3,5,7						
Nortron fb	16.0	1	98	98	98	100	100	41
Standard w/out UpBeet	--	3,5,7						
Nortron fb	24.0	1	98	92	100	100	100	74
Standard w/out UpBeet	--	3,5,7						
Nortron fb	32.0	1	100	96	100	100	100	81
Standard w/out UpBeet	--	3,5,7						
Nortron fb	16.0	1	100	100	99	100	100	97
Micro with UpBeet	--	2,4,6,7						
Nortron fb	24.0	1	100	100	98	100	100	95
Micro with UpBeet	--	2,4,6,7						
Nortron fb	32.0	1	100	100	100	100	100	98
Micro with UpBeet	--	2,4,6,7						
Nortron fb	16.0	1	90	85	98	100	100	67
Micro w/out UpBeet	--	2,4,6,7						
Nortron fb	24.0	1	86	89	92	100	100	73
Micro w/out UpBeet	--	2,4,6,7						
Nortron fb	32.0	1	91	93	96	100	100	68
Micro w/out UpBeet	--	2,4,6,7						
LSD (0.05)			7	8	NS	NS	NS	25

*fb = Followed by.

†Application timings were (1) April 11 preemergence, (2) April 19 to cotyledon beets, (3) April 23 to full cotyledon beets, (4) April 26 to cotyledon to 2-leaf beets, (5) April 30 to 2-leaf beets, (6) May 1 to 2- to 4-leaf beets, and (7) May 16 to 10-leaf beets.

‡The untreated control was not included in the weed control analysis.

§Pigweed species included Powell amaranth and redroot pigweed.

Table 2. Sugar beet injury and yield with preemergence Nortron in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet					
			Injury‡		Yield			
Treatment*	Rate	Timing†	5-5	6-2	Root yield	Sucrose	Extraction	ERS§
	oz ai/acre		------- % -------		ton/acre	------------ % ------------		lb/acre
Untreated control	--	--	--	--	20.4	14.6	91.7	4,810
Standard Rate Program								
Progress + UpBeet	4.0 + 0.25	3	17	11	47.0	13.4	90.8	11,523
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	5						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	7						
Micro-Rate Program								
Progress + UpBeet + Stinger + MSO	1.28 + 0.083 + 0.5 + 1.5% v/v	2, 4	25	10	47.7	15.0	92.1	13,125
Progress + UpBeet + Stinger + MSO	1.95 + 0.083 + 0.5 + 1.5% v/v	6, 7						
Nortron fb	16.0	1	19	13	48.9	14.5	91.4	12,970
Standard with UpBeet	--	3,5,7						
Nortron fb	24.0	1	17	16	49.1	15.1	92.0	13,648
Standard with UpBeet	--	3,5,7						
Nortron fb	32.0	1	15	14	49.7	14.6	91.6	13,306
Standard with UpBeet	--	3,5,7						
Nortron fb	16.0	1	15	14	45.8	14.1	91.7	11,819
Standard w/out UpBeet	--	3,5,7						
Nortron fb	24.0	1	15	15	47.5	14.7	91.8	12,815
Standard w/out UpBeet	--	3,5,7						
Nortron fb	32.0	1	19	15	48.9	14.0	91.4	12,495
Standard w/out UpBeet	--	3,5,7						
Nortron fb	16.0	1	33	12	48.8	15.1	91.6	13,513
Micro with UpBeet	--	2,4,6,7						
Nortron fb	24.0	1	29	9	49.7	14.4	91.8	13,127
Micro with UpBeet	--	2,4,6,7						
Nortron fb	32.0	1	27	11	48.5	14.4	91.8	12,892
Micro with UpBeet	--	2,4,6,7						
Nortron fb	16.0	1	30	13	44.8	14.0	91.7	11,581
Micro w/out UpBeet	--	2,4,6,7						
Nortron fb	24.0	1	25	13	45.7	13.6	91.6	11,514
Micro w/out UpBeet	--	2,4,6,7						
Nortron fb	32.0	1	29	8	46.8	14.0	91.7	11,991
Micro w/out UpBeet	--	2,4,6,7						
LSD (0.05)			6	NS	3.3	NS	NS	1,833

*fb = Followed by.
†Application timings were (1) April 11 preemergence, (2) April 19 to cotyledon beets, (3) April 23 to full cotyledon beets, (4) April 26 to cotyledon to 2-leaf beets, (5) April 30 to 2-leaf beets, (6) May 1 to 2- to 4-leaf beets, and (7) May 16 to 10-leaf beets.
‡The untreated control was not included in the sugar beet injury analysis.
§ ERS = Estimated recoverable sucrose.

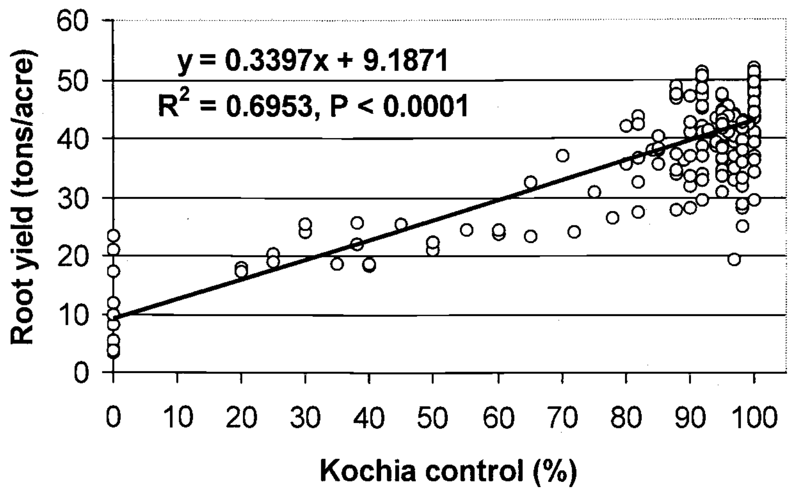

Figure 1. Response of sugar beet root yields to percent kochia control combined over a 3-year period from 2001 to 2003, Malheur Experiment Station, Oregon State University, Ontario, OR.

INFLUENCE OF SOIL-ACTIVE HERBICIDES ON WEED CONTROL WITH MICRO-RATE HERBICIDE PROGRAMS IN SUGAR BEET

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Introduction

Trials were initiated to examine weed control and crop response associated with soil-active herbicides applied postemergence as part of a three- or four-application micro-rate program. The soil-active herbicides evaluated were Outlook (dimethenamid-P), Dual Magnum (s-metolachlor), and Nortron (ethofumesate). Nortron can be applied pre-plant incorporated (PPI), preemergence (PRE), or postemergence (POST) in sugar beet. Outlook is labeled in sugar beet for POST applications only to two-leaf or larger beets. Dual Magnum received a sugar beet label in 2003 for PPI, PRE, and POST applications but due to injury concerns the future status of PPI and PRE applications are uncertain.

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 4, 2003. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 3, kochia, pigweed, and hairy nightshade seed was spread over the entire experimental area to promote an even weed distribution. After planting, the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 13. Plots were sidedressed on June 3 with 176 lb nitrogen (urea), 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre boron. All plots were treated with Roundup (0.75 lb ai/acre) prior to sugar beet emergence on April 11. On May 16, Temik 15G (14 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline (12 fl oz/acre) was applied on June 17 and again on July 2 with Super Six liquid sulfur (16 pt/acre) and Topsin M (0.5 lb prod/acre) was applied on August 4. All fungicide treatments were applied by air. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates.

Micro-rate treatments were applied three or four times. Dual Magnum (21 oz ai/acre), Nortron (16 oz ai/acre), or Outlook (10 oz ai/acre) were applied in the second application to provide residual control of later germinating weeds. All treatments were compared to the micro-rate applied three or four times and to a standard herbicide treatment applied three times. Micro-rate and standard rate treatments were applied broadcast. Micro-rate treatments contained Progress (1.3 oz ai/acre), UpBeet (0.063 oz ai/acre), Stinger (0.5 oz ai/acre), Select (0.5 oz ai/acre), and a methylated seed oil

(MSO) at 1.5 percent v/v. Micro-rate applications were made on April 19, April 30, May 1, and May 12. The standard rate applications were made on April 26, May 1, and May 12. The micro-rate treatments were initiated when sugar beets were in the cotyledon stage. The standard rate treatment was initiated when the cotyledons were fully expanded and the first true leaves had emerged.

Sugar beet injury and weed control were evaluated throughout the season. Sugar beet yields were determined by harvesting the center two rows of each plot on October 6 and 7. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

Pigweed control on June 30 (35 days after treatment [DAT]) was greater with three applications of the micro-rate with Outlook or Dual Magnum in the second application versus the micro-rate applied four times (Table 1). The addition of Outlook or Dual Magnum to the micro-rate applied three times increased pigweed control by 6 percent. Nortron did not significantly improve pigweed control when added to the micro-rate applied either three or four times. Pigweed control was similar among all treatments where the micro-rate was applied four times or when Outlook, Dual Magnum, or Nortron were added to the micro-rate applied three times. There were no differences in control among treatments for common lambsquarters or hairy nightshade. The addition of Outlook or Dual Magnum, but not Nortron, increased kochia control on July 21 (70 DAT) compared to three applications of the micro-rate alone. Similar kochia control was obtained with the standard rate treatment, all four application treatments of the micro-rate, and when Outlook or Dual Magnum were included in the three application micro-rate treatment. All treatments provided 100 percent barnyardgrass control except the micro-rate applied three times or the micro-rate applied three times with either Dual Magnum or Nortron in the second application.

Sugar beet injury on May 5 was greater in treatments with postemergence Outlook, Dual Magnum, or Nortron applications compared to the micro-rate treatments without these herbicides and the standard rate treatment (Table 2). Micro-rate treatments where Nortron was applied injured sugar beets less than micro-rate treatments where Dual Magnum was applied. Sugar beet injury on June 2 was similar among herbicide treatments. Sugar beet root yields were similar among herbicide treatments ranging from 46.7 to 49.2 tons/acre (Table 2). Estimated recoverable sucrose yields ranged from 13,077 to 14,300 lbs/acre and were not different among herbicide treatments. All treatments had greater root and estimated recoverable sucrose yields than the untreated control. There were no differences in percent sucrose content or percent extraction among treatments.

Table 1. Weed control with micro-rate herbicide treatments applied a different number of times and in various combinations in sugar beet, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control‡					
			Pigweed spp†	Lambs-quarters	Hairy nightshade	Kochia		Barnyard-grass
Treatment	Rate	Timing*	6-30	7-21	7-21	6-16	7-21	6-16
	oz ai/acre		%					
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,3,5,6	89	100	99	100	94	100
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,3,5	92	94	98	93	85	96
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	98	95	99	98	96	100
Progress + Upbeet + Stinger + Select + MSO + Outlook	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0	3						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	98	98	100	94	94	99
Progress + Upbeet + Stinger + Select + MSO + Dual Magnum	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0	3						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	95	100	98	97	86	96
Progress + Upbeet + Stinger + Select + MSO + Nortron	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0	3						
Progress + Upbeet + Stinger	4.0 + 0.25 + 1.5	2,4	100	100	100	100	96	100
Progress + Upbeet + Stinger + Select	4.0 + 0.25 + 1.5 + 2.0	6						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	98	100	100	99	94	100
Progress + Upbeet + Stinger + Select + MSO + Outlook	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0	3						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	6						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	98	100	100	95	95	100
Progress + Upbeet + Stinger + Select + MSO + Dual Magnum	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0	3						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	6						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5	96	100	100	100	98	100
Progress + Upbeet + Stinger + Select + MSO + Nortron	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0	3						
Progress + Upbeet + Stinger + Select + MSO	2.0 + 0.063 + 0.5 + 0.5 + 1.5% v/v	6						
Untreated control	--	--	--	--	--	--	--	--
LSD (0.05)			6	5	NS	NS	7	3

*Application timings were (1) April 19 to cotyledon beets, (2) April 23 to cotyledon beets, (3) April 26 to cotyledon to 2-leaf beets, (4) April 30 to 2-leaf beets, (5) May 1 to 2-leaf beets, and (6) May 12 to 8-leaf beets.

†Pigweed species included Powell amaranth and redroot pigweed.

‡The untreated control was not included in the weed control analysis.

Table 2. Sugar beet injury and yield with micro-rate herbicide treatments applied a different number of times and in various combinations in sugar beet, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet					
			Injury†		Yield‡			
Treatment	Rate	Timing*	5-5	6-2	Root yield	Sucrose	Extraction	ERS§
	oz ai/acre		---------- % ----------		ton/acre	----------- % -----------		lb/acre
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,3,5,6	17	8	47.9	15.5	92	13,669
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,3,5	17	5	47	15.1	92.2	13,077
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Outlook	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0	1,5 3	31	14	49.2	14.7	92.1	13,290
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Dual Magnum	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0	1,5 3	32	9	47.3	15.5	92	13,500
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Nortron	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0	1,5 3	28	16	46.7	15.2	92	13,143
Progress + Upbeet + Stinger Progress + Upbeet + Stinger + Select	4.0 + 0.25 + 1.5 4.0 + 0.25 + 1.5 + 2.0	2,4 6	9	11	47.4	15.8	92.7	13,925
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Outlook Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5 3 6	33	10	48.9	15.6	91.8	14,004
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Dual Magnum Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5 3 6	35	6	48.9	15	92.3	13,560
Progress + Upbeet + Stinger + Select + MSO Progress + Upbeet + Stinger + Select + MSO + Nortron Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v 1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0 2.0 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,5 3 6	28	14	49.1	15.8	91.9	14,300
Untreated control	--	--	--	--	16.4	16.5	92.8	5,003
LSD (0.05)			4	9	3.4	NS	NS	1,630

*Application timings were (1) April 19 to cotyledon beets, (2) April 23 to cotyledon beets, (3) April 26 to cotyledon to 2-leaf beets, (4) April 30 to 2-leaf beets, (5) May 1 to 2-leaf beets, and (6) May 12 to 8-leaf beets.

†The untreated control was not included in the sugar beet injury analysis.

‡Sugar beets were harvested on October 6-7, 2003.

§ERS = Estimated recoverable sucrose.

TIMING OF OUTLOOK® AND DUAL MAGNUM® APPLICATIONS FOR WEED CONTROL IN SUGAR BEET

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Introduction

Outlook (dimethenamid-P) and Dual Magnum (s-metolachlor) are soil-active herbicides that are labeled for postemergence application in sugar beet. Outlook can be applied to two-leaf or larger beets and Dual Magnum may be applied to one-leaf or larger beets. Outlook or Dual Magnum were applied as part of a standard rate program in the second or third postemergence application or as a lay-by application. The objectives of this trial were 1) to determine if weed control can be improved with Outlook or Dual Magnum in the standard rate program, and 2) to determine if the application timing of these herbicides influences weed control or crop response.

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 4, 2003. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 3, kochia, pigweed, and common lambsquarters seed was spread over the entire experimental area to promote an even weed distribution. After planting, the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 13 and 14. Plots were sidedressed on June 3 with 176 lb nitrogen (urea), 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre boron. All plots were treated with Roundup (0.75 lb ai/acre) prior to sugar beet emergence on April 11. On May 16, Temik 15G (14 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline (12 fl oz/acre) was applied on June 17 and again on July 2 with Super Six liquid sulfur (16 pt/acre), Topsin M (0.5 lb/acre) was applied on August 4. All fungicide treatments were applied by air. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates.

Soil-active herbicides were applied at various timings as part of a standard rate herbicide program to evaluate the effect of application timing on weed control and crop response with the selected herbicides. The standard rate program consisted of Progress (ethofumesate + desmedipham + phenmedipham) applied at 4.0, 5.4, and 6.7 oz ai/acre in applications one, two, and three, respectively. UpBeet (triflusulfuron) was applied at 0.25 oz ai/acre in all three applications and Stinger (clopyralid) at 1.5 oz ai/acre in the last two applications. Soil-active herbicides included Outlook, Dual Magnum, and Treflan (trifluralin). Outlook was applied at 12.0 oz ai/acre when applied in the second or third application or as a lay-by following the last cultivation. When split across the first and second applications, Outlook was applied at 10.5 and 5.2 oz ai/acre, respectively. Treflan at 6 oz ai/acre was applied with Outlook as a lay-by. Dual Magnum was applied at 20.8 oz ai/acre in the second or third application or as a lay-by. The first, second, third, and lay-by applications were made on April 23, April 30, May 16, and May 21, to cotyledon, 2-leaf, 10-leaf, and 12-leaf beets, respectively.

Sugar beet injury and weed control were evaluated throughout the season. Sugar beet yields were determined by harvesting the center two rows of each plot on October 6 and 7. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

Outlook or Dual Magnum, when added to the standard rate program whether applied in the second or third application or as a lay-by application, did not improve broadleaf weed control compared to the standard rate treatment without any soil-active herbicides (Table 1). All treatments resulted in 97 percent or greater control of broadleaf weed species. Treatments including Outlook or Dual Magnum, regardless of when they were applied, controlled barnyardgrass significantly better than the standard rate treatment without a soil-active herbicide application. Barnyardgrass control was greater with Outlook compared to Dual Magnum when applied in the third standard rate application. Control of barnyardgrass with Outlook was similar whether applied in the second, third, or lay-by applications. Control of barnyardgrass with Dual Magnum was greater when applied in the second application than when applied in the third or lay-by applications.

Sugar beet injury on May 5 was greater with treatments where Outlook or Dual Magnum were applied in the second application compared to the standard treatment alone (Table 2). Injury on May 5, which was only 4 days after the third standard rate application, was similar between treatments with Outlook or Dual Magnum in the third application and the standard treatment without Outlook or Dual Magnum. There were no differences in sugar beet injury among treatments on June 2 (17 days after treatment). Sugar beet root yields associated with herbicide treatments ranged from 47.7 to 49.5 tons/acre and were significantly greater than the untreated control (Table 2). Estimated recoverable sucrose yields were similar among herbicide treatments and were greater than the untreated control.

Table 1. Weed control in sugar beet with standard rate herbicide treatments including postemergence applications of Outlook and Dual Magnum, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control†				
			Kochia	Pigweed spp.‡	Lambs-quarters	Hairy nightshade	Barnyard-grass
Treatment	Rate	Timing*	8-5	8-5	8-5	8-5	6-16
	oz ai/acre		%				
Untreated control	--	--	--	--	--	--	--
Progress + UpBeet	4.0 + 0.25	1	97	98	100	100	81
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 12.0	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	98	92	100	100	99
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger + Outlook	6.7 + 0.25 + 1.5 + 12.0	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 10.5	2					
Progress + UpBeet + Stinger + Outlook	6.7 + 0.5 + 1.5 + 5.2	3					
Progress + UpBeet	4.0 + 0.25	1	98	98	100	100	96
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.5 + 1.5	3					
Outlook	12.0	4					
Progress + UpBeet	4.0 + 0.25	1	98	99	100	100	99
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Outlook + Treflan	12.0 + 6.0	4					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 20.8	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	99	96	100	100	90
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 20.8	3					
Progress + UpBeet	4.0 + 0.25	1	100	96	100	100	93
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Dual Magnum	20.8	4					
LSD (0.05)	--	--	NS	NS	NS	NS	5

*Application timings were (1) April 23 to cotyledon beets, (2) April 30 to 2-leaf beets, (3) May 16 to 10-leaf beets, (4) May 21 lay-by to 12-leaf beets.
†The untreated control was not included in the weed control analysis.
‡Pigweed species included Powell amaranth and redroot pigweed.

Table 2. Sugar beet injury and yield with standard rate herbicide treatments including postemergence applications of Outlook and Dual Magnum, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet					
			Injury†		Yield‡			
Treatment	Rate	Timing*	5-5	6-2	Root yield	Sucrose	Extraction	ERS
	oz ai/acre		------ % ------		ton/acre	---------- % ----------		lbs/acre
Untreated control	--	--	--	--	26.2	16.7	92.7	8,095
Progress + UpBeet	4.0 + 0.25	1	17	14	48.2	15.6	92.6	13,896
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	22	19	49.5	15.7	92.9	14,407
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 12.0	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	18	25	47.7	15.6	92.7	13,773
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger + Outlook	6.7 + 0.25 + 1.5 + 12.0	3						
Progress + UpBeet	4.0 + 0.25	1	20	22	49.8	15.9	92.5	14,601
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 10.5	2						
Progress + UpBeet + Stinger + Outlook	6.7 + 0.5 + 1.5 + 5.2	3						
Progress + UpBeet	4.0 + 0.25	1	20	21	48.2	16.1	92.6	14,350
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.5 + 1.5	3						
Outlook	12.0	4						
Progress + UpBeet	4.0 + 0.25	1	15	21	48.4	16.4	92.7	14,699
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Outlook + Treflan	12.0 + 6.0	4						
Progress + UpBeet	4.0 + 0.25	1	22	22	49.1	15.9	92.3	14,424
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 20.8	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	17	21	48.3	15.8	92.2	14,070
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 20.8	3						
Progress + UpBeet	4.0 + 0.25	1	15	17	49.0	16.4	92.7	14,934
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Dual Magnum	20.8	4						
LSD (0.05)			5	NS	4.1	NS	NS	1,491

*Application timings were (1) April 23 to cotyledon beets, (2) April 30 to 2-leaf beets, (3) May 16 to 10-leaf beets, (4) May 21 lay-by to 12-leaf beets.

†The untreated control was not included in the sugar beet injury analysis.

‡Sugar beets were harvested on October 6-7, 2003.

EVALUATION OF PROGRESS® AND BETAMIX® FORMULATIONS FOR WEED CONTROL AND SUGAR BEET RESPONSE

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Introduction

Pressure from the U.S. Environmental Protection Agency to remove the carrier isophorone from the current formulations of Betamix (desmedipham + phenmedipham) and Progress (ethofumesate + desmedipham + phenmedipham) herbicides has lead Bayer CropScience to develop formulations of these products that use oil-based carriers. The objective of this trial was to determine if sugar beet tolerance and weed control efficacy with the experimental oil-based formulations of Progress (AE B049913) and Betamix (AE B038584) are similar to their respective commercial formulations.

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 4, 2003. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 3, weed seed was spread over the entire experimental area to promote an even weed distribution. After planting the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 13 and 14. Plots were sidedressed on June 3 with 176 lb nitrogen (urea), 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre boron. All plots were treated with Roundup (0.75 lb ai/acre) on April 11 prior to sugar beet emergence. On May 16, Temik 15G (14 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline (12 fl oz/acre) was applied on June 17 and again on July 2 with Super Six liquid sulfur (16 pt/acre). Topsin M (0.5 lb/acre) was applied on August 4. All fungicide treatments were applied by air. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates.

Experimental and commercial formulations of Progress and Betamix were applied alone at 4.0 oz ai/acre and in a micro-rate at 1.28 and 2.56 oz ai/acre with UpBeet (triflusulfuron) at 0.063 oz ai/acre, Stinger (clopyralid) at 0.5 oz ai/acre, and Scoil (methylated seed oil) at 1.5 percent v/v. The experimental and commercial formulations were applied three times alone with the first application to cotyledon beets, the second to two-leaf beets, and the third to six-leaf beets. The three application dates were April 22, May 2, and May 13. The micro-rate treatments were applied four times with applications to cotyledon beets on April 22, two-leaf beets on April 29, four-leaf beets on May 4, and six-leaf beets on May 13.

Sugar beet injury and weed control were evaluated throughout the season. Sugar beet yields were determined by harvesting the center two rows of each plot on October 6 and 7. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

In general, weed control was less with the experimental and commercial Progress and Betamix herbicides applied alone at standard rates compared with the micro-rate treatments (Table 1). On June 6, the experimental formulations, compared with their commercial equivalents, provided similar control of nightshade, common lambsquarters, and kochia. The only difference was observed with the experimental Progress formulation, which controlled pigweed less than its commercial formulation on June 16.

Sugar beet injury ranged from 12 to 22 percent on May 5 prior to the last herbicide application for both the micro and standard rate programs (Table 2). On June 2 (21 days after treatment), sugar beet injury had decreased with most treatments and was similar between the experimental and commercial formulations, whether applied alone at standard rates or in the micro-rate program. Sugar beet root and estimated recoverable sucrose yields were not different when comparing the experimental formulations with their respective commercial formulations applied alone at standard rates or as part of the micro-rate program (Table 2). There were no differences in percent sucrose or percent extraction among any of the treatments.

Table 1. Weed control with experimental and commercial Progress and Betamix formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control[§]					
			Pigweed spp[‡]		Night-shade	Lambs-quarters	Kochia	
Treatment*	Rate	Timing[†]	6-16	8-5	8-5	8-5	6-16	8-5
	oz ai/acre		%					
Exp. Progress Exp. Progress Exp. Progress	4.0 5.3 5.3	2 4 6	80	18	90	95	94	71
Progress Progress Progress	4.0 5.3 5.3	2 4 6	93	48	95	94	90	73
Exp. Progress + UpBeet + Stinger + MSO Exp. Progress + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v 2.56 + 0.064 + 0.5 + 1.5% v/v	1, 3 5, 6	100	93	98	99	95	83
Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v 2.56 + 0.064 + 0.5 + 1.5% v/v	1, 3 5, 6	99	91	100	100	100	94
Exp. Betamix Exp. Betamix Exp. Betamix	4.0 5.3 5.3	2 4 6	84	30	88	98	74	49
Betamix Betamix Betamix	4.0 5.3 5.3	2 4 6	90	43	94	100	83	61
Exp. Betamix + UpBeet + Stinger + MSO Exp. Betamix + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v 2.56 + 0.064 + 0.5 + 1.5% v/v	1, 3 5, 6	100	74	100	100	96	88
Betamix + UpBeet + Stinger + MSO Betamix + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v 2.56 + 0.064 + 0.5 + 1.5% v/v	1, 3 5, 6	100	90	98	100	92	84
Untreated control	--	--	--	--	--	--	--	--
LSD (0.05)			11	34	8	NS	15	28

*Experimental Progress (AE B049913) and Betamix (AE B038584) formulations are oil-based.
[†]Applications were made (1) April 19 to cotyledon beets, (2) April 23 to full cotyledon beets, (3) April 26 to cotyledon to 2-leaf beets, (4) April 30 to 2-leaf beets, (5) May 1 to 2-leaf beets, and (6) May 12 to 8-leaf beets.
[‡]Pigweed species included Powell amaranth and redroot pigweed.
[§]The untreated control was not included in the weed control analysis.

Table 2. Sugar beet injury and yield with experimental and commercial Progress and Betamix formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet					
			Injury†		Yield‡			
Treatment	Rate	Timing*	5-5	6-2	Root yield	Sucrose	Extraction	ERS§
	oz ai/acre		---------- % ----------		ton/acre	---------- % -----------		lb/acre
Exp. Progress	4.0	2	12	16	42.1	16.5	92.7	12,917
Exp. Progress	5.3	4						
Exp. Progress	5.3	6						
Progress	4.0	2	16	13	44.7	16.5	92.9	13,670
Progress	5.3	4						
Progress	5.3	6						
Exp. Progress + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v	1, 3	19	9	46.6	16.1	92.6	13,966
Exp. Progress + UpBeet + Stinger + MSO	2.56 + 0.064 + 0.5 + 1.5% v/v	5, 6						
Progress + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v	1, 3	21	10	46.6	16.3	91.8	14,021
Progress + UpBeet + Stinger + MSO	2.56 + 0.064 + 0.5 + 1.5% v/v	5, 6						
Exp. Betamix	4.0	2	21	12	39.7	16.4	92.9	12,137
Exp. Betamix	5.3	4						
Exp. Betamix	5.3	6						
Betamix	4.0	2	17	7	43.5	16.1	92.5	12,965
Betamix	5.3	4						
Betamix	5.3	6						
Exp. Betamix + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v	1, 3	22	18	45.0	16.3	92.5	13,566
Exp. Betamix + UpBeet + Stinger + MSO	2.56 + 0.064 + 0.5 + 1.5% v/v	5, 6						
Betamix + UpBeet + Stinger + MSO	1.28 + 0.064 + 0.5 + 1.5% v/v	1, 3	22	14	45.6	16.1	92.2	13,561
Betamix + UpBeet + Stinger + MSO	2.56 + 0.064 + 0.5 + 1.5% v/v	5, 6						
Untreated control	--	--	--	--	26.5	16.1	92.7	7,878
LSD (0.05)			6	6	6.4	NS	NS	2,492

*Applications were made (1) April 19 to cotyledon beets, (2) April 23 to full cotyledon beets, (3) April 26 to cotyledon to 2-leaf beets, (4) April 30 to 2-leaf beets, (5) May 1 to 2-leaf beets, and (6) May 12 to 8-leaf beets.
†The untreated control was not included in the sugar beet injury analysis.
‡Sugar beets were harvested on October 7-8, 2003.
§ERS = Estimated recoverable sucrose.

VARIABLE UPBEET® AND PROGRESS® RATES IN STANDARD AND MICRO-RATE HERBICIDE PROGRAMS IN SUGAR BEET

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Introduction

Obtaining satisfactory weed control using the micro-rate program in western sugar beet regions can be difficult when conditions of low humidity and/or a lack of spring precipitation events exist prior to or during herbicide applications. Spring precipitation can increase the efficacy of preemergence applications as well as produce weed flushes that can be controlled by postemergence applications. Weed seedlings growing under dry conditions can be stressed, making them harder to control. In addition, weeds growing under dry conditions often have a heavy wax cuticle on the leaf surface that reduces herbicide penetration. Difficulties in obtaining satisfactory weed control with the micro-rate herbicide program has sparked interest in evaluating weed control and crop response with increased Progress and/or UpBeet rates within the micro-rate program.

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 4, 2003. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 3, kochia, pigweed, and common lambsquarters seed was spread over the entire experimental area to promote an even weed distribution. After planting, the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 13 and 14. Plots were sidedressed on June 3 with 176 lb nitrogen (urea), 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre boron. All plots were treated with Roundup (0.75 lb ai/acre) prior to sugar beet emergence on April 11. On May 16, Temik 15G (14 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline (12 fl oz/acre) was applied on June 17 and again on July 2 with Super Six liquid sulfur (16 pt/acre). Topsin M (0.5 lb/acre) was applied on August 4. All fungicide treatments were applied by air. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates.

Treatments in this trial were designed to evaluate both weed control and crop response with increasing Progress (ethofumesate + desmedipham + phenmedipham) and/or UpBeet (triflusulfuron) rates within the standard and micro-rate weed control programs.

Progress rates ranged from 4.0 to 10.8 oz ai/acre in selected standard rate treatments and from 1.28 to 2.6 oz ai/acre with selected micro-rate treatments. UpBeet rates used in standard rate treatments ranged from 0.25 to 0.5 oz ai/acre and from 0.083 to 0.166 oz ai/acre with micro-rate treatments. Stinger (clopyralid) was applied at 0.5 oz ai/acre in the micro-rate program and at 1.5 oz ai/acre in the standard rate program. Outlook (dimethenamid-P) at 12.0 oz ai/acre was applied postemergence in either the second or third application of selected micro-rate treatments and in the second application of selected standard rate treatments. Nortron (ethofumesate) was applied preemergence at a rate of 18.0 oz ai/acre and postemergence at rates of 0.5, 2.0, and 3.0 oz ai/acre in selected treatments.

Sugar beet injury and weed control were evaluated throughout the season. Sugar beet yields were determined by harvesting the center two rows of each plot on October 6 and 7. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

There were no differences (P = 0.05) in weed control among the herbicide treatments on June 30 (46 days after treatment [DAT]) (Table 1). On August 5 (82 DAT), kochia control was similar among herbicide treatments ranging from 95 to 100 percent. Pigweed control was less, even at 94 percent control, with the traditional micro-rate than all other treatments on August 5. Herbicide treatments gave 100 percent control of hairy nightshade and 97 to 100 percent control of common lambsquarters on August 5. Barnyardgrass control was 98 percent or higher evaluated on June 16 (31 DAT). Weed control in this trial was excellent with all of the herbicide treatments, regardless of the Progress or UpBeet rates.

Sugar beet injury was observed on May 5, 5 days after the second standard rate and 4 days after the third micro-rate postemergence applications (Table 2). Injury ranged from 23 to 40 percent and was greatest with the standard rate treatment applied in combination with methylated seed oil (MSO). The protocol called for 0.5 percent v/v MSO but was inadvertently applied with the traditional micro-rate amount of 1.5 percent v/v. On June 2 (18 DAT), this treatment again displayed the greatest injury. On June 2, sugar beet injury with micro-rate treatments was greater when Outlook and/or Nortron were included in postemergence applications compared to micro-rate treatments alone. Increasing the rates of Progress and/or UpBeet in micro-rate treatments without postemergence Outlook or Nortron did not injure sugar beet more than the traditional micro-rate treatment. Increasing the rate of UpBeet from 0.25 to 0.374 oz ai/acre in the first 2 applications and from 0.25 to 0.5 oz ai/acre in the third application significantly increased sugar beet injury on both May 5 and June 2 with the standard rate treatment with Outlook. By June 16 (31 DAT), differences in sugar beet injury were not detectable among treatments.

In spite of treatment differences with regard to crop injury, yields were not affected by herbicide treatments. Sugar beet root yields were similar among herbicide treatments, ranging from 42.8 to 47.1 tons/acre, all of which were significantly greater than the untreated control (Table 2). There were no differences in either sucrose content or extraction among any of the treatments. All herbicide treatments had estimated recoverable sucrose yields greater than the untreated control.

Table 1. Weed control with variable UpBeet and Progress rates in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control‡				
			Kochia	Pigweed spp.†	Lambs-quarters	Hairy nightshade	Barnyard-grass
Treatment	Rate	Timing*	8-5	8-5	8-5	8-5	6-16
	oz ai/acre % v/v		%				
Untreated control	--	--	--	--	--	--	--
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.083 + 1.5 2.6 + 0.125 + 0.5 + 1.5	1 2 4,6,7	95	100	100	100	100
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 1.5	1 2 4 6,7	99	99	100	100	100
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + Outlook + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 1.5	1 2 4 6 7	100	100	97	100	100
Progress + UpBeet + MSO Progress + UpBeet + Stinger + Nortron + MSO Progress + UpBeet + Stinger + Nortron + Outlook + MSO Progress + UpBeet + Stinger + Nortron + MSO	1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 + 1.5 2.6 + 0.166 + 0.5 + 2.0 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 3.0 + 1.5	2 4 6 7	100	100	100	100	100
Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + Outlook + MSO Progress + UpBeet + Stinger + MSO	1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 1.5	2 4 6 7	98	100	100	100	100
Nortron Progress + UpBeet Progress + UpBeet + Stinger + Outlook Progress + UpBeet + Stinger	18.0 5.4 + 0.374 8.1 + 0.374 + 1.5 + 12.0 10.8 + 0.5 + 1.5	1 3 5 7	100	100	99	100	100
Nortron Progress + UpBeet + MSO Progress + UpBeet+ Stinger + Outlook + MSO Progress + UpBeet+ Stinger + MSO	18.0 5.4 + 0.374 + 1.5 8.1 + 0.374 + 1.5 + 12.0 + 0.5 10.8 + 0.5 + 1.5 + 0.5	1 3 5 7	99	100	100	100	100

Table 1. *(continued)* Weed control with variable UpBeet and Progress rates in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Weed control[‡]				
			Kochia	Pigweed spp.[†]	Lambs-quarters	Hairy nightshade	Barnyard-grass
Treatment	Rate	Timing*	8-5	8-5	8-5	8-5	6-16
	oz ai/acre % v/v		------------------	------------------	%	------------------	------------------
Nortron	18.0	1	100	100	100	100	100
Progress + UpBeet	4.0 + 0.25	3					
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 12.0	5					
Progress + UpBeet + Stinger	6.75 + 0.25 + 1.5	7					
Nortron	18.0	1	100	100	100	100	100
Progress + UpBeet	5.4 + 0.25	3					
Progress + UpBeet + Stinger + Outlook	8.1 + 0.25 + 1.5 + 12.0	5					
Progress + UpBeet + Stinger +	10.8 + 0.25 + 1.5	7					
Nortron	18.0	1	96	94	100	100	98
Progress + UpBeet + MSO	1.28 + 0.083 + 1.5	2					
Progress + UpBeet + Stinger + MSO	1.28 + 0.083 + 0.5 + 1.5	4					
Progress + UpBeet + Stinger + MSO	1.8 + 0.083 + 0.5 + 1.5	6,7					
Nortron	18.0	1	96	99	100	100	100
Progress + UpBeet + MSO	1.28 + 0.083 + 1.5	2					
Progress + UpBeet + Stinger + MSO	2.6 + 0.083 + 0.5 + 1.5	4,6,7					
LSD (0.05)			NS	3	2	NS	NS

*Application timings were (1) April 11 preemergence, (2) April 19 to cotyledon sugar beets, (3) April 23 to full cotyledon sugar beets, (4) April 26 to cotyledon to 2-leaf sugar beets, (5) April 30 to 2-leaf sugar beets, (6) May 1 to 2- to 4-leaf sugar beets, and (7) May 16 to 10-leaf sugar beets.

[†]Pigweed species included Powell amaranth and redroot pigweed.

[‡]The untreated control was not included in the weed control analysis.

Table 2. Sugar beet injury and yield with variable UpBeet and Progress rates in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet						
			Injury†			Yield‡			
Treatment	Rate	Timing*	5-5	6-2	6-16	Root yield	Sucrose	Extraction	ERS
	oz ai/acre % v/v		------------ % ------------			ton/acre	---------- % ----------		lb/acre
Untreated control	--	--	--	--	--	21.0	16.0	91.8	6,208
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.083 + 1.5 2.6 + 0.125 + 0.5 + 1.5	1 2 4,6,7	29	13	0	46.4	16.4	91.9	13,977
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 1.5	1 2 4 6,7	27	11	0	45.5	16.4	92.1	13,749
Nortron Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + Outlook + MSO Progress + UpBeet + Stinger + MSO	18.0 1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 1.5	1 2 4 6 7	34	19	0	42.8	16.6	91.9	13,079
Progress + UpBeet + MSO Progress + UpBeet + Stinger + Nortron + MSO Progress + UpBeet + Stinger + Nortron + Outlook + MSO Progress + UpBeet + Stinger + Nortron + MSO	1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 + 1.5 2.6 + 0.166 + 0.5 + 2.0 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 3.0 + 1.5	2 4 6 7	30	24	0	45.5	16.7	92.3	14,033
Progress + UpBeet + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + Outlook + MSO Progress + UpBeet + Stinger + MSO	1.28 + 0.125 + 1.5 2.6 + 0.125 + 0.5 + 1.5 2.6 + 0.166 + 0.5 + 12.0 + 1.5 2.6 + 0.166 + 0.5 + 1.5	2 4 6 7	28	17	0	47.1	16.2	92.2	14,124
Nortron Progress + UpBeet Progress + UpBeet + Stinger + Outlook Progress + UpBeet + Stinger	18.0 5.4 + 0.374 8.1 + 0.374 + 1.5 + 12.0 10.8 + 0.5 + 1.5	1 3 5 7	33	29	0	46.3	16.4	92.2	14,005
Nortron Progress + UpBeet + MSO Progress + UpBeet+ Stinger + Outlook + MSO Progress + UpBeet+ Stinger + MSO	18.0 5.4 + 0.374 + 1.5 8.1 + 0.374 + 1.5 + 12.0 + 0.5 10.8 + 0.5 + 1.5 + 0.5	1 3 5 7	40	31	2	46.3	16.4	92.2	13,985

Table 2. *(continued)* Sugar beet injury and yield with variable UpBeet and Progress rates in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet						
			Injury†			Yield‡			
Treatment	Rate	Timing*	5-5	6-2	6-16	Root yield	Sucrose	Extraction	ERS
	oz ai/acre % v/v		---------- % ----------			ton/acre	--------- % ---------		lb/acre
Nortron	18.0	1	23	17	0	44.6	16.8	92.6	13,841
Progress + UpBeet	4.0 + 0.25	3							
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 12.0	5							
Progress + UpBeet + Stinger	6.75 + 0.25 + 1.5	7							
Nortron	18.0	1	29	24	0	46.4	16.5	92.5	14,139
Progress + UpBeet	5.4 + 0.25	3							
Progress + UpBeet + Stinger + Outlook	8.1 + 0.25 + 1.5 + 12.0	5							
Progress + UpBeet + Stinger +	10.8 + 0.25 + 1.5	7							
Nortron	18.0	1	25	10	0	46.1	16	91.8	13,546
Progress + UpBeet + MSO	1.28 + 0.083 + 1.5	2							
Progress + UpBeet + Stinger + MSO	1.28 + 0.083 + 0.5 + 1.5	4							
Progress + UpBeet + Stinger + MSO	1.8 + 0.083 + 0.5 + 1.5	6,7							
Nortron	18.0	1	25	11	0	46.7	16.3	91.9	14,000
Progress + UpBeet + MSO	1.28 + 0.083 + 1.5	2							
Progress + UpBeet + Stinger + MSO	2.6 + 0.083 + 0.5 + 1.5	4,6,7							
LSD (0.05)			6	6	NS	4.4	NS	NS	1,341

*Application timings were (1) April 11 preemergence, (2) April 19 to cotyledon sugar beets, (3) April 23 to full cotyledon sugar beets, (4) April 26 to cotyledon to 2-leaf sugar beets, (5) April 30 to 2-leaf sugar beets, (6) May 1 to 2- to 4-leaf sugar beets, and (7) May 16 to 10-leaf sugar beets.
†The untreated control was not included in the sugar beet injury analysis.
‡Sugar beets were harvested on October 6 and 7, 2003.

DUAL MAGNUM® APPLICATIONS FOR WEED CONTROL IN SUGAR BEET

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Introduction

Dual Magnum (s-metolachlor) was labeled in the spring of 2003 for pre-plant incorporated (PPI), preemergence (PRE), and postemergence (POST) applications to sugar beet. Presently, because of injury from PPI and PRE applications to sugar beet this past season in the Red River Valley of North Dakota and Minnesota, the future label status of these application methods is uncertain. The objective of this trial was to evaluate weed control and crop response with PPI, PRE, and POST Dual Magnum applications in sugar beet.

Methods

This trial was conducted in a furrow-irrigated field near Nampa, Idaho. Dual Magnum was applied PPI, PRE, or POST to two-leaf beets at 1.27 or 1.59 lb ai/acre. Nortron (ethofumesate) was applied PPI and PRE at 1.6 lb ai/acre for comparison. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were four rows wide and 27 ft long and treatments were arranged in a randomized complete block design with four replicates. PPI, PRE, and POST treatments were applied on April 17, April 29, and May 23, respectively. PPI treatments were incorporated immediately after application with an Alloway field cultivator equipped with s-tines and rolling baskets. Sugar beets were planted following incorporation. The timing of the PRE applications was not ideal as approximately 20 percent of the sugar beets had already begun to emerge. A standard rate herbicide program consisting of three POST applications of Progress (ethofumesate + desmedipham + phenmedipham), UpBeet (triflusulfuron), and Stinger (clopyralid) was broadcast over the entire experimental area independent of Dual Magnum and Nortron applications. Sugar beet injury and weed control were evaluated throughout the season. Sugar beet stand populations/20 ft of row were recorded on May 23 following PPI and PRE applications. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$). The trial was not harvested.

Results and Discussion

Sugar beet stand populations on May 23 ranged from 32 to 36 plants/20 ft of row and were not different among treatments (Table 1). Sugar beet injury on May 23 was greatest with the PRE treatments. This injury was most likely enhanced because the PRE treatments were applied late and approximately 20 percent of the beets were beginning to emerge, allowing for direct herbicide contact. Sugar beet injury with Nortron was less than with Dual Magnum applied at 1.59 lb ai/acre on May 23 and June 13 and when applied at 1.27 lb ai/acre on June 13. Injury was not different between the PPI treatments and the standard rate program alone. There were no differences in weed control among the PPI treatments (Table 1). The PRE treatments gave similar control of all evaluated weed species. Redroot pigweed control was less with POST Dual Magnum applications than with PPI or PRE treatments of Dual Magnum or Nortron. POST applications of Dual Magnum were applied after many of the weeds had emerged and therefore they were considerably less effective. POST Dual Magnum at either application rate did not improve control of the evaluated weeds when compared to the standard rate alone. Control of kochia, hairy nightshade, and common lambsquarters were similar with Dual Magnum applied POST at 1.59 lb ai/acre and with all PRE treatments. However, when Dual Magnum was applied POST at 1.27 lb ai/acre, control of these weeds was less than with the PRE treatments. Similar control of kochia, hairy nightshade, and common lambsquarters was achieved with all PPI and PRE treatments.

Table 1. Weed control and crop response with Dual Magnum applications in sugar beet, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Sugar beet			Weed control[§]			
			Stand	Injury[‡]		Redroot pigweed	Kochia	Hairy nightshade	C. Lambs-quarters
Treatment*	Rate	Timing[†]	5-23	5-23	6-13	8-14	8-14	8-14	8-14
	lb ai/acre		No./20 ft	----------- %	-----------	------------------------------ %	------------------------------		
Standard rate w/out soil-active	--	--	36	12	1	41	87 b	91 c	61
Nortron	1.6	PPI	34	18	16	76	95 ab	98 ab	95
Dual Magnum	1.27	PPI	33	15	14	86	100 a	89 a	99
Dual Magnum	1.59	PPI	32	19	16	82	94 ab	93 a	99
Nortron	1.6	PRE	36	30	12	85	100 a	100 ab	98
Dual Magnum	1.27	PRE	32	38	23	93	100 a	100 a	96
Dual Magnum	1.59	PRE	33	44	21	97	100 a	100 a	99
Dual Magnum	1.27	POST	36	11	5	25	75 b	80 c	63
Dual Magnum	1.59	POST	36	13	14	28	93 ab	88 bc	74
LSD (0.05)	--	--	NS	8	8	17	--	--	25

*A standard rate herbicide program was blanketed over the entire plot area independent of Dual Magnum and Nortron applications.
[†]PPI applications were made on April 17, PRE on April 29, and POST on May 23, 2003.
[‡]PRE treatments were applied when approximately 20 percent of the sugar beets had just emerged and most likely increased injury with these treatments. POST treatments had not yet been applied at the May 23 evaluation.
[§]In columns where letter designations appear the ANOVA was performed on arcsine square root percent transformed data. Mean separations were applied to non-transformed data. Values with the same letter designations are similar (P = 0.05).

REDUCTION OF IRRIGATION-INDUCED LOSS OF *E. COLI* FROM SURFACE-IRRIGATED PASTURES

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Introduction

Willowcreek is a tributary of the Malheur River, which has its confluence at Vale, Oregon. At the time of Fremont's exploration in 1842 of what would become the Oregon Trail, he took the "Dry Fork" of the Malheur River north, then crossed over the hills to the Snake River to the place that would become known as Farewell Bend. The "Dry Fork" became known as Willowcreek. A photograph from 1907 shows the narrow riparian ribbon from Willowcreek exiting from its valley dominated by sage brush to the Malheur River. Through the decades that followed, pioneers impounded the snow melt runoff in the Willowcreek drainage and used the impounded water for mining and later to irrigate pasture and crops. Runoff from irrigated land sustains the sluggish flow of Willowcreek during the summer.

In recent years ranchers and growers have been concerned with the levels of *E. coli* bacteria in Willowcreek and have sought various methods to reduce the bacterial content. In the present effort, aeration and polyacrylamide (PAM) were used to try to reduce the losses of bacteria from irrigated pastures.

Objectives

1. Evaluate the effect of PAM on the reduction of *E. coli* loss from flood-irrigated pasture.
2. Determine if the PAM application rate can be reduced and still be effective when applied only to the lower 20 percent of the water run.
3. Evaluate whether aeration will reduce irrigation-induced *E. coli* losses.

Materials and Methods

Strips through a pasture on Owyhee silt loam at the Malheur Experiment Station were evaluated for *E. coli* loss during successive 12-hour irrigations. Irrigations were managed to apply approximately 4 acre-inch/acre of water per irrigation. Each strip was 19.7 ft wide (6 m) by 164 ft long (50 m). Treatments included an untreated check, powdered PAM (Soilfix IR, Ciba Specialty Chemicals, Inc., Suffolk, VA) applied in the irrigation water; aeration; and PAM applied to only the bottom of the field (Table 1).

Each treatment was replicated three times in the field with separate strips. Each strip was evaluated for *E. coli* loss through three successive irrigations.

Grazing occurred over the pasture land before each irrigation. During each irrigation, the amount of water applied and in the runoff was measured repeatedly in each plot on hourly to half-hourly time intervals. Water running into each strip was measured with three weirs and the outflow was measured with one weir, so the set-up of each irrigation required 16 weirs, four for each treatment. The water was sampled until runoff ended. Although the irrigations were nominally 12 hours, the actual times of irrigation onset and ending were recorded as well as the actual time and ending of water outflow. At each sampling time, a water sample was collected for *E. coli* analyses and transported to the Bureau of Reclamation laboratory in Boise within 24 hours of sampling.

The loss of *E. coli* was calculated by determining the volume of water and *E. coli* content entering each irrigated strip as integrated over time and determining the volume of water and *E. coli* content of the water leaving each irrigated strip as integrated over time. The software program Infilcal version 5.0 (B.M. Shock and C.C. Shock, Ontario, OR, self-published: version 2.0, 1988; version 5.0, 1992) was modified to take the weir readings and timings and calculate the water into and out of each strip during each irrigation. Infilcal also was modified to calculate the total *E. coli* into and out of the pasture strip. Treatment losses of *E. coli* were compared using ANOVA and standard statistical procedures.

Table 1. Treatments for studying *E. coli* losses from surface-irrigated pasture, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment #	PAM	Aeration
1 untreated check	none	none
2	Treated water, 10 ppm, applying 1 lb/acre	none
3	Granular, broadcast at 1 lb/acre on the bottom 20 %	none
4	none	mechanical

Results

Each set of pasture strips was irrigated four times, rather than three as originally planned. During the first irrigations problems occurred that compromised the accuracy of the measurements. Berms between irrigated strips, uniformity of irrigation, and the sensitivity of laboratory analyses all had to be improved. Consequently the project required more effort in irrigation, *E. coli* analyses, and statistical analyses than originally expected. In total approximately 2,000 inflow, 400 outflow, and 1,000 *E. coli* measurements were made.

During the subsequent nine irrigations, three each on three sets of four pasture strips, the irrigations were well managed and all data were recovered as planned. Each irrigation applied about 4 acre-inch/acre (Table 2). There were no statistically significant differences in water applied, infiltration, or runoff between treatments. This means that neither the PAM nor the aeration improved water retention in the pasture. During each irrigation roughly 80 percent of the water soaked into the pasture strip and 20 percent ran off.

The treatments had no significant effect on the average or total *E. coli* lost in the runoff water (Table 2). The predominant factor was the vast and unexpectedly large *E. coli* enrichment that occurred as the water crossed the sloping pasture ground. The variations in enrichment swamped out any possible measurable effects of the treatments.

Table 2. Average effects of the use of PAM and aeration on irrigation performance, *E. coli* concentrations and *E. coli* losses, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Average irrigation performance			Average *E. coli* counts and losses per irrigation		
Treatment	Inflow	Outflow	Infiltration	Counts in	Counts out	Loss in counts/acre
	--------- acre-inch/acre---------			counts/100 ml		billions
1. Check	3.98	0.63	3.35	4,261	235,605	161
2. PAM	3.89	0.74	3.15	4,466	420,142	317
3. Granular PAM	3.89	0.68	3.21	5,072	363,045	241
4. Aeration	4.07	0.85	3.22	5,274	220,016	302
LSD (0.05)	NS	NS	NS	NS	NS	NS

Discussion

Control of *E. coli* losses from surface-irrigated pasture was not easy to obtain in the current test. The results of this preliminary trial suggest that solutions to *E. coli* losses from sloping ground may lie in other directions or with the use of higher rates of PAM. The PAM rate sufficient to slow or stop *E. coli* loss from sloping surface-irrigated pastures is unknown. Perhaps PAM could reduce *E. coli* loss when used on nearly flat surface-irrigated pastures, conditions not tested in the present study.

Water that is used for surface irrigation of pastures needs to have opportunities for bacteria to settle out of the water. Water exiting a steep surface-irrigated pasture like the one used here may need to enter a settlement pond and be pumped back to the top of another pasture or be pumped into a sprinkler-irrigation system to minimize water runoff losses, thereby precluding *E. coli* losses to streams.

Acknowledgments

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RUSSIAN KNAPWEED CONTROL AS INFLUENCED BY HERBICIDES AND MOWING

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Introduction

Russian knapweed is an invasive perennial weed that thrives in rangeland and other non-cultivated sites. It forms dense colonies that survive because of a large root system. Fall-applied herbicides have been effective in controlling Russian knapweed. Research on other perennial invasive weeds has shown that mowing prior to herbicide application increases control. One possible reason for increased control with mowing is that the removal of plant biomass may allow more of the herbicide to reach the soil surface where it is more likely to be taken up by the plant. This research investigated the use of the Brown Brush Monitor™ (Brown Manufacturing Corp., Ozark, AL) for mowing and herbicide application compared to herbicides sprayed without mowing.

Methods

Trials were established at a Russian knapweed infested site near the Snake River, south of Nyssa, Oregon to evaluate Tordon (picloram) and Transline (clopyralid) applied alone or following mowing with a Brown Brush Monitor. The Brown Brush Monitor incorporates a mower and sprayer into one machine. It removes the above-ground plant material, discharging it to the side of the machine, and then sprays the herbicide from a boom mounted under the rear of the mower deck. Spray-only applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots that were mowed and sprayed measured 15 ft wide by 30 ft long while spray-only plots were 10 ft wide and 30 ft long. Treatments were replicated four times in a factorial design with herbicide and mowing completely randomized within each replication. Treatments with the Brown Brush Monitor were made October 31, 2001 and spray-only treatments were made on November 1, 2001. Russian knapweed response to treatments was determined by visually evaluating control and measuring shoot height and shoot density. Evaluations were made August 5, 2002 and June 26, 2003.

Results and Discussion

Herbicide applied alone or following mowing in the fall of 2001 provided excellent control of Russian knapweed (Table 1). Visual control on August 5, 2002 was slightly higher when Transline was applied following mowing compared to Transline alone. However, in 2003 there was no difference. Close to 2 years after treatment, both herbicides, regardless of mowing, were still providing 93 percent or greater Russian knapweed control. Herbicides with or without mowing and mowing alone reduced Russian knapweed height compared to the untreated control in 2002 and 2003. It is interesting that Russian knapweed plants were shorter in the mowed treatment even 2 years after mowing. This response might be related to soil moisture, competition for light, or soil temperature differences where the biomass was removed by mowing compared to the untreated plots. Mowing alone did not reduce Russian knapweed density. Herbicide treatments with or without mowing reduced Russian knapweed densities in both years. Russian knapweed densities appeared to be stable across years in the mowed-only and untreated plots. While only small differences in Russian knapweed control were apparent among treatments, mowing appeared to enhance recovery of the perennial grasses that were present. Grass populations were not uniform enough to evaluate, but visible differences in grass growth were apparent between mowed and unmowed plots.

Table 1. Russian knapweed control, height, and density in response to herbicides applied alone or in combination with mowing, south of Nyssa, OR. Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

		Russian knapweed†					
		Control		Height‡		Density	
Treatment*	Rate	8-5-02	6-26-03	8-5-02	6-26-03	8-5-02	6-26-03
	lb ai/acre	------------%----------		---------inches---------		--------no/ft²--------	
Untreated	--	0 c	0 b	20 a	23 a	11 a	14 a
Mowed	--	0 c	0 b	14 b	19 b	11 a	13 a
Tordon	0.5	93 a	95 a	11 c	15 c	0 b	1 b
Tordon + Mowing	0.5	94 a	96 a	11 c	14 c	0 b	1 b
Transline	0.38	87 b	94 a	10 c	14 c	0 b	1 b
Transline + Mowing	0.38	91 a	93 a	14 b	16 bc	1 b	1 b

*Treatments that were mowed were applied on October 31, 2001 while spray-only treatments were applied November 1, 2001.
†Within columns, numbers followed by the same letter are not significantly different according to LSD at (P = 0.05).
‡In plots where control was high, Russian knapweed height is based on the few plants that survived.

DOWNY BROME CONTROL AND DESIRABLE SPECIES ESTABLISHMENT AS INFLUENCED BY BURNING AND PLATEAU® APPLICATION RATE AND TIMING

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Introduction

Invasive weed species continue to spread across rangeland. Once established, invasive weeds often have a competitive advantage over native plants. Invasive grass species like downy brome *(Bromus tectorum)* quickly use the available moisture in the spring, set seed, and senesce by early to mid-summer. Once the moisture is depleted and the plants have matured and dried, they become a serious fire hazard. Areas infested with downy brome are more likely to burn on a regular basis. Native species not adapted to frequent burning are further eliminated, resulting in monocultures of downy brome.

The need for herbicides that effectively control downy brome while allowing for the establishment of desirable species is of considerable importance in reclaiming downy brome-infested pastures and rangelands. Plateau (imazapic) herbicide has shown promise for the control of noxious weeds in rangeland, having fair to excellent selectivity on several newly seeded and established desirable grass species. The ability to control downy brome without injury to newly seeded grasses would be a great tool for reclaiming badly infested sites. Plateau needs to be tested under regional conditions to determine its efficacy on downy brome in eastern Oregon and southwestern Idaho. The objectives of this trial were 1) to evaluate the influence of duff removal by burning on downy brome control with Plateau herbicide, 2) to evaluate Plateau application rate for downy brome control and desirable species establishment, and 3) to evaluate Plateau application timing on desirable species establishment.

Methods

A trial was established near Ontario, Oregon to evaluate fall applied Plateau at rates of 0.031, 0.064, 0.094, 0.125, 0.157, and 0.188 lb ai/acre applied prior to or following seeding of various desirable species. In addition, the herbicide treatments were applied to burned and unburned whole plots to compare the effect of duff removal on downy brome control and desirable species establishment. Duff was removed by burning on October 12, 2001. Plateau treatments were applied broadcast with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots measured 10 ft by 35 ft and treatments were replicated three times. The trial was designed as a randomized complete block with a split plot arrangement. Each whole plot (i.e., burned or unburned) received 13 different treatments; 6 preplant Plateau treatments, 6 postplant

Plateau treatments, and an untreated control treatment. Preplant and postplant Plateau treatments were applied on October 18, 2001. Five species were planted lengthwise across the burned and unburned whole plots using a rangeland drill. The species were Valvalov Siberian wheatgrass, Goldar bluebunch wheatgrass, Magnar Great Basin wildrye, Bozoisky wildrye, and western yarrow. Downy brome control and desirable species establishment were evaluated at various dates following trial initiation.

Results and Discussion

Downy brome control was not influenced by Plateau application timing when evaluated in 2002. Both herbicide rate and duff removal by burning influenced downy brome control (Table 1). There was a significant ($P < 0.05$) interaction between burning and Plateau rate with regard to downy brome control when evaluated 188 days after treatment (DAT) on April 24, and July 2, (257 DAT) 2002. On April 24, Downy brome control from Plateau treatments ranged from 73 to 99 percent when applied to burned plots and from 49 to 88 percent applied to unburned plots. Downy brome control was similar with Plateau applied at 0.094, 0.125, 0.157, and 0.188 lb ai/acre when applied following duff removal. In unburned plots, downy brome control was similar with Plateau at 0.125, 0.157, and 0.188 lb ai/acre. Duff removal by burning increased downy brome control from Plateau at rates from 0.031 to 0.125 lb ai/acre on April 24 and from 0.031 to 0.157 lb ai/acre on July 2. In unburned plots, 0.064 and 0.094 lb ai/acre of Plateau were required to achieve control similar to 0.031 and 0.064 lb ai/acre in burned plots when evaluated on April 24 and July 2, respectively. A full 0.157 lb ai/acre of Plateau applied to unburned plots was necessary to give downy brome control similar to 0.094 lb ai/acre applied to burned plots on April 24. By July 2, 2002, the 0.094 lb ai/acre rate of Plateau applied to burned plots gave greater downy brome control than all treatments applied to unburned plots except the 0.188 lb ai/acre rate. The increased efficacy of Plateau applied to burned versus unburned plots may be attributed to increased herbicide soil contact following duff removal. Downy brome acts as an annual or winter annual, therefore increased Plateau concentrations in the soil during germination should provide greater control. In addition, fall burning may have destroyed enough downy brome seed to noticeably reduce downy brome pressure the following spring.

Downy brome control on July 10, 2003 (630 DAT), was influenced by duff removal, Plateau rate, and Plateau application timing (Table 2). Downy brome control with Plateau ranged from 8 to 92 percent in burned plots and from 5 to 62 percent in unburned plots. In burned plots, preplant and postplant applications provided similar downy brome control at all rates except 0.031 lb ai/acre. In unburned plots, preplant applications resulted in greater downy brome control than postplant applications when Plateau was applied at 0.031 or 0.064 lb ai/acre. Conversely, downy brome control was greater with postplant Plateau at rates of 0.094 or 0.157 lb ai/acre versus preplant applications at the same rates.

Establishment of desirable species at this location was difficult due to the extremely dry conditions preceding and following planting. Of the five species that were seeded in the trial, only Bozoisky wildrye failed to establish. The other four species established to varying degrees with the most prolific being Valvalov Siberian wheatgrass. There was a significant interaction between duff removal by burning and herbicide rate with regard to Valvalov, Goldar, Magnar, and yarrow establishment on July 2, 2002 (257 DAT) (Table 3). Valvalov establishment was greater in burned versus unburned plots at all Plateau rates except for the highest rate of 0.188 lb ai/acre. Goldar and Magnar establishment was greater in burned plots compared to unburned plots at Plateau rates of 0.031, 0.064, and 0.094 lb ai/acre. Yarrow establishment was greater in burned plots compared to unburned plots at plateau rates of 0.031 and 0.064 lb ai/acre. The treatments providing the highest rates of establishment for the various species were obtained with duff removal by burning and Plateau applied at 0.094 lb ai/acre for Valvalov, 0.031 lb ai/acre for Goldar and yarrow, and 0.064 lb ai/acre for Magnar (Table 3). Establishment of the various species in unburned plots did not differ with Plateau rate. Valvalov and Magnar establishment were greater with preplant versus postplant Plateau treatments applied to burned plots (Table 3). Establishment of these species was not influenced by Plateau application timing to unburned plots.

Valvalov Siberian wheatgrass establishment on July 10, 2003 (630 DAT), was influenced by duff removal, Plateau rate, and Plateau application timing (Table 5). Valvalov establishment with Plateau ranged from 528 to 3,408 shoots/50 ft^2 in burned plots and from 134 to 512 shoots/50 ft^2 in unburned plots. The greatest Valvalov shoot production was with Plateau applied preplant at 0.094 lb ai/acre. Preplant applications in burned plots resulted in significantly greater shoot production with Plateau applied at 0.094, 0.157, and 0.188 lb ai/acre when compared to their respective postplant applications. Although downy brome control was similar with preplant and postplant applications at these rates, Valvalov shoot production was less with the postplant applications, possibly due to direct herbicide contact with the Valvalov seed at planting. Due to poor downy brome control, there were no differences in Valvalov shoot production with regard to Plateau rate or application timing in unburned plots.

Duff removal by burning was beneficial for both downy brome control and desirable species establishment. The duff layer at the trial location was heavier than what would typically be found at a range site in eastern Oregon or southwestern Idaho. Duff removal by burning may not have as great an effect at a location with less plant biomass. Although it may differ somewhat among seeded species, Plateau applied at 0.064 to 0.094 lb ai/acre appeared to provide the best combination of downy brome control and desirable species tolerance.

Table 1. Interaction between burning and herbicide rate for downy brome control, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

	Downy brome control†			
	April 24, 2002		July 02, 2002	
Plateau rate*	Burned	Unburned	Burned	Unburned
lb ai/acre	%		%	
0.031	73	49	76	35
0.064	83	64	86	70
0.094	92	73	96	82
0.125	96	75	97	86
0.157	96	84	98	89
0.188	99	88	98	92
LSD (0.05)	13		7	

*All Plateau treatments were applied with a non-ionic surfactant at 0.25% v/v.
†The April 24 and July 2 evaluation dates were 188 and 257 DAT, respectively.

Table 2. Interaction between burning, herbicide rate, and application timing for downy brome control, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Downy brome control			
	July 10, 2003†			
	Burned		Unburned	
Plateau rate*	Preplant	Postplant	Preplant	Postplant
lb ai/acre	%		%	
Untreated	0		0	
0.031	8	43	27	5
0.064	52	64	25	7
0.094	74	61	13	41
0.125	73	78	28	38
0.157	87	87	25	62
0.188	91	92	62	53
LSD (0.05)	22			

*All Plateau treatments were applied with a non-ionic surfactant at 0.25% v/v.
†The July 10 evaluation was 630 DAT.

Table 3. Interaction between burning and Plateau application rate for desirable species establishment, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

	Valvalov Siberian wheatgrass		Goldar Bluebunch wheatgrass		Magnar Great Basin wildrye		Western yarrow	
	July 2, 2002†							
Plateau rate*	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned
lb ai/acre	Plants/50 ft²							
0.031	26	6	8.5	0.2	5.3	0.0	24	3
0.064	21	12	6.3	1.3	8.7	0.0	13	3
0.094	35	13	4.2	1.0	4.7	0.7	3	4
0.125	24	9	2.3	1.3	2.5	0.0	3	4
0.157	22	7	2.2	0.8	3.2	0.5	2	4
0.188	11	7	1.0	0.2	0.8	0.3	3	6
LSD (0.05)	NS		3.1		3.1		8	
LSD (0.10)	8		--		--		--	

*All Plateau treatments were applied with a non-ionic surfactant at 0.25% v/v.
†The July 2 evaluation was 257 days after Plateau treatment.

Table 4. Interaction between burning and herbicide application timing with Valvalov Siberian wheatgrass and Magnar Great Basin wildrye establishment, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

	Valvalov establishment		Magnar establishment	
	July 2, 2002			
Timing	Burned	Unburned	Burned	Unburned
	Plants/50 ft²		Plants/50 ft²	
Preplant	27	9	5.6	0.3
Postplant	20	9	2.8	0.2
LSD (0.05)	NS		1.6	
LSD (0.10)	5		--	

Table 5. Interaction between burning, herbicide rate, and application timing for Valvalov Siberian wheatgrass establishment, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Valvalov Siberian wheatgrass establishment†			
	July 10, 2003			
	Burned		Unburned	
Plateau rate*	Preplant	Postplant	Preplant	Postplant
lb ai/acre	Shoots/50 ft^2		Shoots/50 ft^2	
Untreated control	26		0	
0.031	1,608	2,273	154	329
0.064	1,551	988	372	348
0.094	3,408	1,409	405	350
0.125	2,242	1,743	322	512
0.157	1,530	528	158	198
0.188	1,466	638	220	134
LSD (0.05)	711			

*All Plateau treatments were applied with a non-ionic surfactant at 0.25% v/v.
†The April 24 and July 2 evaluation dates were 188 and 257 DAT, respectively.

ROTATIONAL RESPONSE OF ALFALFA AND SUGAR BEET TO CLARION™ AND STEADFAST™ HERBICIDES

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Introduction

Informed herbicide selection in diverse crop rotations is crucial to avoid adverse effects on future crops from herbicide carryover. Sulfonylurea herbicides are some of the most effective and low-use rate herbicides available. However, the rotational restrictions can be as long as 26 months for selected crops. One such herbicide is Steadfast 75 WDG which is a premix of the sulfonylurea herbicides nicosulfuron and rimsulfuron at a 2:1 ratio. Steadfast provides selective postemergence (POST) grass and broadleaf weed control in field corn. Steadfast has a rotational restriction of 12 months for alfalfa and 10-18 months, depending on soil pH, for sugar beet. A newly registered product, Clarion 75 WDG (formerly DPX-79406) also consists of nicosulfuron and rimsulfuron but in a 1:1 ratio. The reduced amount of nicosulfuron in Clarion compared to Steadfast may potentially decrease the rotational restrictions for sugar beet and alfalfa. A field trial was conducted to evaluate the rotational tolerance of alfalfa and sugar beet to Clarion and Steadfast herbicides.

Materials and Methods

Clarion and Steadfast were applied postemergence (POST) to field corn on May 29, 2002 preceding alfalfa and sugar beet establishment in the spring of 2003. Clarion was applied at the labeled rate of 0.375 oz ai/acre and at twice the labeled rate at 0.75 oz ai/acre. Steadfast also was applied at 1x and 2x rates of 0.56 and 1.12 oz ai/acre, respectively. Steadfast and Clarion were applied to corn plots measuring 20 by 30 ft. Treatments were arranged in a randomized complete block design with four replicates. Plot size for the rotational crops measured 10 by 30 ft with half of the original 20 by 30 ft plots planted to alfalfa and the other half to sugar beet in 2003. Following corn harvest the trial area was roto-tilled on October 28 and bedded on 22-inch rows on November 7, 2002. Alfalfa (var. Surpass) was seeded at a rate of 20 lb/acre on April 30, 2003 (11 months after treatment [MAT]). Sugar beets (var. Hilleshog PM 21) were planted on April 30, 2003 (11 MAT) at a 2-inch seed spacing (~142,000 seeds/acre). After sugar beet planting, the trial was corrugated and Counter 20 CR was applied in a 7-inch band over the row at a rate of 6 oz/1,000 ft of row. Temik 15G was applied on June 2 for sugar beet root maggot control at a rate of 9.5 oz/1,000 ft of row. Plots were sidedressed with 176 lb nitrogen, 96 lb phosphate, 100 lb potash, 38 lb sulfates, 62 lb elemental sulfur, 2 lb zinc, and 1 lb/acre of boron on June 3, 2003. Sugar beets were thinned to an 8-inch plant spacing (~35,640 plants/acre) on June 10, 2003. The soil was an Owyhee silt loam with a sand, silt, and clay content of 19, 63, and 18 percent, respectively. A soil test determined a pH of 8.0, cation exchange capacity of 12, and an organic matter content of 1.8 percent. Weeds were controlled in both the alfalfa and sugar beet plots using hand labor.

Sugar beet and alfalfa injury were evaluated throughout the season. The alfalfa stand was evaluated by counting seedlings within four, 1-ft² quadrats in each plot on May 29. The sugar beet stand was evaluated by counting the number of plants within the entire length of the center two rows in each plot prior to thinning on May 29 and again prior to harvest on October 7. Sugar beet yields were determined by harvesting the center two rows of each plot on October 7. Sugar beet yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Alfalfa yields were determined by cutting a 3-ft by 26-ft swath from the center of each plot using a flail mower on July 15 and August 13. Biomass from the harvest area was weighed to determine the total fresh weight. A subsample was weighed from each plot and dried in a forced air dryer at 140°F. Once dry, the sample was removed and reweighed to determine the percent moisture at the time of cutting. Alfalfa forage yield was reported based on 12 percent moisture.

Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for crop injury.

Results and Discussion

Injury to seedling alfalfa planted 11 months after POST-applied Steadfast and Clarion ranged from 20 to 66 percent on May 29, 2003 (365 days after treatment [DAT]) (Table 1). Injury to alfalfa seedlings consisted of stunting and chlorosis of new growth. The greatest alfalfa injury was observed with Steadfast at 1.12 oz ai/acre. Clarion applied at 0.375 oz ai/acre produced significantly less injury than all other herbicide treatments 365 DAT. Herbicide carryover also resulted in reduced alfalfa stand. At 365 DAT, all herbicide treatments except Clarion applied at 0.375 oz ai/acre resulted in a significant alfalfa stand loss compared to the untreated control. Alfalfa injury on July 1 (397 DAT) was similar with both Clarion treatments and Steadfast at 0.56 oz ai/acre. Injury with Steadfast at 1.12 oz ai/acre was greater than all other herbicide treatments at 38 percent. Injury associated with Clarion treatment did not significantly reduce forage yield on July 15. Herbicide injury resulted in reduced forage yield on July 15 for both Steadfast treatments. There was no visually detectable injury to alfalfa regrowth on July 24, 10 days after the first cutting (data not shown). Yields from the second cutting on August 20 were similar among all treatments.

Sugar beet injury on May 29, (365 DAT), ranged from 5 to 59 percent (Table 2). Injury was greater with Steadfast at 1.12 oz ai/acre than from all other treatments. Sugar beet injury was similar with the labeled rate of Steadfast (0.56 oz ai/acre) and with Clarion applied at twice its labeled rate at 0.75 oz ai/acre. Clarion applied at the labeled rate of 0.375 oz ai/acre injured sugar beet significantly less than all other herbicide treatments on May 29, 2003. Sugar beet injury on July 1 (397 DAT) was greatest with Steadfast applied at 1.12 oz ai/acre. All other herbicide treatments provided similar injury. Sugar beet stand on May 29 (365 DAT) was not different among treatments prior to thinning. Steadfast applied at 1.12 oz ai/acre was the only treatment that reduced stand compared to the untreated control prior to harvest on October 7. There were no significant differences among treatments with regard to root yield, percent sucrose content, or estimated recoverable sucrose yields.

Since this trial was conducted, Clarion has been registered for use in field corn. The label stipulates the same rotational restriction of 12 months for alfalfa as does the Steadfast label. The rotational restriction for sugar beet following Steadfast application is 10 months for soils with pH $\leq$ 6.5 and 18 months with pH > 6.5. The rotational restriction for sugar beet following Clarion application is 10 months, regardless of soil pH.

Table 1. Alfalfa injury, stand, and yield in response to Clarion™ and Steadfast™ herbicides applied the previous year to field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

		Alfalfa‡				
		Injury§		Stand	Yield¶	
Treatment*	Rate†	5/29	7/1	5/29	7/15	8/13
	oz ai/acre	----------- % -----------		No/ft^2	------ ton/acre ------	
Clarion	0.375	20	4	47	1.54	1.82
Clarion	0.75	38	9	40	1.50	1.76
Steadfast	0.56	43	5	37	1.40	1.72
Steadfast	1.12	66	38	31	1.34	1.72
Untreated control	--	--	--	59	1.65	1.81
LSD (0.05)		14	10	18	0.17	NS

*Treatments were applied to field corn on May 29, 2002.
†Clarion and Steadast were applied at 1x (0.375 or 0.56 oz ai/acre) and 2x (0.75 or 1.12 oz ai/acre) the labeled rates, respectively.
‡Alfalfa was seeded on April 30, 2002.
§The untreated control was not included in the analysis of variance for alfalfa injury.
¶Alfalfa forage yields were adjusted to a moisture content of 12 percent.

Table 2. Sugar beet injury, stand, and yield in response to Clarion™ and Steadfast™ herbicides applied the previous year to field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

		Sugar beet‡						
		Injury		Stand§		Yield¶		
Treatment*	Rate †	5/29	7/1	5/29	10/7	Root	Sucrose	ERS
	oz ai/acre	--------- % ----------		------ No./10' ------		ton/acre	%	lb/acre
Clarion	0.375	5	8	42.7	16.1	36.7	16.1	10,902
Clarion	0.75	25	11	44.8	16.2	37.5	15.9	10,928
Steadfast	0.56	24	8	39.6	16.6	36.2	16.3	10,807
Steadfast	1.12	59	24	39.0	15.2	36.9	15.9	10,759
Untreated control	--	--	--	43.7	17.0	35.5	16.6	10,909
LSD (0.05)		16	11	NS	1.0	NS	NS	NS

*Treatments were applied to field corn on May 29, 2002.
†Clarion and Steadast were applied at 1x (0.375 or 0.56 oz ai/acre) and 2x (0.75 or 1.12 oz ai/acre) the labeled rates, respectively.
‡Sugar beets were planted April 30 and harvested on October 7, 2003. The untreated control was not included in the analysis of variance for sugar beet injury.
§Sugar beet stands on May 29 were recorded prior to hand thinning on June 10, 2003.
¶ERS = Estimated recoverable sucrose.

YELLOW NUTSEDGE GROWTH IN RESPONSE TO ENVIRONMENT

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Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in the Treasure Valley of eastern Oregon and southwestern Idaho. It is particularly problematic in onion production. Onions are relatively short statured plants with vertical leaves producing an incomplete canopy with limited potential to effectively suppress weeds. Yellow nutsedge has a C_4 photosynthetic pathway and therefore responds well to conditions of high light intensity that exist in onion production. Management practices including frequent irrigation and high nitrogen fertilization required to maximize onion yield also serve to stimulate yellow nutsedge growth (Keeling et al. 1990).

Yellow nutsedge reproduces and is dispersed primarily by tubers that are formed at the apical ends of underground rhizomes. Tubers are produced in the upper 18 inches of the soil profile with the greatest concentration located in the upper 6 inches (Stoller and Sweet 1987, Tumbleson and Kommedahl 1961). After a period of dormancy, tubers germinate and produce shoots in subsequent growing seasons. Tubers may remain viable for 1-3 years providing an effective means of survival. Asexual reproduction by yellow nutsedge tubers can be quite prolific. Tumbleson and Kommedahl (1961) reported that a single tuber produced 6,900 tubers the first fall after planting, and 1,900 plants the following spring in an area of approximately 34 ft^2. Yellow nutsedge grows best where soil moisture is high (Bendixin and Nandihalli 1987). Garg et al. (1967) reported that nitrogen promotes vegetative growth over reproductive growth in yellow nutsedge, leading to increased basal bulb formation (and subsequent shoot production) as opposed to tuber formation.

Two trials were conducted in 2003 at the Malheur Experiment Station to evaluate yellow nutsedge growth with various environmental factors.

Methods

Yellow Nutsedge Emergence and Growth as Influenced by Depth of Germination
The objectives of this experiment were to 1) determine the depth from which a yellow nutsedge tuber can emerge in the field, 2) determine the date of emergence based on depth of burial, and 3) determine the growth (i.e., shoot and tuber production) potential based on burial depth.

Yellow nutsedge tubers were harvested from the bank of an irrigation canal on March 19, 2003. The tubers were then washed from the soil, rinsed with deionized water, and placed in a refrigerator at 38.5°F for approximately 21 days. Both washing and chilling have been shown to effectively break tuber dormancy (Tumbleson and Kommedahl 1961, Bell et al. 1962). This was necessary to ensure that the tubers would readily germinate when buried and that any differences in emergence would be based on depth of burial and/or soil temperature and not differences in dormancy. Ten tubers were buried in a single container at a depth of 2, 4, 6, 8, 10, 12, 14, 16, or 18 inches on April 17. Each depth was replicated four times. Containers consisted of 10-inch-diameter pvc pipe for depths below 12 inches. Large pots were used for depths from 2 to 12 inches. Temperature sensors were placed at 6 and 12 inches in the pots and 6, 12, and 18 inches in the pvc pipe. Watermark sensors were buried at depths of 6 and 12 inches in 4 of the pots and at depths of 6, 12, and 18 inches in 4 of the pvc pipes to monitor soil moisture. Each container was irrigated by a single drip emitter with an output of 0.5 gal per hour. Soil water potential was measured every morning and irrigations were initiated each time the average of the Watermark sensors (Irrometer Company Inc., Riverside, CA) at the 6-inch depth was greater than or equal to -20 kPa.

Shoots were counted up to the point where every container had at least 10 shoots present and again prior to tuber harvest on July 21. Shoot biomass was taken at harvest. Tubers were harvested on July 22 and their lengths were quantified in 6-inch increments of 0-6, 6-12, 12-18, and 18-24 inches.

Yellow Nutsedge Growth in Response to Irrigation and Nitrogen Fertilization
The objectives of this experiment were to 1) monitor patch expansion from a single yellow nutsedge tuber in the absence of crop competition over the course of one growing season, 2) evaluate the effects of selected irrigation regimes on yellow nutsedge growth, and 3) evaluate the effect of nitrogen fertilization on yellow nutsedge growth.

Tubers were harvested from a ditch bank on March 19, 2003. The tubers were then washed from the soil, rinsed with deionized water, and stored in a refrigerator at 38.5°F for approximately 40 days. Tubers weighing from 0.18 to 0.2 g and measuring between 6 and 7 mm were selected and planted in flats in the greenhouse on May 28. Tubers of similar size and weight were selected because research has shown that tuber size can affect early plant vigor, with plants from smaller tubers being less vigorous. On June 2, germinated tubers with a shoot of at least 1 inch in length were transplanted into the center of a circular plot with a 6-ft diameter. Transplanted yellow nutsedge plants were used to ensure a more uniform date of establishment among the 18 individual plots. The circular plots consisted of 14-inch-wide galvanized valley flashing cut to a length of 19 ft with the ends riveted together to produce a circle with a diameter of 6 ft. The flashing was then buried approximately 10 inches deep in the soil. Ten days before transplanting, each plot was irrigated to a soil moisture potential of -20 kPa to incorporate fertilizer applications and to provide similar moisture conditions for early yellow nutsedge establishment.

The trial consisted of 18 circular plots, 6 each for the 3 irrigation regimes and 3 each for the 2 fertilization levels split over the irrigation regimes. Irrigation water was applied to the plots through six drip emitters evenly spaced in a circular pattern where each emitter was located 1.5 ft from the center of the plot. The six emitters had a combined output of 3.0 gal/hour. The values for irrigation criteria were -20, -50, and -80 kPa and were selected to represent soil moisture conditions similar to those in wheat, sugar beet, and dry bulb onion production systems, respectively. The two fertilization levels consisted of plots receiving nitrogen (46 percent urea) at rates of either 90 or 268 lbs/acre. All plots were fertilized before transplanting with 90 lb/acre P, 90 lb/acre S, 1 lb/acre Cu, 1 lb/acre B, and 9 lb/acre Mg. Soil water potential was measured in each plot with a single Watermark soil moisture sensor installed at a 6-inch depth equidistant from the yellow nutsedge plant at the center of the plot and the drip line. Irrigation water was applied independently for each regime when the average 6-inch soil water potential from the six sensors reached -20, -50, or -80 kPa. The sensors were read by a datalogger every 12 hours and when the soil water potential exceeded the treatment criteria irrigation was initiated using a solenoid valve. Water meters were installed between the solenoid valves and the water line for each individual irrigation regime to record the amount of water applied daily.

Yellow nutsedge growth was measured initially by counting shoot numbers within each plot. At a point where shoots became too numerous to efficiently count, nutsedge growth was evaluated by taking overhead digital images of each plot. These images were used to quantify the plot area that was covered by yellow nutsedge shoots using a software program produced at Oregon State University. Shoots and tubers were harvested from subsamples within each plot on September 3 and 4. Thirteen subsamples were collected across the 6-ft diameter of the plots. The subsamples consisted of 4.25-inch-diameter circles from which shoots were counted to estimate the total shoot number per plot. The shoots were then clipped at ground level and placed in bags to be dried. The dry weights were used to estimate the total above-ground biomass. Once the shoots were removed a soil core measuring 4.25 inches in diameter by 8 inches in depth was taken from the same area as the shoots were removed. The individual core samples were bagged and recorded as to their location within the plot. The core samples were then emptied into a bucket with multiple 11/64-inch holes in the bottom and sides. Water was sprayed into the bucket to remove the soil from the tubers. The tubers were then counted and those numbers were used to estimate the total tuber population for each of the plots.

Results and Discussion

Yellow Nutsedge Emergence and Growth as Influenced by Depth of Germination

The first shoots to emerge from the 2-, 4-, 6-, and 8-inch burial depths were observed 36 days after planting (Table 1). Thirty-nine days were required for the first observed shoot to emerge from the 10- and 12-inch depths. The 14-inch depth required 42 days and the 16- and 18-inch depths each took 46 days from the planting date for the first shoot to emerge. Despite similar dates for first-shoot emergence, it took 7 days longer to produce an average of 10 shoots per container in the 4-, 6-, and 8-inch depths compared to the 2-inch planting depth. An additional 11 days were required for the 10-, 12-, and 14-inch depths to produce an average of 10 shoots per container and the 16-inch and 18-inch depths took 21 and 25 days longer, respectively, than the 2-inch burial depth. The average daily soil temperatures for planting depths of 4, 8, 12, and 16 inches from time of planting to the point where each container had at least 10 shoots are illustrated in Figure 1. Figure 2 shows the increase by depth of emergence of yellow nutsedge shoots across a 35-day period from the first shoot observation on May 23 through June 27, at which time each container had at least 10 shoots. Shoot numbers were significantly greater for burial depths of 2, 4, 6, and 8 inches than those associated with 12-, 14-, 16-, and 18-inch depths on all observation dates from June 4 through June 27. The final shoot counts were taken on July 21, 59 days after the first shoot emergence. Shoot numbers ranged from a low of 121 with the 18-inch burial depth to 212 with the 10-inch burial depth (Table 2).

Yellow nutsedge shoot biomass (total g/container) was similar among the 2- through 10-inch burial depths and were significantly greater than all other depths (Table 2). The 12-inch depth produced greater total shoot biomass than the depths of 14, 16, and 18 inches. The average weight per shoot (average g/shoot) at the 2-inch depth was 0.49 g, which was similar to the 4-inch depth and greater than all other burial depths (Table 2). In general, both the total shoot biomass per container and the average weight per shoot decreased as the depth of tuber burial increased. This pattern is likely the result of both the time delay involved between shoot emergence based on burial depth as well as reduced shoot vigor following emergence due to depletion of tuber resources with deeper planted tubers. For example, while the total number of shoots produced was similar for both the 6-inch and 12-inch depths, the total shoot biomass and average weight per shoot were significantly less for the 12-inch depth (Table 2). The 6-inch depth produced an average of 1 shoot per container 3 days earlier and an average of 10 shoots per container 4 days earlier than the 12-inch depth. These data suggest that yellow nutsedge shoots lose vigor as the depth of their tubers increases.

Tuber numbers ranged form a high of 1,384 per container in the 4-inch burial to a low of 328 from the 18-inch burial (Table 3). There were no differences in tuber production among burial depths of 2 to 10 inches. Parent tubers buried at 12 inches produced tuber numbers similar to the 10-, 14-, and 16-inch depths. More tubers were produced from parent tubers buried at 4 and 8 inches than from those buried at depths between 12 and 18 inches. No attempt was made to differentiate between initial parent tubers and daughter tubers during the recovery process. Therefore, as many as 10 tubers harvested from the same zone as they were buried in may be parent tubers. This will probably have a greater influence on tuber counts from 12- to 18- and 18- to 24-inch incremental depths. For example, the only tubers recovered from the 18- to 24-inch depth zone were associated with the 18-inch burial depth and were most likely parent tubers since no other burial depth resulted in daughter tubers produced in that zone. However, it is interesting to note that tubers were found in the 12- to 18-inch zone for burial depths of 2-10 inches; these are almost certainly daughter tubers. More than 10 tubers were found between 12 and 18 inches for burial depths of 14, 16, and 18 inches. The depth of burial of the parent tubers did not influence the depth at which the daughter tubers were produced. When averaged across all burial depths, approximately 85 percent of all tubers were produced in the 0- to 6-inch zone and 13 percent were produced in the 6- to 12-inch zone (data not shown).

These data suggest that there are no differences in yellow nutsedge shoot biomass or tuber production from parent tubers distributed from 2 to 10 inches deep in the soil profile maintained at a soil water potential of -20 kPa. Yellow nutsedge growth appears to be less vigorous as the depth of germination increases in the soil profile. Although we did not address it in this trial, we could reasonably assume that less vigorous nutsedge plants would be less competitive. Both the duration of competition due to delayed emergence and the intensity of competition from fewer and smaller shoots may be less from nutsedge plants that germinate deeper in the soil profile.

Table 1. Yellow nutsedge shoot emergence as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Yellow nutsedge shoot production			
Depth of burial	1st shoot emergence*	Average ≥1 shoot/container†	Average ≥10 shoots/container‡	Average ≥10 shoots/container§
	Days after planting			Days after 1st emergence
2 inch	36	39	46	10
4 inch	36	36	53	17
6 inch	36	36	53	17
8 inch	36	39	53	17
10 inch	39	39	57	21
12 inch	39	39	57	21
14 inch	42	42	57	21
16 inch	46	48	67	31
18 inch	46	53	71	35

*Days after planting in which the first shoot appeared in any of the four replicates for the given depth of burial.
†Days after planting in which the average of the four replicates for the given depth of burial was greater than or equal to 1.
‡Days after planting in which the average of the four replicates for the given depth of burial was greater than or equal to 10.
§Days after 1st shoot emergence in which the average of the four replicates for the given depth of burial was greater than or equal to 10.

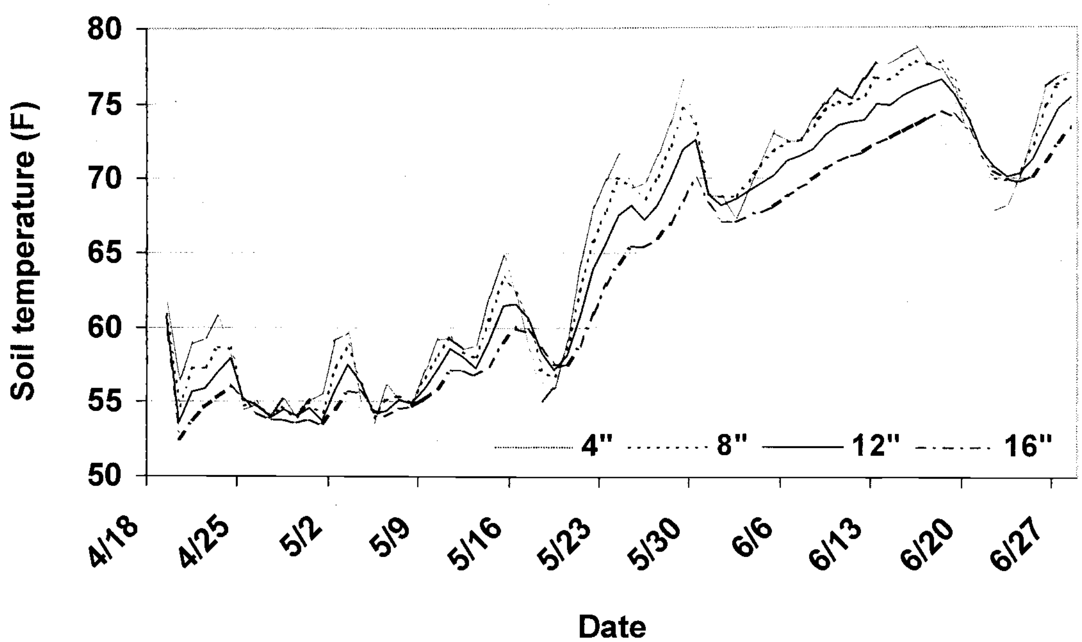

Figure 1. Average daily soil temperature at 4-, 8-, 12-, and 16-inch planting depths from date of planting up to the time when each container had at least 10 yellow nutsedge shoots, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

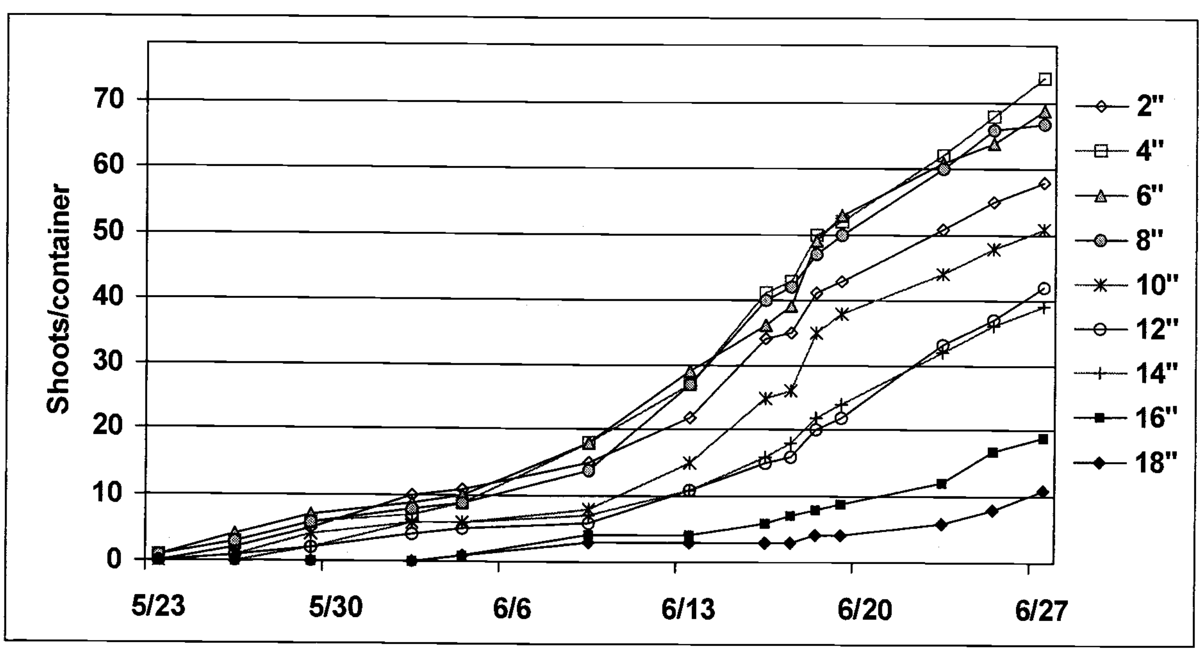

Figure 2. Yellow nutsedge shoot emergence over time as influenced by depth of tuber burial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 2. Yellow nutsedge total shoot number, weight, and weight per shoot at harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Depth of burial*	Yellow nutsedge shoots† No/plot	Wt/plot	Wt/shoot
		---------- grams ----------	
2 inch	164 bc	77 a	0.49 a
4 inch	196 ab	84 a	0.43 ab
6 inch	209 a	80 a	0.38 b
8 inch	210 a	85 a	0.41 b
10 inch	212 a	77 a	0.37 bc
12 inch	209 a	63 b	0.31 cd
14 inch	153 c	43 c	0.28 d
16 inch	158 bc	45 c	0.3 cd
18 inch	121 c	33 c	0.27 d

*Yellow nutsedge tubers were buried on April 17, 2003.
†Yellow nutsedge shoots were harvested on July 22, 2003.

Table 3. Yellow nutsedge tuber production as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Yellow nutsedge tubers†				
	Recovery depth				
Depth of burial*	0-6 inches	6-12 inches	12-18 inches	18-24 inches	Total
	----------	----------	number/depth	----------	----------
2 inch	930 abc	146 ab	2 d	0 b	1,078 abc
4 inch	1174 a	207 a	4 cd	0 b	1,384 a
6inch	1096 ab	94 bc	3 cd	0 b	1,193 abc
8 inch	1154 a	150 ab	5 cd	0 b	1,308 a
10 inch	1098 ab	154 ab	17 ab	0 b	1,268 ab
12 inch	818 bc	120 abc	6 cd	0 b	944 bcd
14 inch	695 cd	173 ab	23 a	0 b	891 cd
16 inch	521 de	108 abc	16 ab	0 b	644 de
18 inch	282 e	34 c	11 bc	1 a	328 e

*Yellow nutsedge tubers were buried on April 17, 2003.
†Yellow nutsedge tubers were harvested on July 22, 2003.

Yellow Nutsedge Growth in Response to Irrigation and Nitrogen Fertilization

Nitrogen fertilization had no significant (P = 0.05) influence on yellow nutsedge shoot or tuber number, total weight per plot, or individual shoot or tuber weight (data not shown). Since both shoot and tuber variables were not affected by nitrogen fertilization, data were averaged over fertilization variables to evaluate irrigation effects on yellow nutsedge. Irrigation events and total water applied are shown in Table 4. Soil moisture potential over time by irrigation regime is illustrated in Figure 3. Irrigation had a significant effect on both yellow nutsedge shoot number and total weight (Table 5). The -20 kPa irrigation treatment produced an average of 2,968 shoots per plot. This was significantly greater than the -50 kPa and -80 kPa irrigation treatments, which produced 1,512 and 974 shoots per plot, respectively. The -50 kPa treatment produced a greater number of shoots per plot than did the -80 kPa treatment. In terms of total pounds of shoot biomass per plot, the -20 kPa treatment produced an average of 3.9 lb per plot, 2.4 times more than the -50 kPa treatment and 2.7 times more than the -80 kPa treatment produced (Table 5). While more shoots were produced in the -50 kPa treatment than the -80 kPa treatment, they both had similar total weights of 1.6 and 1.4 lb, respectively. The average weight per shoot was not different among irrigation treatments. Based on the digital images, the percent of the plot area covered by yellow nutsedge shoots grew more rapidly with the -20 kPa treatment than with either the -50 or -80 kPa treatments (Fig. 4). The percent of the plot area covered was fairly small from June 2 to July 15. Over a 20-day period from July 15 to August 4 the percent of the plot area covered by yellow nutsedge increased by 70, 22, and 15 percent with the -20, -50, and -80 kPa treatments, respectively. At harvest the -20 kPa treatment gave 95 percent coverage with an average of 105 shoots/ft^2 , the -50 kPa treatment produced 43 percent coverage with 53 shoots /ft^2, and the -80 kPa treatment gave 23 percent coverage with an average of 34 shoots /ft^2.

Yellow nutsedge tuber production increased with increasing soil water potential (Table 6). An average of 18,789 tubers per plot were produced from a single plant with the -20 kPa treatment. This was 4,217 and 7,462 tubers per plot greater than the -50 and -80 kPa treatments, respectively. There was a twofold increase in tubers produced between the -50 and -80 kPa treatments. Tuber production increased 1.3 times with a soil moisture potential of -20 kPa compared to -50 kPa. An increase of 1.4 lb of tubers per plot was produced between -80 kPa and -50 kPa and between -50 kPa and -20 kPa (Table 6).

These results that indicate the ability of yellow nutsedge to increase both shoot and tuber production with increasing soil water potential are not surprising. However, the total shoot and tuber production from a single yellow nutsedge tuber is greater than previously reported in the literature; tuber production from a single parent tuber in this trial was significantly greater than that reported by Tumbleson and Kommedahl (1961), where tuber production was evaluated under dryland production.

Table 4. Number of irrigations, amount applied per irrigation, and total water applied, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Irrigations		Total applied*
kPa	number/plot	inches/event	inches/plot
-20	74	0.32	24.3
-50	15	1.0	17.5
-80	4	1.38	8.0

*Total includes 0.6 inch of rainfall. The -50 and -80 kPa treatments received 1.9 inches of irrigation water between August 28 and September 1 to bring all plots to a soil moisture potential of -20 kPa at harvest to facilitate core sampling.

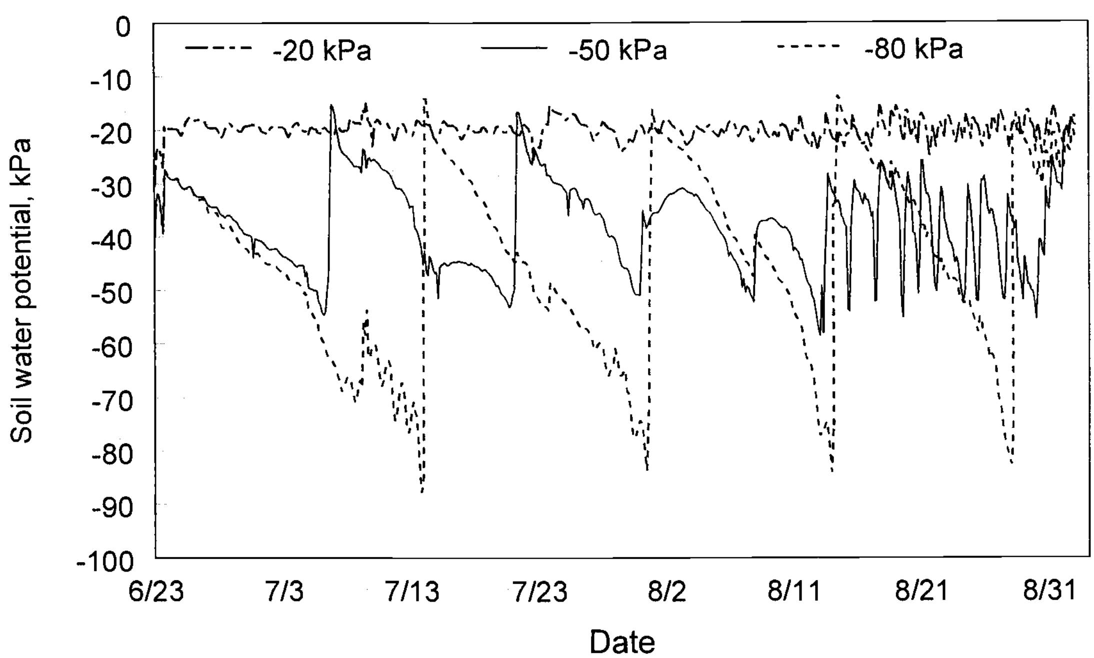

Figure 3. Soil moisture potential over time by irrigation regime, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 5. Yellow nutsedge shoot production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Yellow nutsedge shoots*				
kPa	no/plot	no/ft^2	lb/plot	lb/ft^2	g/shoot
-20	2,968 a	105 a	3.9 a	0.14 a	0.61 a
-50	1,512 b	53 b	1.6 b	0.05 b	0.56 a
-80	974 c	34 c	1.4 b	0.04 b	0.61 a

*Values followed by the same letter designation are not statistically different (P = 0.05).

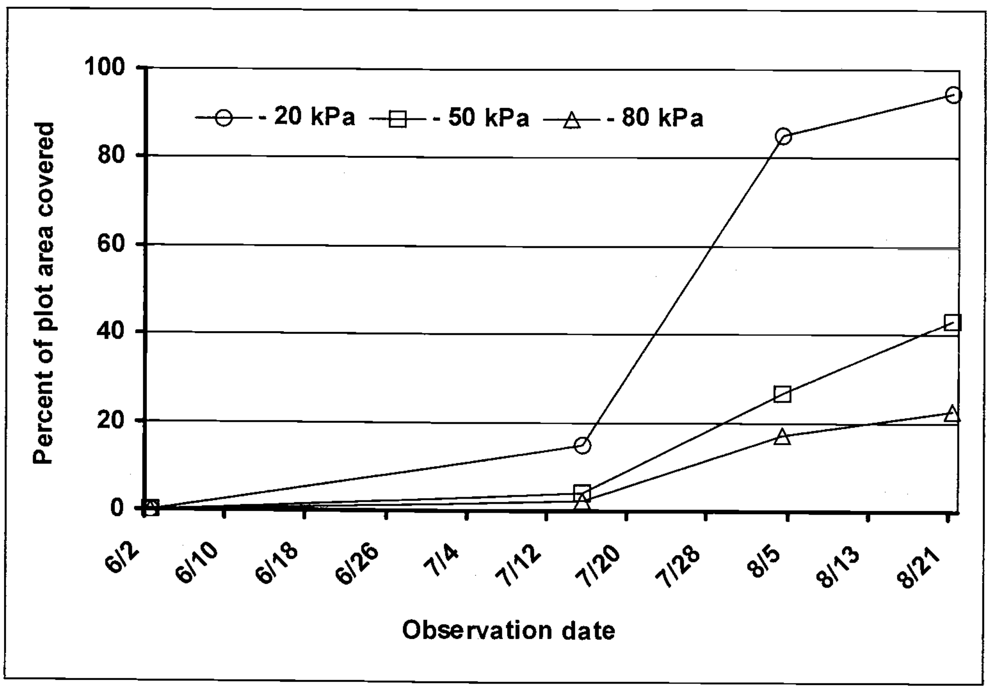

Figure 4. Yellow nutsedge patch expansion over time based on percent ground coverage between transplanting and harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 6. Yellow nutsedge tuber production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Yellow nutsedge tubers				
kPa	no/plot	no/ft^2	lb/plot	lb/ft^2	g/tuber
-20	18,789 a	665 a	4.8 a	0.17 a	0.12 a
-50	14,572 b	515 b	3.4 b	0.12 b	0.11 a
-80	7,110 c	251 c	2.0 c	0.07 c	0.13 a

*Values followed by the same letter designation are not statistically different (P = 0.05).

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YELLOW NUTSEDGE CONTROL IN VARIOUS CROPS

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Introduction

Yellow nutsedge is an increasing weed problem in the Treasure Valley of eastern Oregon and southwestern Idaho. Yellow nutsedge is particularly detrimental in onion production due to the noncompetitive nature of the crop and the ability of yellow nutsedge to proliferate under the growing conditions that exist in onion production. Previous research conducted in the Treasure Valley evaluating yellow nutsedge control in onion has met with limited success, in part due to the lack of effective herbicide options and the weed's ability to germinate over long periods of time during the growing season. An integrated approach is needed to manage yellow nutsedge, including the use of effective herbicide treatments in each of the crops within a rotation. This research was conducted to evaluate the effects of crop species and herbicides on growth and development of yellow nutsedge in field corn, dry bean, potato, and sugar beet production.

Methods

Studies were conducted in a field heavily infested with yellow nutsedge located north of Ontario on the Oregon Slope. The soil was a Owyhee silt loam with pH 8.5 and 1.7 percent organic matter. The field was disked on April 14 and ground hogged on April 16. The field was harrowed and bedded for corn, dry bean, potato, and sugar beet on April 17 and 18. A trial with wheat was also established but was abandoned due to the late planting date. Plot size varied among trials, but plots were replicated four times in all trials. Pretreatment nutsedge tuber numbers were sampled April 21 through April 28. Sampling for yellow nutsedge tubers consisted of taking eight core samples measuring 4.25 inches in diameter and 7 inches deep from the center furrow within each individual plot. The samples were combined and the tubers were extracted from the soil by washing the soil through screens with 11/64-inch holes. To determine treatment effects on tuber numbers, core samples were taken again at the time the crops were harvested. Season-end sampling differed by crop and will be described within the individual crop methods. The extraction process for season-end yellow nutsedge tubers was the same as for the initial samples. In total, tuber sampling involved taking 2,800 core samples, washing tubers from approximately 8.6 tons of soil, and individually counting 70,000 nutsedge tubers. Herbicide applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Crop injury and visual evaluations of yellow nutsedge control were made throughout the growing season. Yields were taken for each crop and specific methods are described by crop.

Corn

Beds were harrowed on May 23 and preplant incorporated herbicide treatments were applied to plots and incorporated by making two passes with the bed harrow in opposite directions. Pioneer 'P-36N18 Roundup Ready' (103-day relative maturity) field corn was planted May 23 on a 7-inch seed spacing on 30-inch rows. Corn was sidedressed, prior to planting, on May 15 with 121 lb N, 48 lb P, 62 lb K, 22 lb sulfate, 30 lb S, 1 lb Zn, 2 lb Mn, and 1 lb B per acre. Dual II Magnum (s-metolachlor) was applied prelant incorporated (PPI) to some plots on May 22. Early postemergence treatments (EPOST) were applied June 5, mid-postemergence (MPOST) treatments were applied June 9, and late postemergence (LPOST) treatments were applied on June 17. Postemergence treatments included Basagran (bentazon), Permit (halosulfuron), and Roundup (glyphosate). Basagran and Roundup were applied either twice alone or twice following PPI Dual II Magnum. Permit was applied one time alone or one time alone following PPI Dual II Magnum. Basagran and Permit were applied in combination with a crop oil concentrate (COC) while ammonium sulfate (AMS) was added to Roundup applications. Yield was determined by harvesting ears from a 15-ft section of the center two rows of each plot on October 10. The ears were shelled, and grain moisture content and weights were recorded. Final yields were adjusted to 12 percent moisture content. Yellow nutsedge tuber numbers were determined by taking eight core samples from the tops of the center two beds in each plot.

Dry Bean

On May 20, beds were harrowed and PPI herbicide treatments were applied and incorporated by harrowing the beds two more times in opposite directions. After the PPI herbicides were incorporated, 'GTS-900' pinto beans were planted and Prowl (pendimethalin) was applied preemergence to help control weeds other than yellow nutsedge. Problems with the planter required replanting some plots, resulting in an erratic stand. PPI treatments included Dual Magnum (s-metolachlor), Eptam (EPTC), and a combination of Dual Magnum plus Eptam. Postemergence treatments were applied June 12 and included Sandea (halosulfuron) plus non-ionic surfactant (NIS) and Basagran plus COC. The plots treated with Basagran received a second application of Basagran on June 23. On August 28, plants were pulled from 10 ft of row where the bean stand was consistent to determine dry bean yield. After the bean plants had dried, the beans were threshed by hand. Final nutsedge tuber numbers were determined by taking four core samples from the same 10-ft section of row that the beans were harvested from.

Potato

'Russet Burbank' potatoes were planted May 1 with a 9-inch seed spacing on 36-inch rows. Potatoes were sidedressed on May 9 with 200 lb N, 250 lb P, 150 lb K, 95 lb S, 4 lb Mn, and 1 lb B per acre. On May 13, the potato beds were re-hilled with a lilliston cultivator, preemergence herbicides were applied and incorporated with another pass of the lilliston. All plots received preemergence Prowl for general weed control. Past research has shown that Prowl has no effect on yellow nutsedge. Herbicides applied for yellow nutsedge control included Dual Magnum, Outlook (dimethenamid-P), and Eptam applied preemergence and incorporated and postemergence applications of Matrix (rimsulfuron), and Permit. Postemergence treatments were applied June 5. On August 19, the vines were flailed. On September 9, potatoes were harvested from 10 ft of the center two rows. Potatoes were graded to size on September 12-17. To evaluate nutsedge tuber production, eight core samples were taken from the shoulder of the center two potato hills prior to potato harvest on August 21.

Sugar Beet

On April 28, Hilleshog variety 'WS PM-21' was planted at a 2-inch spacing to ensure a stand of sugar beets. Beets were planted on 22-inch rows. Counter 20 CR was applied for insect control on April 29. Asana was applied at 8 oz/acre on May 12 for cutworm control. Temik 15 G (14 lb/acre) was applied June 6 for sugar beet root maggot control. On June 17, the stand was hand thinned to one plant every 8 inches. Plots were 4 rows wide, 27 ft long, and arranged in a randomized complete block design. The trial was sidedressed on June 6 with 150 lb N, 122 lb P, 108 lb K, 3 lb sulfate, 102 lb S, 2 lb Zn, 3 lb Mn, and 1 lb B per acre. All plots were treated with a standard herbicide program of Progress (ethofumesate + desmedipham + phenmedipham), Upbeet (triflusulfuron), and Stinger (clopyralid) applied three times. The Progress rate increased with each application, while the Upbeet and Stinger rates were the same for all three applications. Dual Magnum or Outlook were applied for yellow nutsedge control at different timings and in various combinations. Treatments for yellow nutsedge were applied when sugar beets had two true leaves (May 21), or eight true leaves (June 6). One treatment included Eptam applied on June 30 just prior to the last cultivation. Sugar beet yields were taken by harvesting 10 ft of row containing healthy sugar beets on September 26. Harvesting only healthy sections of beets was necessitated by a severe rhizoctonia infestation. Nutsedge tuber numbers were sampled by taking 4 cores from the same 10-ft area that the sugar beets were harvested.

Results and Discussion

Spring bedding, difficult growing conditions, and late planting made the potato and sugar beet crops at this location less competitive than would be expected in commercial fields. Also, late planting gives the crop less time to grow before yellow nutsedge emerges and becomes competitive.

Corn

The corn rotation had some of the best yellow nutsedge control and appeared to suppress yellow nutsedge tuber numbers better than the other crops at this location. Corn was not injured by any of the herbicide treatments evaluated (Table 1). Yellow nutsedge control ranged from 57 to 93 percent. Dual II Magnum alone had among the least control. Basagran applied twice gave less control than treatments containing Permit or Roundup applied twice. All treatments reduced final tuber numbers compared to the untreated plot and the percent change in tubers ranged from a 17 percent gain in the untreated to a 50 percent reduction when Dual II Magnum was applied PPI and followed by two postemergence applications of Roundup. Corn yields did not differ significantly among treatments and ranged from 56 to 72 bu/acre. Low corn yields were attributed to heat stress during pollination as the ears did not completely fill.

Dry Bean

There appear to be effective options for yellow nutsedge control in dry beans. Treatments containing Sandea caused 21-28 percent dry bean injury (Table 2). Other treatments did not injure the beans. Eptam, Dual Magnum, and a combination of Eptam plus Dual Magnum provided among the least yellow nutsedge control of all the treatments. Inadequate incorporation may have lead to the poor control provided by these herbicides. Treatments with Sandea either alone or following PPI Eptam or Dual Magnum and Basagran applied twice following PPI Dual Magnum provided 73-84 percent yellow nutsedge control. Dry bean yields were correlated with yellow nutsedge control. Eptam and Sandea at the two higher rates had final tuber numbers that were not different from the untreated control. All other treatments had reduced tuber numbers compared to the untreated control. The average percent change of tubers ranged from an 81 percent increase to a 41 percent decrease. Eptam alone and the middle rate of Sandea had tuber increases similar to the untreated control. All other treatments had significant reductions in tuber numbers compared to the untreated control.

Potato

Herbicides applied in potatoes worked poorly, possibly because furrow irrigation was not effective for herbicide activation. Late planting, extreme heat, and potato vines dying early resulted in a less than desirable potato crop. The postemergence application of Permit was the only treatment to cause significant potato injury (Table 3). Yellow nutsedge control was among the highest with Dual Magnum, Permit, and Outlook. Treatments with Eptam PPI, or Matrix alone postemergence, or Eptam followed by Matrix had among the poorest yellow nutsedge control. Tuber numbers were variable and both final tuber numbers and the average percent change in tuber numbers were not affected by herbicide. Permit was the only treatment that resulted in a decrease (-105/ft^2) in tubers at harvest compared to the spring sampling. The untreated control had an increase of 104 tubers/ft^2 between spring and harvest sampling. Potato yields ranged from 56 to 79 cwt/acre.

Sugar Beet

Sugar beets were planted late and developed rhizoctonia during the season. Prolonged heat stress also impacted the crop. No differences in sugar beet injury were observed among herbicide treatments (Table 4). Yellow nutsedge control was variable and a statistical separation of differences among treatments was not possible. Control ranged from 31 to 61 percent. The average numbers of yellow nutsedge tubers and the percent change in tuber numbers were not different among herbicide treatments. Yellow nutsedge tubers increased by 109 to 300 percent. It was surprising that yellow nutsedge tuber numbers increased so much in a sugar beet crop with a healthy canopy we would expect that yellow nutsedge tuber production would be suppressed. Sugar beet root yields were also not significant and ranged from 15 to 19 tons/acre.

These data suggest that corn suppressed yellow nutsedge growth better than the other crops, and that the herbicides available for use in corn caused additional reductions in tuber numbers. Both a competitive crop and effective herbicides must be used in order to control yellow nutsedge and reduce yellow nutsedge tuber numbers.

Table 1. Corn injury, corn yield, yellow nutsedge control, and yellow nutsedge tuber response to herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

			Crop injury		Nutsedge control	Average nutsedge tubers		
Treatment*	Rate	Timing†	6-24	Crop yield	7-25	Initial	Final	Change
	lb ai/acre	Leaf	---%---	bu/acre	---%---	----------no/ft²---------		---%---
Dual II Magnum	1.6	PPI	0	71	57	149	112	-34
Basagran + COC Basagran + COC	1.0 + 1.0% v/v 1.0 + 1.0% v/v	MPOST LPOST	0	67	62	138	66	-39
Permit + COC	0.031 + 1.0% v/v	MPOST	0	72	81	183	150	-31
Permit + COC	0.063 + 1.0% v/v	MPOST	0	70	90	138	90	-49
Roundup + AMS Roundup + AMS	0.75 + 2.5 0.75 + 2.5	EPOST LPOST	0	68	91	114	59	-47
Dual II Magnum + Roundup + AMS	1.6 + 0.75 + 2.5	MPOST	3	64	74	133	104	-1
Dual II Magnum Roundup + AMS Roundup + AMS	1.6 0.75 + 2.5 0.75 + 2.5	PPI MPOST LPOST	0	66	93	125	54	-52
Dual II Magnum Basagran + COC Basagran + COC	1.6 1.0 + 1.0% v/v 1.0 + 1.0% v/v	PPI MPOST LPOST	0	70	76	158	86	-51
Dual II Magnum Permit + COC	1.6 0.031 + 1.0% v/v	PPI MPOST	0	66	86	137	93	-36
Untreated control	--	--	-	56	-	204	238	17
LSD (0.05)	--	--	NS	NS	19	NS	76	40

*COC = crop oil concentrate, AMS = ammonium sulfate.

†Application timing abbreviations and dates: preplant incorporated (PPI) on May 22, early postemergence (EPOST) on June 5, mid-postemergence (MPOST) on June 9, and late postermergence (LPOST) on June 17.

Table 2. Dry bean injury, dry bean yield, yellow nutsedge control, and yellow nutsedge tuber response to herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment*	Rate	Timing†	Crop injury	Crop yield	Nutsedge control	Average nutsedge tubers		
			6-24		8-18	Initial	Final	Change
	lb ai/acre	Leaf	---%---	cwt/acre	---%---	----------no/ft²---------		---%---
Dual Magnum	1.6	PPI	0	26	51	210	217	0
Eptam	3.9	PPI	0	25	10	202	379	101
Sandea + NIS	0.031 + 0.25% v/v	POST	22	32	74	215	222	-7
Sandea + NIS	0.035 + 0.25% v/v	POST	28	33	73	251	425	61
Sandea + NIS	0.047 + 0.25% v/v	POST	23	29	79	199	279	20
Eptam Sandea + NIS	3.9 0.031 + 0.25% v/v	PPI POST	23	35	81	213	182	-16
Dual Magnum Sandea + NIS	1.6 0.031 + 0.25% v/v	PPI POST	21	30	84	222	126	-41
Dual Magnum Basagran + COC Basagran + COC	1.6 1.0 + 1.0% v/v 1.0 + 1.0% v/v	PPI POST LPOST	4	36	84	214	147	-27
Eptam + Dual Magnum	3.9 + 0.95	PPI	0	31	28	229	248	9
Untreated control	--	--	-	22	-	231	412	82
LSD (0.05)	--	--	7	5.7	13	NS	156	61

*The entire trial was treated with Prowl (1.0 lb ai/acre) preemergence for control of weeds other than yellow nutsedge. NIS = non-ionic surfactant, COC = crop oil concentrate.

†Application timing abbreviations and dates: preplant incorporated (PPI) on May 20, postemergence (POST) on June 12, and late postermergence (LPOST) on June 23.

Table 3. Potato injury, potato yield, yellow nutsedge control, and yellow nutsedge tuber response to herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment*	Rate	Timing†	Crop injury 6-24	Crop yield‡	Nutsedge control 8-18	Average nutsedge tubers Initial	Final	Change
	lb ai/acre	Leaf	---%---	cwt/acre	---%---	----------no/ft²---------		---%---
Dual Magnum	1.9	PREI	0	57	61	252	307	79
Outlook	0.84	PREI	0	67	58	215	224	100
Eptam	6.0	PREI	0	60	26	242	319	32
Eptam Matix + COC	6.0 0.023 + 1% v/v	PREI POST	0	64	40	278	306	118
Dual Magnum Matix + COC	1.9 0.023 + 1% v/v	PREI POST	0	79	66	271	265	0
Matix + COC	0.023 + 1% v/v	POST	0	61	29	298	448	101
Permit + COC	0.023 + 1% v/v	POST	20	72	50	297	192	-38
Untreated control	--	--	--	56	-	278	418	65
LSD (0.05)	--	--	2	NS	20	NS	NS	NS

*The entire trial was treated with Prowl (1.0 lb ai/acre) preemergence for control of weeds other than yellow nutsedge. COC = crop oil concentrate.

†Preemergence incorporated (PREI) treatments were applied on May 13 and postemergence (POST) treatments were applied on June 5.

‡Reported potato yield is total yield.

Table 4. Sugar beet injury, sugar beet yield, yellow nutsedge control, and yellow nutsedge tuber response to soil-active herbicides added to standard sugar beet treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment*	Rate	Timing†	Crop injury 6-24	Crop yield	Nutsedge control 7-28	Average nutsedge tubers Initial	Average nutsedge tubers Final	Average nutsedge tubers Change
	lb ai/acre	Leaf	---%---	ton/acre	---%---	--------no/ft²-------		---%---
Standard Program			-	15	-	188	482	202
Betamix+ Upbeet	0.25 + 0.016	cot						
Betamix+ Upbeet + Stinger	0.33 + 0.016 + 0.094	2-leaf						
Betamix+ Upbeet + Stinger	0.42 + 0.016 + 0.094	8-leaf						
Standard Program	same	cot, 2, 8-lf	9	18	41	175	357	109
Dual Magnum	1.6	2-leaf						
Standard Program	same	cot, 2, 8-lf	4	16	45	150	366	248
Outlook	0.84	2-leaf						
Standard Program	same	cot, 2, 8-lf	8	18	47	132	365	167
Outlook	0.66	2-leaf						
Standard Program	same	cot, 2, 8-lf	5	18	31	155	475	300
Dual Magnum	1.6	2-leaf						
Eptam	3.0	Layby						
Standard Program	same	cot, 2, 8-lf	4	18	61	177	396	121
Dual Magnum	1.6	2-leaf						
Outlook	0.84	8-leaf						
Standard Program	same	cot, 2, 8-lf	5	19	41	163	416	154
Dual Magnum	1.6	2-leaf						
Dual Magnum	0.9	8-leaf						
Standard Program	same	cot, 2, 8-lf	13	16	40	183	410	179
Dual Magnum + COC	1.6 + 1.0% v/v	2-leaf						
LSD (0.05)			NS	NS	NS	NS	NS	NS

*COC = crop oil concentrate.
†Applications were made when sugar beets were cotyledon (cot) on May 12, two-leaf (2-lf) on May 21, eight-leaf (8-lf) on June 6, and layby on June 30 just prior to the final cultivation.

COMPARISON OF THE AM400 AND IRROMETER MONITOR FOR PRECISE IRRIGATION SCHEDULING

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Summary

The efficient use of irrigation water requires several kinds of information. One element of an efficient irrigation scheduling is monitoring the soil to assure that the crop irrigation goals are being met. During previous years various soil moisture measuring devices have been tested for irrigation scheduling in silt loam and sandy loam (Eldredge et al. 1993; Shock et al. 1998a, 2002, 2003). In this year's trial Watermark soil moisture sensors were tested as read automatically by Irrometer Monitors and AM400 dataloggers. Practical suggestions are provided to use soil moisture sensors to the benefit of crop production and water conservation.

Introduction

Precise irrigation scheduling is necessary to optimize marketable yield of high-value crops while conserving water and protecting water quality. Irrigation scheduling is greatly facilitated by any soil moisture sensor that can provide timely and responsive information on soil water or soil water potential status. For a particular sensor to be useful for a particular crop and soil, it needs to respond rapidly and reliably to the range of variation of water status in that soil, which is important for marketable yield.

Materials and Methods

The response of Watermark soil moisture sensors to irrigation events and the termination of irrigation was read automatically using two AM400 Hansen data loggers (M.K. Hansen Co., East Wenatchee, WA) and two Irrometer Watermark Monitors (Irrometer Co., Riverside, CA) in furrow- and drip-irrigated onion.

Automated reading of Watermark soil moisture sensors was done in a furrow-irrigated Greenleaf silt loam planted to onions. The sensors were installed with their centers 8 inches deep directly below the onion plants. The sensors were installed in the lower part of the field where the furrow irrigations were less effective at wetting the soil. Six Watermark soil moisture sensors and a temperature probe were connected to each AM400 Hansen datalogger that automatically read the sensors three times a day. Data were recovered from the AM400s using a palm computer as previously described (Shock et al. 2001).

Seven Watermark soil moisture sensors and a temperature probe were connected to two Irrometer Watermark Monitors. A computer and the WaterGraph program (Irrometer Co., Inc.) was used to set the sensor data collection frequency at 15 minutes. Data was recovered from the Irrometer Watermark Monitors using a laptop and the WaterGraph program.

Results and Discussion

The automated collection of Watermark sensor data by an AM400 Hansen datalogger and an Irrometer Watermark Monitor (Irrometer Co.) provided similar interpretation of wetting and drying cycles in both a furrow-irrigated onion field (Fig. 1) and in a drip-irrigated onion field. There were few soil water fluctuations in the drip-irrigated onion field and the results are not shown. The Watermark sensors responded to irrigation within 1 hour. Small differences in calibration equations can be noted (Fig. 1D) and slight differences in the interpretation of soil water potential near saturation are evident (Fig. 1C).

The AM400 was convenient for following and scheduling irrigation events in the field due to its graphic display. Irrometer Watermark Monitor was convenient for setting the data logger reading frequency, easy data retrieval, and computer-aided interpretation of the data. The operation, advantages, and limitations of Watermark soil moisture sensors are described elsewhere (Shock 2003).

The results from both data loggers were readily applicable for the management of onion irrigations. We have previously shown that it is best to furrow irrigate onion grown on silt loam when the soil dries to about -27 kPa clear to the end of the growing season (Shock et al. 1998b, 2000). It is best to maintain drip-irrigated onion grown on silt loam at a water potential of -20 kPa (Shock et al. 2000). The results provided by both data loggers could be readily used to manage accurate irrigation scheduling.

Acknowledgments

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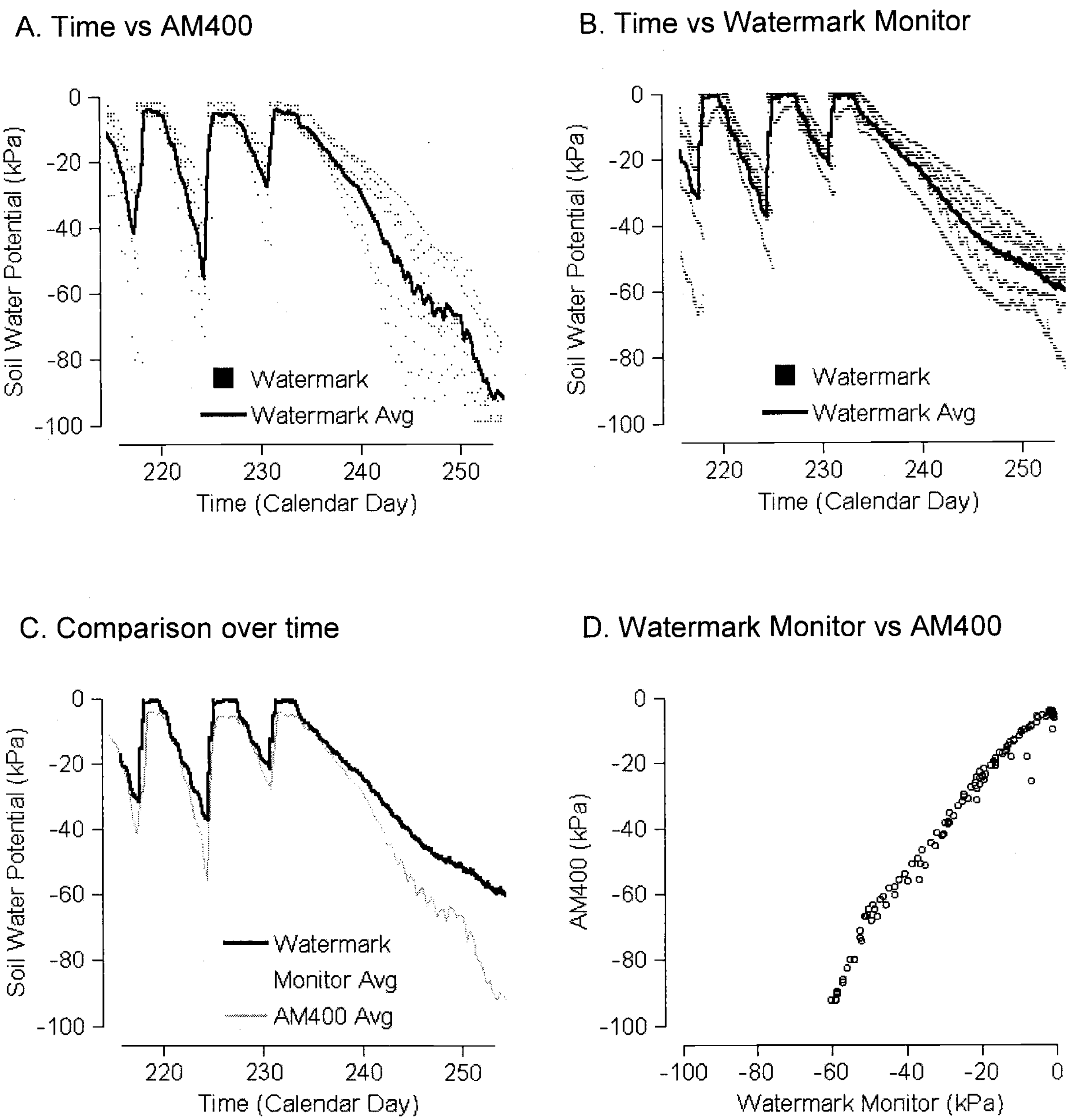

Figure 1. Response of Watermark soil moisture sensors to irrigation events and the termination of irrigation as measured by an AM400 Hansen datalogger (A) and an Irrometer Watermark Monitor (B). The average readings of the an AM400 Hansen datalogger and an Irrometer Watermark Monitor are compared over time (C) and over the measured range of soil water potential (D), Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

APPENDIX A. HERBICIDES AND ADJUVANTS

Trade Name	Common or Code Name	Manufacturer
Aatrex	atrazine	Syngenta
Accent	nicosulfuron	DuPont
Banvel	dicamba	BASF Ag Products
Basagran	bentazon	BASF Ag Products
Betamix	desmedipham + phenmedipham	Bayer CropScience
Bronate	bromoxynil + MCPA	Bayer CropScience
Buctril	bromoxynil	Bayer CropScience
Callisto	mesotrione	Syngenta
Chateau	flumioxazin	Valent
Clarion	nicosulfuron + rimsulfuron	DuPont
Clarity	dicamba	BASF Ag Products
Dacthal	DCPA	Syngenta
Distinct	diflufenzopyr + dicamba	BASF Ag Products
Dual Magnum, Dual II Magnum	metolachlor	Syngenta
Eptam	EPTC	Syngenta
Goal 2XL	oxyfluorfen	Dow Agrosciences
Matrix	rimsulfuron	Dupont
Option	foramsulfuron	Bayer CropScience
Outlook	dimethenamid-p	BASF Ag Products
Nortron	ethofumesate	Bayer CropScience
Permit	halosulfuron	Monsanto
Plateau	imazapic	BASF Ag Products
Poast, Poast HC	sethoxydim	BASF Ag Products
Progress	desmedipham + phenmedipham + ethofumesate	Bayer CropScience
Prowl, Prowl H_2O	pendimethalin	BASF Ag Products
Roundup Ultra, Roundup UltraMax	glyphosate	Monsanto
Sandea	halosulfuron	Gowan Company
Select	clethodim	Valent
Scoil	methylated seed oil	Agsco
Sencor	metribuzin	Bayer CropScience
Spartan	sulfentrazone	FMC
Steadfast	nicosulfuron + rimsulfuron	DuPont
Stinger	clopyralid	Dow Agrosciences
Topnotch	acetochlor	Dow Agrosciences
Tordon	picloram	Dow Agrosciences
Transline	clopyralid	Dow Agrosciences
Treflan	trifluralin	Dow Agrosciences
UpBeet	triflusulfuron	Dupont
Valor	flumioxazin	Valent

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES

Trade Name	Common or Code Name	Manufacturer
Asana	esfenvalerate	DuPont
Aza-Direct	azadirachtin	Gowan Company
Bayleton	triadimefon	Bayer CropScience
Bravo, Bravo Weather Stik	chlorothalanil	Syngenta
Captan	captan	Micro Flo
Capture	bifenthrin	FMC
Counter 20 CR, Counter 15G	terbufos	BASF Ag Products
Dibrom	naled	UAP
Dimethoate	dimethoate	Several
Dithane	mancozeb	Dow Agroscience
Ecozin	azadirachtin	Amvac
Gaucho	imidacloprid	Gowan Company
Guthion	azinphos-methyl	Bayer CropScience
Headline	pyraclostrobin	BASF Ag Products
Kocide	copper hydroxide	Griffin
Lannate	methomyl	DuPont
Lorsban	chlorpyrifos	Dow Agroscience
Malathion	malathion	UAP
Messenger	harpin protein	Eden BioScience
Metasystox-R	oxydemeton-methyl	Gowan Company
Mustang	zeta-cypermethrin	FMC
Ridomil Gold MZ	metalaxyl	Syngenta
Success	spinosad	Dow Agrosci.
Super-Six	liquid sulfur	Plant Health Tech.
Telone C-17	dichloropropene + chloropicrin	Dow Agrosci.
Telone II	dichloropropene	Dow Agrosci.
Temik 15G	aldicarb	Bayer Cropscience
Thimet	phorate	BASF Ag Products
Topsin M	thiophanate-methyl	Cerexagri, Inc.
Tops-MZ	thiophanate-methyl	UAP
Vapam	metham sodium	Amvac
Vydate	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-'Goldar'	*Pseudoroegneria spicata*
corn	*Zea mays*
dry edible beans	*Phaseolus spp.*
Great Basin wildrye-'Magnar'	*Leymus cinereus*
hicksii yew	*Taxus x media*
onion	*Allium cepa*
pacific yew	*Taxus brevifolia*
poplar trees, hybrid	*Populus deltoides* x *P. nigra*
potato	*Solanum tuberosum*
Russian wildrye-'Bozoisky	*Psathyrostachys juncea*
Siberian wheatgrass-'Valvalov'	*Agroyron fragile*
soybeans	*Glycine max*
spearmint, peppermint	*Mentha sp.*
sugar beet	*Beta vulgaris*
supersweet corn	*Zea mays*
sweet corn	*Zea mays*
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*
common lambsquarters	*Chenopodium album*
downy brome	*Bromus tectorum*
green foxtail	*Setaria viridis*
redroot pigweed	*Amaranthus retroflexus*
barnyardgrass	*Echinochloa crus-galli*
kochia	*Kochia scoparia*
hairy nightshade	*Solanum sarrachoides*
Powell amaranth	*Amaranthus powellii*
Russian knapweed	*Acroptilon repens*
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	
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*
willow sharpshooter	*Graphocephala confluens* (Uhler)